Crawford Fund FOR A FOOD SECURE WORLD

FOOD AND NUTRITION SECURITY

The biosecurity, health, trade nexus

The Crawford Fund 2021 ANNUAL CONFERENCE

QT Hotel, Canberra ACT, Australia
and Online

13-14 December 2021

Editor A. Milligan

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.

The Crawford Fund
Building 7, Unit 7, 1 Dairy Road, Fyshwick ACT 2609, Australia

Phone: +61 (0)2 6280 8611
Email: crawford@crawfordfund.org
Web: http://www.crawfordfund.org
Twitter: @CrawfordFund
YouTube: https://www.youtube.com/user/CrawfordFund

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CHAIRS

The Hon. John Anderson AO
Chair, The Crawford Fund

Professor Wendy Umberger
President of the ACIAR Policy Advisory Council and Executive Director of the Centre for Global Food and Resources, and Professor of Agricultural Economics and Food Policy at the School of Economics and Public Policy at the University of Adelaide

Dr TJ Higgins
Honorary Fellow CSIRO Food and Agriculture, and 2021 Crawford Fund Medal Winner

Andrew Egan
Assistant Secretary, Climate Change and Sustainability Division, Department of Foreign Affairs and Trade

Dr Robyn Cleland
Chief Environmental Biosecurity Officer, Department of Agriculture, Water and the Environment

Cathie Warburton
Interim Managing Director, Grains Research and Development Corporation (GRDC)

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Foreword and Welcome

Hon. John Anderson AO

Chair, The Crawford Fund

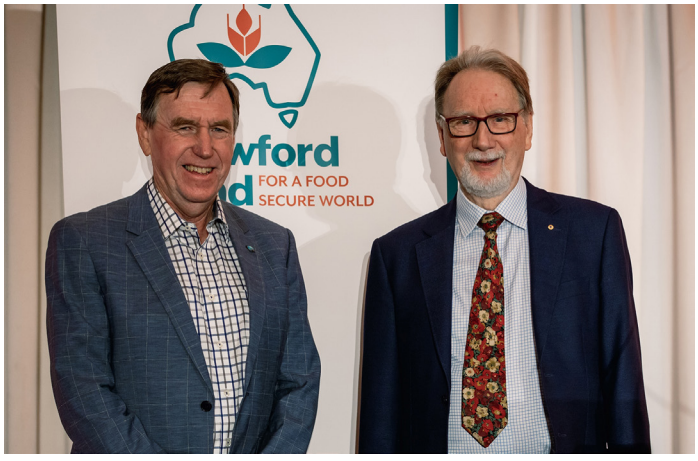
Welcome to this Crawford Fund conference for 2021, 'Food and nutrition security: the biosecurity, health, trade nexus'. The conference was planned originally for 2020 and has been almost 24 months in the making, because of the COVID pandemic.

Biosecurity is all about protecting plants, animals and humans from known pests and diseases, and also about predicting risks from emerging pests and diseases. This timely conference is a great opportunity to hear about current risks, factors enhancing pest and disease risks across the globe, and technologies important in recognising and finding these threats; and also about how governments, at all levels, and the private sector may respond.

Agricultural biosecurity is critical, not only to food supply but also because the boundaries between environment, agriculture, nutrition and human health are increasingly blurred. Considering the links between them is now often described as taking a One Health approach, or using a One Health lens.

It would be easy to despair at the challenges, the potential for upsets, that confront us. However, two great Australian scientists at this conference (photo below) – Dr Brian Keating and Dr TJ Higgins – have made their contributions by confronting various challenges using calm, reasoned and thoughtful approaches, rather than as if catastrophe was brewing. We will do well to follow their example in the global fight for food and nutrition security.

There is nothing new about massive challenges in life. We should learn from our forefathers that the way to approach these things is with an air of positivity,



Dr Brian Keating (left) was awarded the Crawford Fund Medal for 2020, and Dr TJ Higgins was awarded the Crawford Fund Medal for 2021, at the conference dinner on 13 December.

of collaboration, of cooperation, and by working together. That approach is what we shall hear about today. Let us not be demotivated, but rather let us be stimulated to work together.

The speakers at this conference will help us recognise the key issues in biosecurity, and the scientific and technological policy solutions, and they will show us that Australian R&D is really important and globally significant. It is an area where Australia 'punches very far above our weight'. Australia is one of the seven biggest contributors to the work of the international agricultural research consortium CGIAR. Internationally there are six nations and Bill Gates, and during the last decade Australia has been one of those six nations.

We recognise that the number of conference delegates attending in-person this year is well down on previous conferences, because of COVID. However, we are delighted that so many could make it; that so many have been keen to see it happen; and that so many of our sponsors have come forward and guaranteed that we can make this conference a success. We are also delighted that there are many delegates attending the conference online, from around Australia and over 20 other countries. Welcome also to those attending the special events being held by our Crawford Fund committees in Western Australia, the Northern Territory and Tasmania.

In today's audience, in-person and online, are the group of around 40 university students who were the Conference Scholars* this year; they will now have that full experience in 2022. Those young eager people are keen to confront the challenges of today and to overcome them; not be overcome by them. Delegates also include members of the Researchers in Agriculture for International Development Network (RAID). Two of them – Rebecca Cotton, who is here, and Madaline Healey, who is online in Queensland – are our designated 'keynote listeners'. Their report on the event will be on the Crawford Fund website**. Thank you to them, in advance.

And thank you again to our sponsors, many of which have stayed with us despite all the contortions around getting the conference to physically happen. That loyalty is greatly appreciated.

Hon. John Anderson AO
Chair, The Crawford Fund

* Conference Scholars are asterisked in the Participants list, pages 136–145.

** https://www.crawfordfund.org/news/2021-cf-conference-keynote-listeners-report/

2021 SIR JOHN CRAWFORD MEMORIAL ADDRESS

Five reflections to transform our food systems and achieve the Sustainable Development Goals

Dr Agnes Kalibata

UN Secretary-General's Special Envoy to the 2021 Food Systems Summit

Let me start my presentation by acknowledging and recognising The Honourable John Anderson, and the leadership of The Crawford Fund in general. I really appreciate the opportunity to talk to you all, to engage with you all in this conversation that we have had over the last two years under the Food Systems Summit that was led by the UN Secretary-General. It is a pity that I cannot join you in Australia: I would have loved to. When we started towards this Summit, my ambition was that we would reach every person, to the extent possible, and make sure that we are joining hands in the transformation of our food systems; so I feel this gap in my ability to be with you and engage you personally. But these are the times we are living in, and I am going to talk to you through this Zoom conversation.

As many of you know, the Secretary-General two years ago launched what we now call the 2021 Food Systems Summit. Every year we commemorate World Food Day, and on that day in mid-October at the World Food Summit of 2019 he announced he was going to launch a Food Systems Summit in 2021. Two months later, I got a call and was asked to be part of leading this Summit.

I already have a day job: I work as a full-time President of the Alliance for a Green Revolution in Africa (AGRA); I have two kids; I was not looking for another job. But I have been working on the African continent for some time now in the agricultural sector, and every day we see the challenge of how farmers are struggling – and although the continent had started recovering, that recovery now seems far away. I realised that this call was not something that I could let go; it is an opportunity to work with everybody together to find solutions to some of the challenges we are seeing. So I said yes to the challenge.

Now I will tell you the story of how we did it: the story of the last two years. How we set in motion a process that would help us engage the world and ensure that we come out with a clear idea of how we might be able to transform our food system; a clear understanding of the challenges of the world's food systems; a clear way of ensuring that every person in the world understands their role. Then, as I end this conversation with you, I will share a few reflections that will help us understand how we go forward from here.

This record of the 2021 Sir John Crawford Memorial Address on 13 December has been prepared from transcripts.

On that day in 2019 when the Secretary-General launched the Food Systems Summit, what he was looking for was to ensure that we use the power of food; that we unleash the power of food to deliver on all 17 of the Sustainable Development Goals (SDGs). The Secretary-General said that food has the ability to help us deliver across all 17 SDGs. He said that food is so powerful because it is important to all of us; it brings us together as families, as communities, as nations; it underpins many of our cultures; and it offers huge economic opportunities for lots of countries around the world.

He said that if there is one thing that can bring us together in a conversation, it is to start working on how we might fix our food system. But he also was recognising that our food system is becoming a challenge to our environment and to how we deliver – and I am going to take you through all these aspects.

Food system challenges

Here are the points the Secretary-General recognised as challenges.

First, that the world has been working for some time towards producing enough food – as you in Australia would know; you are one of the countries and continents that figured out, very early, that producing food for export is also an opportunity for economic growth. But despite what we are achieving, as a world, in food production, and despite the fact that over 50 years ago we recognised the need to produce more food, we still have millions of people who are hungry. We still have 820 million people who go to bed hungry, and that number has even gone up because of COVID-19.

Second, that a number of people are malnourished. People's potential is still being completely diluted by the types of vitamins they have in their diets. Still over 45% of the children of this world, especially in developing countries, are not achieving their potential because of malnutrition. On the other hand, about two billion people are obese or overweight, and as a result they are subject to all sorts of illnesses. This is part of our food system.

Third, that in the midst of all that, our food system is contributing to climate change. We now know that 30% of contributions towards climate change come from our food system.

And fourth, that our food system's most significant damage is to biodiversity. We are losing biodiversity at such a rate that 80% is the figure that we are now talking about as biodiversity loss resulting from how we manage our food system and what we are trying to do to get food and make it less expensive, at any cost.

These are things that need to stop.

We also now know that hundreds of zoonotic diseases are beginning to impact our world in ways they have not done before, because our food system is in closer proximity to our environment: probably too close for comfort.

There is no question that we need to do a few things going forward.

- We definitely must deal with the challenge of hunger, paying attention to the related challenges around nutrition.

Dr Agnes Kalibata delivered the Sir John Crawford Memorial Address via Zoom.

- We need to shift consumption habits and to be a little bit more aware of how our consumption and diets can be more sustainable for the world's climate.
- We need to fix our environmental challenges. We need to start thinking about how protecting our environment and its capacity for regeneration might be done in the years ahead.
- We need to think about equity: COVID-19 has shown us that there are so many people in the world who cannot feed their families with a decent meal. This is something that we need to address.
- We need to address the challenges of resilience. There are many people that are living from one shop to another. Here in Africa we have become used to the fact that out of every two seasons, one season will fail.

These are things that we have to fix. We cannot postpone them. These are not things we can pass on to the next generation. These are things we need to deal with today.

Among my own personal priorities, and from an African continent perspective, I am one hundred per cent committed to ensuring that as a continent we understand what is at stake, that we understand the link between today's farming systems and climate change. Today African farmers still produce yields at the expense of the environment: 30% of our production comes from using new land nearly every year, and we have a huge impact on biodiversity loss. These are things we definitely can do something about.

With all this in mind we put the Food Systems process in motion, and really focused on a few things:

(i) on how we might use the food system to recover from COVID-19, and

(ii) how we might use the food system to deliver on SDGs, and

(iii) how we might use our thinking about food systems to start understanding the types of transformations that are required in our food system.

A People's Summit

We recognised that we needed to be bold, we needed to be ambitious, and we needed to go as far as we could. So we focused first of all on making this a People's Summit, asking ourselves what type of people do we need to bring on board? Where? When? Who is being left out? And who needs to come into this conversation?

We cast our net very wide. I was telling the team, as we started, that we need to reach five billion people, which means that every adult in this world would need to know what is at stake from a food systems perspective.

Each of us eats three times a day – apart from the 820 million people that are struggling for food – and each of those meals has an implication for our food system, and so we needed to bring in as many people as possible. So we made it a People's Summit, and I want to tell you now how that has worked.

– We reached out to a diverse range of 'actors' to engage, be heard, and act in their own ways: countries; consumers; the private sector; producers; civil society; youth activists; indigenous leaders; scientists; and many others.

– We had a scientific group that had a network of over 25 scientific institutions that were working to ensure that what we do in the Food Systems Summit is anchored in science.

– We literally opened the door to everyone, to ensure that the conversation was happening in all corners of the world.
We have since had hundreds of independent dialogues; recently we celebrated the 1000th independent dialogue. Independent dialogues are spaces where different groups of people are coming together, not because they are part of government but because they care about where the world is going and the impact our food system is having, to have real conversations around how things can change.

– We also put governments into the 'drivers seat', so they understand that at the end of the day this work happens at a country level, and that governments are going to have to accept their responsibility to lead. As a result, governments have also had hundreds of dialogues – over 600 national dialogues now. We shall see what all that has produced.

A Solutions Summit

We also made it a Solutions Summit. In addition to reaching out to as many people as we could, we also wanted to ensure that we were mobilising as many ideas and as many solutions as possible. We do not have a lot of time, so we wanted not to sit and talk but instead to build on we already had. What we already had were thousands of ideas sitting in so many different spaces, so many different institutions, and we needed to bring them together.

– We put in place 'action tracks' across the areas that I mentioned that are very critical to our food system. Through these action tracks, we were able to mobilise over 2200 ideas that have since been clustered into 52 solution clusters.

A solution cluster is where you find the institutions behind ideas and the people behind these institutions, and they are available to help countries develop and to help different people deal with the different challenges of our world.

For example, sustainable livestock: if you have a community that is trying to understand how to address the challenge of sustainable livestock, we have a solution cluster that brings all the relevant institutions and all the relevant experts together in one place, where you can, at a click of a button, understand who to go to and where to find ideas.

In this, we were mobilising and building on ideas that already exist.

– We also chose to lean into 'courageous conversations', and really talk about trust and the whole idea of the level of trust within our midst. If you followed our Summit closely, you will know that a number of people in the Summit were not happy about certain things, especially in relation to the private sector. But you know what? When you have challenges in your midst, the easiest way to deal with them is probably to face them, rather than push them aside.

– We made sure that we were encouraging people to talk about what was not working in our system; what parts of our society were not delivering in the ways we should have been delivering, and why; and how to make sure that those spaces were becoming available.

– We certainly would like the private sector to do things differently. There are opportunities for them to do things differently – whether it is from a nutrition perspective; whether it is from a business perspective and rethinking business models; whether it is all the things that could happen to impact our environment, and the private sector's opportunities to do things differently. They, like our governments, have to rethink their models.

– Of course, our governments have to rethink their models too. Right now, the agricultural sector is driven largely by subsidies that are probably influencing the wrong behaviour. The scientific group wrote a paper on this: the opportunity to repurpose these subsidies, so as to enhance better behaviour for people and for the environment, is sitting right there.

These are all conversations that we needed to have.

– There was the conversation around consumers and how each of us, you and I, waste so much food, contributing to US$1 trillion loss in waste food and 80% to emissions.

These are things we do not need; these are things that we can do without.

– Also we recognised that we needed to engage better with civil society, and for them to engage better. They wanted to present issues that are very important to us, and to discuss those issues, and we made it very clear that there were spaces in the Summit where they could come in and address those issues. We welcomed them.

Many of them took up that opportunity. Many others of them decided to voice the issues from outside. We took note of those issues, and we still encourage all

of us to sit around a table when an opportunity like this presents itself, so that we can build trust rather than continue building differences among us.

The results of the Summit

All these processes were very important to ensuring that we have a few critical things going forward.

The most important of those was the Secretary-General's statement, being very clear about areas where he wanted to see governments providing action and providing leadership. He highlighted five areas that he will be monitoring and revisiting every two years to see the progress we are making.

- The first and most important area is about **nourishing people**.
- The second area is about attending to **environmental issues**.
- The third is about delivering on **equity**.
- The fourth is about focusing on **resilience**.
- And the fifth area is **implementing action** on all these challenges.

Member states also stepped forward in a strong way – 164 member states. Of those, more than 90 Heads of State and Government, including 77 Presidents, spoke about the work they had been doing preparing for the Summit, and about their commitments as individual countries, and how they were going to tackle those commitments.

By the date of the Summit there were 148 countries having national dialogues: that is, spaces where countries are coming together to discuss how different sectors can work together to deliver a food systems transformation. Those transformations are delivered to the Summit process through what we are calling national pathways, and 103 national pathways were delivered by the time of the Summit. The number of national pathways is still growing and has reached 110 now. I was particularly proud that the African continent engaged very well.

The African continent and many other developing places probably had reasons not to engage in this Summit. The question I keep being asked is: Summits and Summits and Summits … what comes out of them? We told them that this was going to be different. It was going to be different in the sense that it engages, and that it needs all of us to engage.

This Summit is not about who owes what to whom. It is not about who helps whom deliver what. It is about how we, as a world, are engaged, and how we as individuals start delivering together. So I was very proud to see that the African continent stepped forward, not just as 49 countries that were engaged but with a clear common continental position that is informing how they go forward and whose key indicators are being proposed for adjusting the continental framework they have on food, so that they can also add food systems indicators.

A number of countries came together in what we are calling 'coalitions'. Coalitions are spaces and areas where people felt that no one country, no one nation, no one institution can come through alone.

There were 30 multi-stakeholder coalitions. Examples include a school feeding coalition, which is extremely important to the 321 million children that are going

without a meal. There is a sustainable production coalition, and a blue food coalition. Also, a number of coalitions were launched, including a coalition called aim for climate. All these are extremely important to helping us think through how we work together as a community.

There were more than 230 other commitments – we provided a commitments registry – remembering that the Secretary-General had called for all of us to commit to doing things differently. The commitments range from something as small as a community in Nepal committing to reduce the amount of erosion on their slopes, to something as big as the school feeding coalition which has more than 40 countries and several institutions subscribed to it.

We engaged many networks, and we registered what we are calling 'constituency statements' as well. In each constituency, whether it was producers, whether it was civil society, whether it was indigenous people, whether it was private sector, or youth, we told them – and we were very clear – that **we come here not looking for answers from other people; we come here looking to provide answers ourselves**. We asked them to tell us how they would provide answers to problems we are having as a world. And they provided declarations that contained their commitments; how they see themselves as a community contributing to how our world is changing.

In attending many of these meetings, delegates usually expect someone else to solve the problem, but here we put heavy emphasis on 'the solution to the problem starts with you; what is your commitment?'. Communities made declarations, and they are recorded in a compendium that we put together and which is available on the Food Systems Summit website*. A Science Reader has also put together all the papers run by the Scientific Group, and you can access that on the website as well. It publishes world class material that helps shape where we are going.

Of all the surprising things that I feel we achieved, probably the most gratifying was how much we elevated the discourse on the political relevancy of food systems on the global agenda, and how countries and individuals and communities are now thinking differently about food. We set out to change the paradigm around food – from 'food' to 'food systems' – and to move from silos to systemic thinking, and we feel that thinking is now 'on the table'. Of course, the question now is how we go forward and how we deliver on that paradigm shift, and I will come to that in a second. But there was no question in my mind or that of anybody who participated in the Summit that we definitely elevated the discourse on food systems.

Australia, specifically, engaged in a number of ways – such as in food systems dialogues and in action tracks – leading to a number of ideas that I have mentioned. Australians participated in some of the emerging coalitions. Someone who was managing the Food Systems Summit Secretariat made a contribution focused on supporting developing states and small island states so that they could participate. That participation was mostly because we had resources to facilitate that, and Australia provided leadership here.

* https://www.un.org/en/food-systems-summit

What we wanted from Australia

Australia did as we hoped, to a large extent, but we also want Australia to post its food systems pathway. We want Australia to have its food systems strategies out in public. We want Australia to provide the leadership that we are looking for, recognising fully well that this food system conversation, this food systems transformation, is not just a developing country agenda: it is as much a developed country agenda as it is a developing country problem. None of us can succeed if all of us do not engage. I strongly encourage Australia to finish some of the processes that we have started.

We will be looking forward to Australia posting your food systems pathway, and we want to learn from the strategies that you are designing. Australia has done a lot of research and a lot of work in climate-smart agriculture that the world can benefit from, so please do make that available, and be part of leading from the front and supporting everybody else.

From Summit to action

To follow up all this work, the Secretary-General has put in place a hub that is to start in January 2022. The work of the Secretariat that I was leading closes by the end of December 2021 – and it is very important that happens. We need to shift from a Summit thought-process and a dialogue thought-process, where everybody is engaged in conversation, to an action thought-process where everybody focuses on delivery.

I am really happy that my team and I have brought us this far, and that my team and I are closing business on dialogues so that a new team can begin with a focus on action, so that the world adopts the message that **it is time to shift into implementation and action** – and takes action.

The hub is to be based in the Director-General's Office at FAO. It is an independent hub that will support coordination to ensure that we think now with a food systems approach, and avoid falling back into siloed thinking. The hub will report back to the Secretary-General so that at the end of two years the Secretary-General can report to the Heads of State about the commitments that they made and about how well we are making progress on those commitments. The hub will ensure that we maintain connection and engagement with the countries and people who were appropriately engaged in the Summit process – the world that we reached out to, including the producers, the indigenous people, the youth that we engaged in new ways and helped to understand their individual roles. The hub will also focus on how to continue providing support to that community so that they can continue understanding their individual roles and start shaping how we all deliver together.

Reflections

Now I want to share a few reflections on some of the points that we must be looking at as we go forward.

There is no question that the Summit has set us on the right path, but setting out well is only a quarter of the journey, as a popular Spanish proverb says. Our feet are pointing in the right direction; our minds are engaged; our institutions

and countries are all engaged, but this is only the beginning. The rest of the work needs to happen.

We need to start demonstrating that we can deliver without being in silos: that we can work together as sectors. In my own country, Rwanda, as Minister of Agriculture I worked with different Ministries to be able to deliver on some of the challenges we had. Being a small country, we quickly hit our environmental limit, and being able to work together was important for us. So working together is doable; I have seen it in action. We can do this: sectors coming together and delivering together.

Some countries are already beginning to think about how communities can engage in very deliberate and very significant ways. How all of us can align around critical issues, as we have seen with coalitions. This is something we can do. We are just beginning, and I am one hundred per cent sure that we can deliver action.

These are my thoughts, as hunger persists and as malnutrition and poverty and environmental degradation continue; as we strive to make a better future for our children, and to deliver on the SDGs; and also as we remain on track not to overshoot the 1.5 degrees.

There is no question that we must focus on doing the right thing.

- First, we need to think about a **holistic approach** and how we do that at country level. A country-led approach is essential, empowering countries irrespective of where they are, ensuring that we are working together as countries with clear plans and clear strategies, recognising again that the agenda for a southern country is just as critical as the agenda for a northern country. Here in Africa we experience the impacts of climate change, though many of the farmers that lose crops every season do not even know what climate change is about and have contributed nothing to it. There cannot be success unless we all work on achieving success. That is very important. Countries need to align internally, and regionally and globally, and we all need to think through what working together looks like.
- My second point is about **embracing innovation**. That shone through all the 2200 ideas that came up for the Summit. The world can produce plenty of innovation, but the world is on a very fast-moving treadmill, you might say, and we need to be thinking about the types of innovations that are needed to keep us on course while also ensuring we are building *sustainability* into our systems. Is it about different diets – as people were talking about meat alternatives? Is it about regenerative agriculture? Is it about climate-smart agriculture, and better tools and new ways to do that? Is it about carbon farming, moving from the huge jurisdictions that we are seeing today, to smallholder scale, recognising that the smallholder farmers are part of our global farming system? Or is it about the true value of food, recognising that we are paying in the wrong places – that we are paying for malnutrition and obesity instead of paying for good nutrition; that we are paying for environmental damage instead of paying for good agricultural practices? These are things we must think through and innovate around.

- Third: **inclusion**. I mentioned to you how COVID-19 has laid us bare on inclusion. It doesn't matter where in the world you look: in each of our countries there are people who are unable to put the right meal on the table; there are people that are living just one season away from failure in their systems; there are people whose earnings have been completely eroded; and there are food value chains that are not remunerating people well enough for them to be able to feed their families.

  Is this right? Is this how we must continue? We can't afford this! We need to do something about it. We need to be deliberate around inclusion; around women and how we bring them into value chains; around youth and how we create jobs; and around decent work and how value chains remunerate people for the right type of work.

- Fourth, we need to continue leaning into **courageous conversations**. One of the things that gives me hope is seeing COP26 (26th UN Climate Change Conference of the Parties, Glasgow, November 2021) – seeing how much countries were engaged around the types of changes we need to be having in our systems, recognising that we will overshoot the 1.5 degrees. It does not matter whatever economic systems we are nurturing and protecting today, the crash will come if we do not do the right things. For us, living on the equator, for these farmers, the crash is already here. So it is time for those conversations around the types of energies we need, the types of factories we need.

  The time has come for us to understand that we have a finite planet and we need to manage it as a finite resource and we need to understand that we need to do it together. Whether it is a business working in the food value chain or a business somewhere else, these conversations need to be had, and to include conversations around nutrition. Why would one in every two people have obesity when we know the right thing that needs to be done?

  We have the ability to fix many of these situations that we live with. We also have the ability to have conversations that allow us to start remodelling our businesses. We are people; we have creativity; we have the ability to do this. We just need to get it done.

- My fifth point is about putting **science at the centre** of this. I completely believe that we need to use science and that science must direct the decisions we make. Science uses the evidence that is in our midst, and should inform our policies. Let us not turn a blind eye nor a deaf ear to science. Let us do the right thing.

Conclusion

Finally, I want to conclude as I started. I told you that we set out to reach individuals; to reach each person among us; to engage everyone in what we can do as institutions.

One of the things that I was proud of during the time of the Summit was seeing Louise Fresco, who heads the Wageningen University & Research Executive Board, stepping forward and saying: We've just made all the research we've

done, over all the years, publicly available so that countries that don't have the ability to do this type of research can have this material available to them. I wanted to say: Thank you for your great leadership, recognising that many of our countries and our universities and our research institutions would take thousands of years to reach where the Netherlands is in its research. That type of leadership is going to be vital.

We need to start defining that type of leadership.

Here at AGRA, the institution I lead, work has mostly in the past focused on ensuring farmers have access to good inputs, because when Kofi Annan started this institution he thought that the missing link was that African farmers did not have improved seed; they did not have access to good fertilisers, nor to good ways of applying those fertilisers. But things have since moved on, and now we need to think about sustainable farming.

I am trying to make sure my institution understands that working farmers have access to carbon farming, that they understand what that means, that they understand restoration and are taking responsibility for some of the restoration that needs to happen.

Governments also need to understand that farmers cannot work alone. As a result, we are working with governments to help them understand the policy environment, the capacities that are needed to be able to ensure that farmers in Africa can use the agricultural sector as an opportunity rather than seeing it as a burden in which they are stuck in poverty.

That is a commitment that I have made in the work that I do every day.

In my institution we keep asking ourselves – and the constituencies we work through – about our commitment. We ask (via a forum that we have on the African continent): How will you lead? I just told you how I will lead from an AGRA perspective and from an African perspective.

I pose the same question to Australia as a government: How will you lead?

I pose it to ACIAR and CSIRO: How will you lead on your research and on improvements of food systems?

And I pose it to businesses and the private sector: How will you lead our world going forward?

How would you want us to lead? Do you all recognise – and I know you do, and I don't want to be patronising about this – that we have to ask ourselves the same question: How will we lead?

One thing is for a fact: our planet is finite. We have to make sure that in our lifetime we use the incredible opportunity we have in our midst to do things together. The food system has highlighted that, and brought us together on the critical issues of our food system.

We need to make sure that our legacy is defined by what we did well together to put our planet back on track, and not defined by how we left a huge burden to future generations. So, if you ask me, there is only one option: **let us focus on transforming our food system.**

I look forward to seeing what you will do as Australia, and what we manage to do as a global community together, because I know there are so many people that are calling in to this conference from different parts of the world, and you all and us and I have a huge responsibility to leave this world back on track.

Thank you again for giving me the opportunity to talk to you.

As the UN Secretary-General's Special Envoy, Dr Kalibata worked with the United Nations system and key partners to provide leadership, guidance and strategic direction towards the 2021 Food Systems Summit. She was responsible for outreach and cooperation with key leaders, including governments, to ensure the Summit serves as a catalytic process within the Decade of Action to improve food systems around the world to deliver on the Sustainable Development Goals (SDGs) and Paris Agreement.

Born in Rwanda to smallholder farmers displaced during the struggle for independence in the early 1960s, Dr Kalibata grew up at a refugee camp in Uganda, where her parents grew beans and maize, and kept cows. The education of Dr Kalibata and her siblings was funded through the family's income from agriculture, ultimately allowing her to study entomology and biochemistry at Makerere University before earning her PhD from the University of Massachusetts Amherst.

After graduating, Dr Kalibata joined the International Institute of Tropical Agriculture (IITA) at Kawanda Agricultural Research Institute, where she started a career as a research scientist through a combination of research and study between IITA and Makerere University, and the IITA and University of Massachusetts, before returning to Rwanda to become the Minister of Agriculture and Animal Resources (MINAGRI) from 2008 to 2014. In this time, Dr Kalibata drove programs that supported smallholders like her father and helped the country recover from continued impacts of the 1994 genocide to food security.

The success of Dr Kalibata's tenure as agriculture minister contributed towards moving her country from a food insecure to a food secure status, becoming a reference point for other countries that sought to deliver agriculture transformation.

Since 2014, Dr Kalibata has also served as President of the Alliance for a Green Revolution in Africa (AGRA), where she leads the organisation's efforts with public and private partners to ensure a food-secure and prosperous Africa through rapid, sustainable agricultural growth, improving the productivity and livelihoods of millions of smallholder farmers in Africa.

Dr Kalibata has a distinguished track record as an agricultural scientist, policymaker and thought leader. She has been awarded the Yara Prize, now the Africa Food Prize; an Honorary Doctorate from the University of Liège; an Honorary Doctorate from McGill University; and the Public Welfare Medal of the National Academy of Sciences for her work to drive Africa's agricultural transformation through modern sciences and effective policy, thereby improving livelihoods of smallholder farmers.

Opening address, 14 December 2021

Su McCluskey

Special Representative for Australian Agriculture;
Member, Commission for International Agricultural Research

Welcome delegates to the Crawford Fund conference on food and nutrition security: the biosecurity, health and trade nexus.

I would like to thank the Honourable John Anderson AO, Chair of the Crawford Fund, and the Board for inviting me to speak this morning. I would also like to acknowledge and thank everyone for attending here today in person and those joining us online and especially our international participants. I am absolutely honoured to be asked to provide opening remarks to the conference in my capacity as the newly appointed Special Representative for Australian Agriculture.

At today's conference we will be hearing about biosecurity, health and trade, all within the context of global food security and nutrition. And it is important to consider the interplay of these three factors as we look to agriculture to feed a growing world, particularly given the impact that COVID-19, floods, fire and drought have had on the world, our economies and individuals.

Critical to this is how do agriculture and health systems work together more closely to manage the threat of zoonoses? How do countries work together more closely to ensure free and open trade? How can industry, government and research organisations collaborate more effectively to create the right conditions for sustainable agricultural production?

You will hear today from Rob Kaan, Managing Director of Corteva Agriscience, that the influences on trade flow are diverse – and collaboration and transparency between key stakeholders are essential in managing future emerging trends that will impact trade flow.

Dr Rob Horsch, Adviser to the Global Commission on Adaptation at the World Resources Institute, will talk about how innovative tools and technologies are essential to future-proofing agriculture against biosecurity threats.

And you will hear some wonderful case studies about technologies and tools employed to meet the challenges of fall armyworm, African swine fever, foot-and-mouth disease, and cereal rusts.

I feel I am in good company today, in this, my first official presentation as the Special Representative for Australian Agriculture.

The headline statement about my role is that I am here to promote the importance of the global rules-based trading system, and the importance of

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international standard-setting bodies in supporting safe, sustainably produced, affordable food and fibre.

But today I would like to provide you with some context for the creation of the role, and then some thoughts on what I think I can bring to it. And I am interested in exploring how I may support you in your work in trade, biosecurity policy, regulation and technology, and building connections across health and agricultural systems.

First, to some context.

Australia exports over 70 per cent of our agricultural produce, and the global rules-based system for trade is key to agricultural exports.

Trade is not just important to Australian farmers but to everyone. Global food security depends on it.

As you might be aware, there is this beast called the agricultural multilateral system – it is complex in its structure, its rules and its procedures, but it underpins trade in food and fibre and all the inputs required to produce it.

This system has been operating, both at the policy and leaders level and at the highly technical level for some 75 years. It has been credited as the system that has smoothed the volatility that keeps nations vulnerable to poverty and food insecurity and has helped lift the economic standing of many countries.

It is the system that Australia, as a mid-sized economy, has benefited from economically, underpinning our access to safe food and creating opportunities for our farmers to export their produce.

And it is the system that has allowed Australia to say no to imports that might introduce exotic pests and diseases.

My role is to promote our ongoing commitment to the multilateral system and to the rules-based order as a sound basis to meet the global challenges.

Australia, and particularly the Department of Agriculture, Water and the Environment (DAWE), puts a lot of effort into supporting the institutions that underpin Australian farmers' access to trade. We do this through Agriculture counsellors based in 16 countries and through the technical experts that live and breathe the rules, the procedures and the principles of standard setting.

You will hear later today from Nicola Hinder, First Assistant Secretary of the Exports and Veterinary Services Division within DAWE, how the standards set by these bodies are integral to maintaining a transparent, rules-based trading environment and reducing risk for those operating in the increasingly connected global value chain.

But the multilateral system and its institutions and principles – including the highly technical institutions – are under challenge. And this matters.

It matters if the role of global trade in supporting global food security is dismissed, and that national self-sufficiency and slogans of buy local are being promoted as the only way to ensure cleaner, greener and affordable food.

It matters that Australia acknowledges that some countries are better off with a hazard-based approach for chemical use rather than Australia's risk-based approach. Context matters. Differing national capabilities matter. Just as it matters that no one trading bloc or country should seek to have its standards of sustainable agricultural production accepted as the global standard.

Our eyes and our agreements should be on the outcome – sustainable economic, social and environmental production and trade in food and fibre. There is something quite perverse in being prescriptive, at a global scale, on how that outcome is achieved. But the outcome being sought is vital, not just for one country, but for the world.

What works on the average 80 ha wheat farm in northern France will not work for the 800 ha wheat farm in Western Australia. But that is the sort of challenge the multilateral system and institutions are under.

It matters that we continue to allow nuance and context to be part of decision-making, be it around measures to reduce greenhouse gases, to promote biodiversity conservation or to increase the productivity of our farm operations.

Our international standard-setting bodies allow for that nuance. Simplistic headlines and scare campaigns do not.

For instance, with respect to climate change and emission reductions, we need to address the impact of fossil fuel subsidies on the production of greenhouse gases. But we also need to address the impact of the support for domestic agriculture provided by so many of our trade competitors, which also contributes to the production of greenhouse gases and undermines environmental sustainability.

So, what will I be doing in this clearly complicated space?

Part of my role will be to promote outcomes-based approaches, not prescriptive approaches, and to counter simplifications with reference to scientific decisions.

I will support a more prominent public leadership role, emphasising the importance of trade for global food security and the critical role that standard-setting bodies play in setting science-based and risk-based rules for trade.

I will highlight the importance of countries investing in and abiding by the rules and standards that govern agricultural trade.

An important part of this will be to recognise differences in country circumstances, and that a one-size-fits-all approach to issues such as chemical use or animal welfare just does not work.

I will highlight the fantastic Australian practices to help to counter misperceptions about Australian agriculture.

And I will be particularly focused on supporting Australia's commitment to science-based and risk-based decision making within that multilateral system.

So why me in this new role?

Well, I come with a very strong background in risk-based and rules-based systems, as well as coming with an agricultural background. And being the first in a role is not new to me. I was the inaugural head of the Office of Best Practice Regulation and the inaugural CEO of the Regional Australia Institute. I have been a policy director at the National Farmers' Federation and CEO of the Council of RDCs. I am also a Director on the Boards of LiveCorp, the NSW Rice Marketing Board and the Australasian Pork Research Institute. And I am an ACIAR Commissioner.

When I am not doing all that, I am a beef cattle farmer not far from here.

I am really excited about this role and look forward to highlighting the importance of science and risk in the engagements I will have.

At the moment, I am doing a lot of listening. I am meeting with government, industry and research organisations that are engaged in this multilateral space.

And given my role straddles industry and government, I want to work closely with industry to encourage their involvement in the multilateral system.

I want to discuss with industry why it is important that we engage in the big policy debates on the various world stages, as well as in the highly technical standard-setting bodies.

Through my work with them, I expect to better understand the issues faced by agricultural producers and exporters as well as building up a bank of case studies to support my international representation.

I will be an additional resource for international engagement and will work with the many government efforts already underway, including speaking one on one with officers based around the world supporting Australian agricultural trade.

In all this, I am looking for the connections; looking for the gaps that I might help to fill; and seeing how I can help to support the great efforts already being undertaken. Which is a good note to finish on.

With biosecurity, health and trade being the focus of today's discussion, and with a fantastic line up of speakers, I am sure that all of us will leave with a stronger appreciation of the complexity of this space, and the importance of staying engaged in the big policy debates as well as the highly technical decision-making.

It is a great privilege to open this conference in my first official role as the Special Representative for Australian Agriculture.

There is a huge opportunity to really make a difference here and my biggest challenge will be identifying where I can get the best bang for the buck.

I look forward to working with you in meeting the challenges that you will be discussing today and I wish you every success in your deliberations.

Ms McCluskey is the first Special Representative for Australian Agriculture. She is an experienced senior business executive and company director with a strong background in agricultural policy, production and research. Currently her roles include directorships at Australian Unity, LiveCorp, Foundation for Young Australians, Australasian Pork Research Institute, NSW Rice Marketing Board and Energy Renaissance and she is a Commissioner for International Agricultural Research.

Ms McCluskey was a Commissioner on the National COVID-19 Advisory Board, a member of the Deregulation Taskforce Advisory Panel, the Charities Review and the Small Business Digital Taskforce. She was also a member of the Independent Review Panel for CPA Australia, the Harper Review of Competition Policy and the NSW Review of the Regulatory Framework.

Previously, Ms McCluskey has been the CEO of the Regional Australia Institute and the Council of Rural Research and Development Corporations (RDCs) and the Executive Director of the Office of Best Practice Regulation. She has also held senior positions with the Business Council of Australia, the National Farmers' Federation and the Australian Taxation Office.

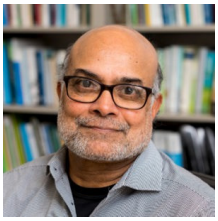
Ms McCluskey is a beef cattle farmer at Yass, NSW, and was named the Westpac/Australian Financial Review Regional Woman of Influence in 2013 and received the Women in Agribusiness award in 2014 for outstanding contribution to policy development.

Threats to global food systems from biosecurity issues

Professor Prabhu Pingali

Tata-Cornell Institute for Agriculture and Nutrition, Cornell University

ABSTRACT



Global food systems have gone through periodic transformations over the past sixty years: the Green Revolution, the Livestock Revolution, and the globalisation of food trade are some of the epochal events observed. The nature and magnitude of biosecurity risks have evolved with the rising intensity and complexity of agriculture and food systems. While transboundary crop pests continue to challenge global food security, zoonotic diseases are rising as risks to human health. The global movement of goods and people has further expanded biosecurity risks, in terms of scale and intensity of impacts. Rising global temperatures will further exacerbate the risks associated with transboundary pest and zoonotic diseases. COVID-19 provides an important example of food systems impacts from a global health shock. Policy and management opportunities for managing biosecurity risks and rebuilding food system resilience need urgent assessment and global action.

Today I want to talk about food systems transformations and biosecurity threats. As we all know, biosecurity threats are threats through plant pests and plant diseases and animal diseases, and they have been around throughout history. But what is important for us to recognise is that the incidence of these threats, the frequency of these threats, the magnitude of these threats have dramatically increased over the past half a century or so; and they have increased as food systems have changed and as food systems have transformed themselves. That is the subject of this talk: the way in which food systems have transformed, and how pests, diseases, animal pests, plant pests, and zoonotic diseases* have evolved over time, along with these transformations in food systems.

When I think about food systems transformations, I think about them in terms of four distinct periods. First, the two decades starting in the 1960s when much of the world was focused on hunger reduction and improving food security, and doing that through improving staple crop productivity: the famous Green Revolution – the Green Revolution in rice and wheat.

The second big period for food systems change happened as a consequence of the Green Revolution, with the growth in incomes; the way in which agricultural growth led to structural transformation, and kickstarted overall economic growth, especially in Asia; the rising middle-class populations, urban

This record has been prepared from a transcript and the slides of the Zoom presentation.

* Zoonotic diseases/zoonoses – diseases that can transfer from vertebrate animals to humans (WHO).

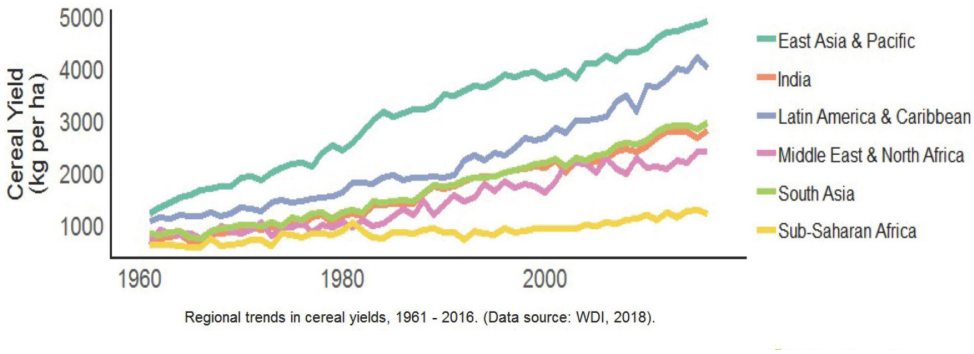


Figure 1. Global trends in cereal yields 1960–2016.
Data source: World Development Indicators 2018.

populations; and how all of that resulted in changes in demand for food, changes in demand for diversity of food, especially animal-source foods.

The third big period started around 2000 with the signing of the World Trade Organization agreement on agriculture, and the opening up of food markets, and the broad integration of food trade around the world. At the same time there was increased homogenisation of consumer tastes, which had consequences for food and food systems.

The fourth period is today, where we are looking at food and food systems in relation to environmental degradation, in relation to human health consequences, and at this nexus between food, health, environment and climate, etcetera.

All these changes in food systems have also brought about changes in biosecurity, and that is the big message from my talk today.

Green Revolution (1960–1980) focus on reducing hunger and growing staples

The Green Revolution, as we know, has had tremendous impact on overall productivity of staple grains. Figure 1 shows very clearly the change that has taken place in productivity in regions of the world that went from being desperately food insecure to becoming food self-sufficient, and in many cases becoming export-oriented economies and exporters of food. The exception is sub-Saharan Africa, but even in sub-Saharan Africa more recent trends show more positive changes happening to food security.

There have been many unintended consequences of the Green Revolution, and we know many of them in terms of environmental degradation, water pollution, biodiversity loss, etcetera, but we do not spend enough time connecting the Green Revolution and the intensification of agriculture with the problems of transboundary pests and transboundary pest infestations. The intensification of transboundary pest infestations happened as the Green Revolution happened, and as the Green Revolution changed the overall food systems across the world, particularly in the developing world.

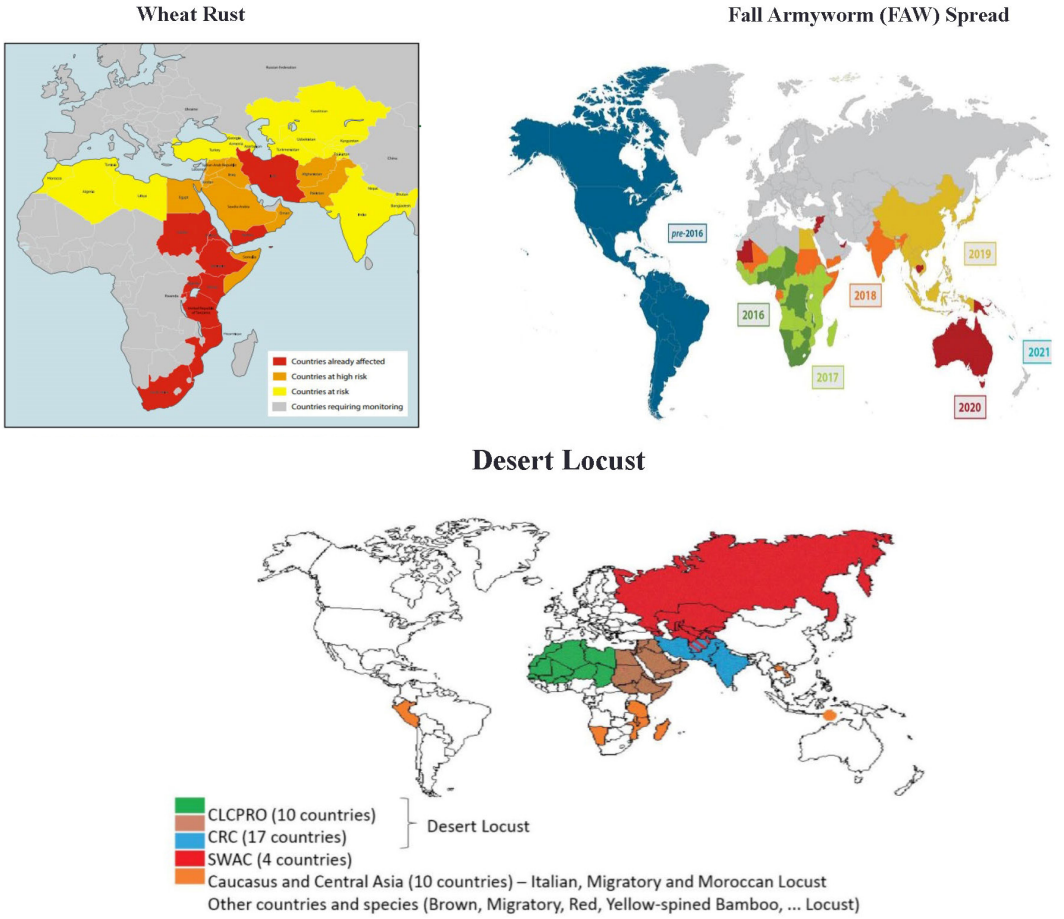


Figure 2. Geographical distribution of transboundary pest infestations. *Source:* FAO.

wheat rust Ug99 – https://www.fao.org/3/i3730e/i3730e.pdf
fall armyworm – https://www.fao.org/fall-armyworm/monitoring-tools/faw-map/en/

Figure 2 shows some examples of some of those effects. Wheat rust spread rapidly across Africa and through the Middle East and into India. Wheat rust Ug99 has become one of the major pest problems for wheat, and the spread has happened primarily because of increased homogenisation of the wheat crop. Very similar varieties are being grown very intensively across the wheat growing regions, spreading across from the Middle East, all the way into South Asia and into northern parts of Asia.

Similarly, we see the spread of fall armyworm for maize, and you can see the way in which fall armyworm spread from Africa towards South Asia, and then to the other parts of Asia, and now into Australia (Figure 2). That spread has happened because of similarities in the crops grown, and also because of the increased trade, increased movement of commodities that has happened through globalisation. Another example is the spread of desert locusts

Table 1. Predicted economic losses.

Pest	Estimated annual loss	Crop or region affected	Source of information
Wheat rust	~$3 billion	wheat	CIMMYT
Fall armyworm (FAW)	$4.6 billion	maize	FAO
Brown plant hopper (BPH)	$300 million	Asia, especially SE Asia	
Total plant diseases	>$220 billion	global economy	World Economic Forum
Invasive insects, such as desert locusts	≥$70 billion		World Economic Forum

(Figure 2). The spread of desert locusts and the effects they have had on agriculture are very visible and often shown on TV news programs, especially affecting the poorest countries in Africa.

Losses

There have been several estimates of the losses through transboundary pests (Table 1). For wheat rust, losses are around $3 billion per year, and close to $5 billion for fall armyworm. Brown plant hopper is a major pest problem in Asia, especially in South East Asia, resulting in losses of around US$300 million annually. The World Economic Forum reports that the total costs of plant diseases amount to around $200 billion around the world, and that costs from invasive pests and insects like the desert locusts amount to at least $70 billion per annum.

As a global community, we have been facing those phenomenal losses that happen because of transboundary pests, and the challenges of trying to manage them especially in smallholder systems, for the past three to five decades, and we have not been able to manage these losses successfully in a way that is sustainable or that creates more resilience in these systems.

1980–2000: rising incomes and food diversity

The second period, from the 1980s up to, say, 2000, was a period of rapid economic growth especially in Asia. There was rapid growth in middle class populations and incomes, and rising demand for food diversity. Figure 3 shows changes in diets, between 1970 and 2018, for Bangladesh, India, Thailand, Malaysia and China. Across the region, per capita consumption of staple grains dropped (mid-blue bars in Figure 3), while at the same time consumption of non-staple food groups started to rise. There was particularly more consumption of livestock products such as meat, milk and eggs (green bars), and also in vegetable products and fresh fruit (yellow, orange, grey bars). These changes happened as incomes grew, and it is interesting that similar changes and trends have been fairly universal not only across Asia but also in other parts of the world, including Latin America and more recently in sub-Saharan Africa.

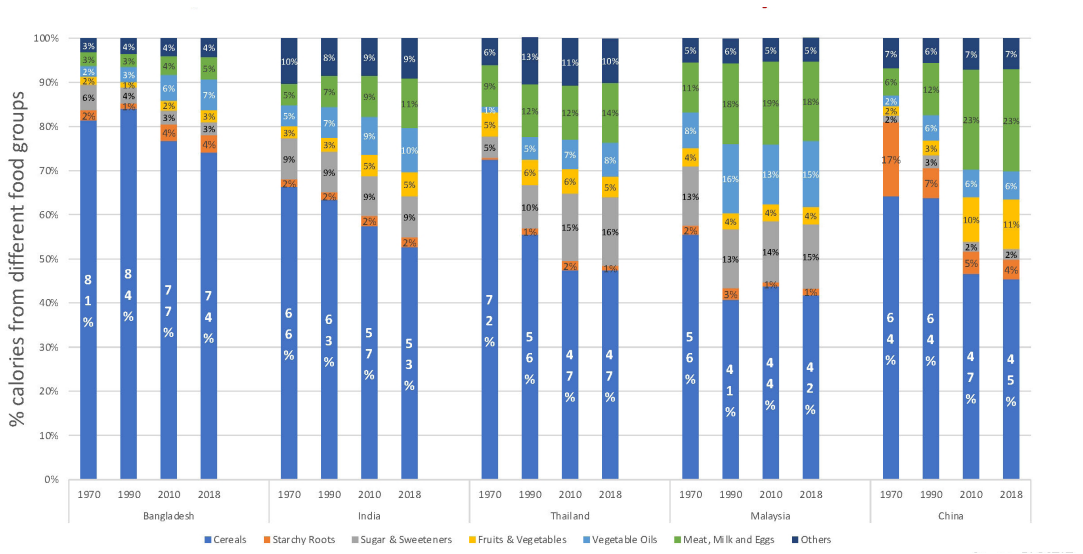


Figure 3. Diversifying of calorie sources: less reliance on cereals over time; increase in consumption of meat and fruits and vegetables. *Source:* FAOSTAT.

As demand for livestock products grew, so overall livestock populations increased around the world (Figure 4). There has been rapid rise in poultry and a steady rise in sheep and goats and cattle. Livestock systems are not only the large-scale organised industrial production systems, but also the smallholder systems with, say, a few cows, a few chickens, because that is where the growth has happened – and where many of the risks in biosecurity begin.

Unless we address these risks in the smallholder systems, we will not get on top of biosecurity risks broadly.

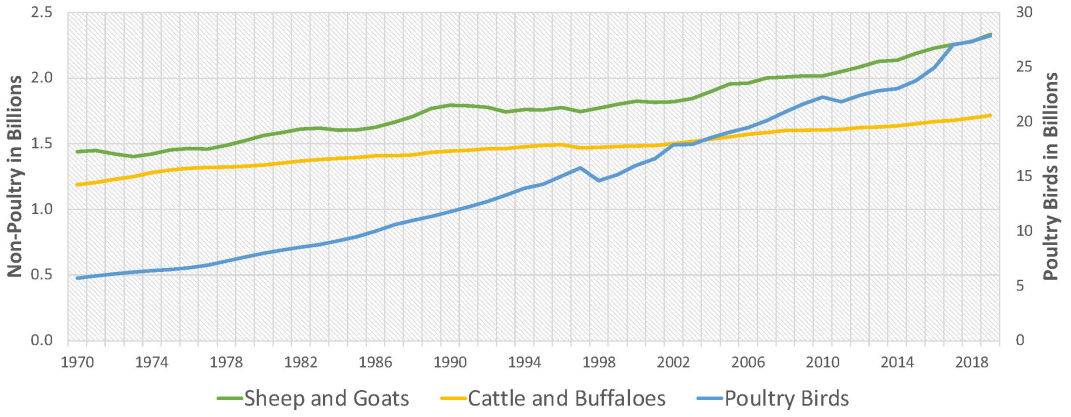


Figure 4. Phenomenal increase in the total number of livestock over the past 5 decades: global livestock populations over time. *Source:* FAOSTAT

The risks have been significant. Since the livestock revolution, the diseases linked to livestock have also risen quite significantly. The frequency of foot-and-mouth disease (FMD) has risen, as have the big impacts of foot-and-mouth disease across the world. There were outbreaks for example in 2005 in China, in 2007 in UK, and in 2010–2011 in Japan and South Korea. Foot-and-mouth disease is estimated to have caused at least $6.5 billion of annual losses. Similarly, mad cow disease (BSE, bovine spongiform encephalopathy), with multiple outbreaks in the 21st century, has become a major concern in the way it affects cattle and also human lives.

Avian influenza has been in the news several times in the last couple of decades, and it has been one of the major zoonotic diseases of concern to us as a global community (Figure 5). There have been numerous outbreaks in the recent past: it has been a particularly big problem in Asia, and has also affected the Middle East and Europe. In Asia, avian influenza is estimated to have cost around $10 billion; during the height of the infection up to 200 million birds either died or had to be culled. That had a significant impact on the livestock industry and on livestock producers, especially smallholder producers in the region.

2000–2020: globalisation of trade and consumer tastes

After the year 2000, the borders for trade were removed and there was significant global integration of food trade. Food markets expanded dramatically across the world. At the same time, consumer tastes changed and became more Westernised, more globalised and more homogenised. There was increased consumption of a wide variety of imported products, and we saw a very close relationship between the rise in food imports and the spread of invasive species: pests, diseases and weeds spreading through trade and food commodities that were brought in from other countries. To give you an idea of the magnitude, 77% of the invasive species pests in tropical Africa in the last 25 years came in through trade. For the US alone, economic losses from non-native species account for around $162 billion annually, and globally that number would be scaled up five or six or 10 times.

An important point is that although invasive species have always spread around the world throughout history, today the spread is significantly faster because of the fast movement of commodities and people around the world. Therefore, a common question is: Shouldn't we be going local in terms of our food systems? And shouldn't we be going organic?

It turns out that there is a case to be made for local food systems being more resilient to market disruptions and pandemics, but for organic food it is not clear that the connection with pest problems is negative. It is not clear that if you switch to organic food you will see less pest damage or pest infestation or transboundary pest risk. Studies have shown that organic produce is just as susceptible to harmful pathogens such as *E. coli*, *Salmonella*, etcetera. Studies at Kansas State University show there is no difference in the prevalence of *E. coli* between organically and conventionally raised cattle. There have been similar studies that look at vegetables, fruit and other products. So organic by itself is

Figure 5. Countries affected by avian influeza H5N1 beween 2003 and 2008.
Source: FAO and WHO.

not the answer: you still need to have safe production systems even when you look at organic systems.

Now: the food, environment, climate, human health nexus

In the years I have been an agricultural economist, since 1982, I have never seen as much interest in food and food systems as there is today. One reason for the interest is because food is seen as a reason for several environmental problems and human health problems, and as contributing to climate change. At the same time, food systems are also seen as part of the solution.

That interest in food, trying to address and solve the problems, is very welcome and something that we need to build on.

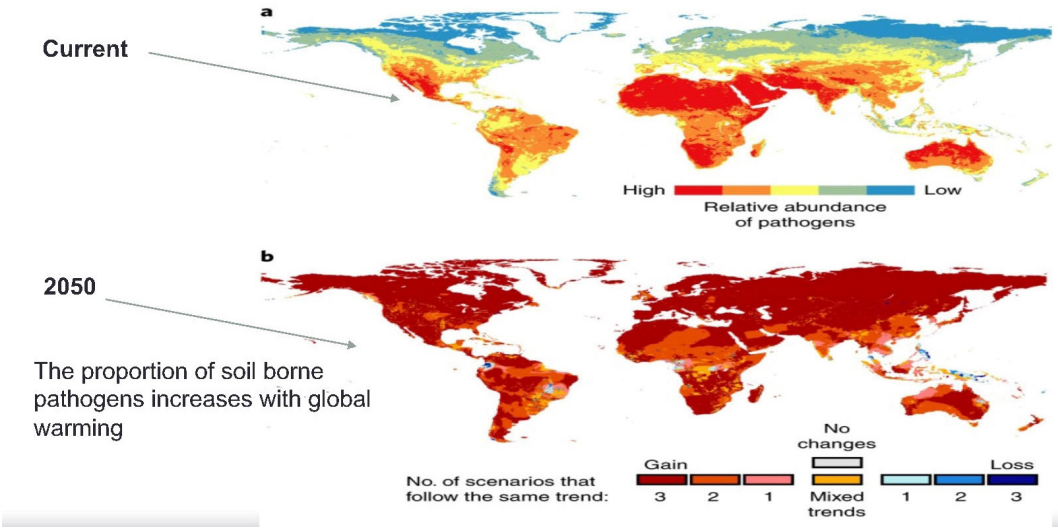


Figure 6. Current relative abundance and temporal projections (to 2050) of potential plant pathogens across the globe. *Source:* Delgado-Bacuerizo *et al.* 2020.

Climate change

Climate change and transboundary pests and diseases are very closely related. As temperatures and amounts of precipitation rise, and areas become warmer and more humid, then the incidence of pest infestation also rises. Temperate zones that did not have certain pests are starting to see pests from lower latitudes, for example. Since about 1960, crop pests and diseases have been moving north and south at an average of three kilometres a year, from tropical zones to temperate zones. Even as we talk about temperate zones benefiting from climate change, we must be clear that the negative effects of more plant and animal pests and diseases and the associated risks will also be an important factor (Figure 6). That is, the net benefits from climate change for the more temperate zones may not be as great as some people are thinking. To quote from CIMMT, 'An increase in temperature and precipitation levels favors the growth and distribution of most pest species by providing a warm and humid environment and providing necessary moisture for their growth.'

COVID-19

Consider COVID-19 – which is one type of biosecurity issue – and global food systems (Figure 7). COVID-19 provides a good example of the rapid spread and the massive impact of zoonotic diseases. Whether one considers COVID-19 zoonotic (as classified by the WHO) or not, the human health impact is very clear: it has been disastrous across the world, and one would anticipate that similar zoonotic diseases may have similar effects in the future, especially in this globally interconnected world.

However, the disease has had interesting impacts on food systems. Food systems have been found to be much more resilient than we thought they would be. Despite short-term shocks to labour and the supply chain disruptions, food systems have bounced back. Staple grain systems particularly have been found

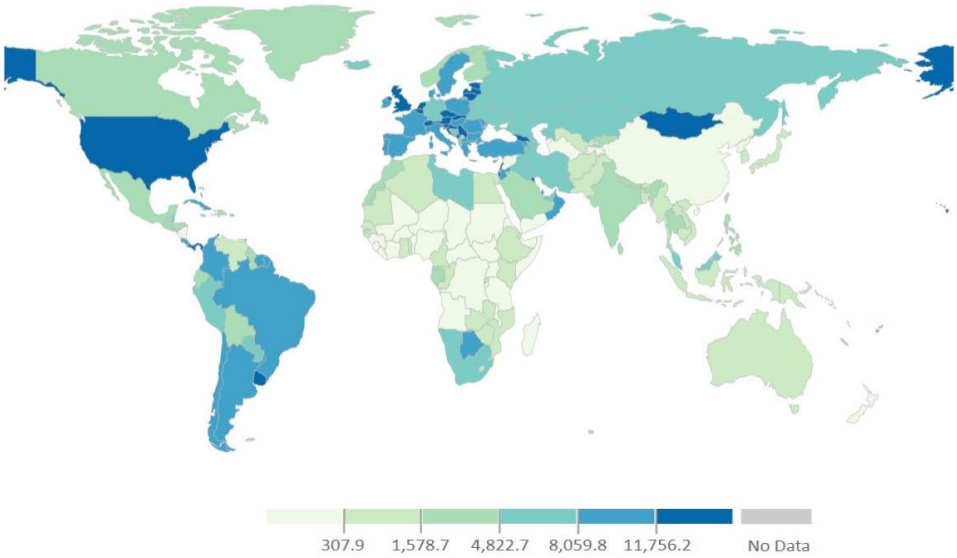


Figure 7. Global cumulative cases of COVID-19 reported per 100,000 population as at 2 December 2021. *Source:* CDC (Centers for Disease Control and Prevention, cdc.gov).

significantly resilient through the crisis. In developing countries, perishable product supply chains have been more affected than staple grain systems, through disruptions in labour, especially in movements of migrant labour and recent disruptions in supply chain labour. Also, although there has been severe food insecurity especially among poorer populations, it has been clearly a problem of diminished access because of income loss, especially for migrant labour, rather than of supply and availability of food.

A valuable observation we can take away from COVID-19 is that resilience has less to do with the production system *per se*, and more to do with labour imports and connections in the value chain. There are some important lessons there in relation to how to create safety nets during these crisis situations.

Building resilience in food systems

How do we build resilience in food systems, and protect them from biosecurity risks? (Figure 8)

When people think about biosecurity, much of their attention is on control, and on preventing biosecurity risks entering a country. I think that more attention needs to be given to addressing the problem at its source – to **preventing the incidence of biosecurity risks**.

In most cases, the problem starts with smallholder agricultural systems in developing countries, either crop farmers or animal farmers – always on small farms. We need to find ways of reducing biosecurity risks on these farms in developing countries, and by doing that we should reduce the prospect of those biosecurity impacts in other parts of the world.

Developing Country Small Farm Agricultural Systems

- Promote Diversified and mixed farming systems in place of large-scale monocultures
- "Good Agricultural Practices" (GAP) for horticulture and livestock products
- Create scale by aggregating produce through farmer producer organizations
- Climate resilient food systems that resist novel pest infestations

Value Chain Investments

- Rural Market infrastructure, including water & sanitation
- Temperature controlled transport & storage systems
- Investing in supply chain traceability

Societal Investments

- Research and Technology development for managing biosecurity risks (eg. Pest resistant varieties)
- Systems for biosecurity information exchange. (E.g. Locust watch dashboard by FAO)
- Better data systems including AI and machine learning to monitor pests and diseases
- Incorporate One Health Approach in Policy Making
- Public health infrastructure investments, including access to health services for the poor
- Behavior change at the individual and community level that promotes safe food systems

Figure 8. Building resilience against biosecurity risks.
Prevention vs control.

I think one path is to promote **more diversified and mixed farming systems**, in place of the large-scale monoculture systems that we see across the developing world, particularly with respect to staple grains. I see the importance of bringing in **good agricultural practices (GAP)** as promoted by FAO for horticulture products and for livestock products, which should improve their safety and reduce the risk of pest infestations being imported.

To connect small-scale agriculture and its produce to the value chain, safely, requires quality standards, safety standards, testing requirements, etcetera, and those, for small farms, take enormous amounts of time and create large transaction costs. How can we create a way of aggregating the produce of small farms, which will **create scale and economies of scale** in the processes of testing, and in bringing much safer products into the value chain?

I think that is an area that needs a great deal more attention.

In relation to the impacts of climate change, I think it is important for us to think about ways in which we can make **a more climate-resilient food system** that can resist normal pest infestations, such as by using varieties that are resistant to pests and diseases.

At the next level of investment are value chain investments, and for mainly rural systems those are investments in **rural market infrastructure including water and sanitation**, and in **temperature-controlled transport and storage systems, and in supply chain traceability**. I think this will be a challenge in smallholder systems, but that if there can be aggregation of produce to farmer producer organisations then traceability also becomes possible, and at much lower cost, especially with some of the new tools available today for tracing the source of different food that comes into the value chain.

In relation to society-level investments, country-level investments, or even more globally, I think **R&D is absolutely crucial for managing biosecurity risks**. Finding pest-resistant varieties offers opportunities for R&D, both for improved technologies for varieties and weeds, and also for improving value chains and processing that lead to much safer products. That is a big area.

Information exchange and early warning systems are extremely important. For example, FAO has created a locust watch dashboard. Such information platforms are very important, but by themselves do not solve the information problem unless there are good data to go onto the dashboard.

It is absolutely crucial that there be investments in **better data systems** on pests and diseases, and on our ability to track the movement of pests and diseases. The new Artificial Intelligence tools and machine learning tools may make that much easier than were past attempts at building such data systems.

From a policy point of view, I think it is vital to think about **a One Health approach** – one that looks at animal health, plant health, environmental health and human health all together – and to look at ways in which that integrated health system promotes safety across all these components and reduces biosafety risks in the future. Public health infrastructure, as we are learning from experience during COVID, is not at the level that it ought to be, especially in developing countries.

Public health infrastructure, even in relation to basics such as water and sanitation, is essential. Also essential is access to health services, especially for the poor; such services are currently extremely limited. Making those investments should help reduce the risks associated with zoonotic diseases and other diseases, especially as they affect rural communities, poor communities, and others.

Finally, I think **behaviour change** is also very important: behaviour change from the producer side in terms of understanding what is good agricultural practice; behaviour change across the value chain in identifying the points of contamination, identifying ways of ensuring safe transit of these products; and behaviour change at the consumer level in demanding better quality products, safer products, and investments in safety, making sure that as consumers we are part of this process of building a biosafe food system.

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Prabhu Pingali is a Professor in the Charles H. Dyson School of Applied Economics and Management at Cornell University with joint appointments in the Division of Nutritional Sciences and Department of Global Development, and the Founding Director of the Tata-Cornell Institute for Agriculture and Nutrition (TCI). He is also chair of the governing board of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). Prior to joining Cornell, he was the Deputy Director, Agricultural Development Division of the Bill & Melinda Gates Foundation, from 2008 to May 2013. He was director of the UN Food and Agriculture Organization's Agriculture and Development Economics Division from 2002 to 2007. In addition, he worked with the CGIAR for 15 years from 1987 to 2002, first with IRRI in the Philippines and then with CIMMYT in Mexico. Pingali is a member in the US National Academy of Sciences and an AAEA Fellow. He has over three decades of experience working with some of the leading international agricultural development organisations as a research economist, development practitioner and senior manager. Pingali has written 13 books and over 120 refereed journal articles and book chapters on food policy.

Q&A

Chair: Professor Wendy Umberger, ACIAR

Panel: Professor Prabhu Pingali

Q: Robyn Alders, Australian National University, and merino sheep farmer

Thank you very much, Professor Prabhu, for an excellent presentation. So much of what you said links to good policy, particularly around prevention. I'm wondering what your advice would be to countries that don't yet have a national food policy? What elements do you think are key, and how do you achieve inclusive policymaking using the One Health approach that you mentioned, inter-sectoral policy? And here I simply mention that Australia doesn't yet have a national food policy either. Thank you.

A: Prabhu Pingali

Thank you so much for that question. You know, one of the issues regarding food policy in many developing countries is that food policy is seen as the same as food security policy, and because of that much of the attention around food policy is on growth of staple grain productivity, continuing the type of policies of the Green Revolution for productivity improvement. That has led to conflict between agricultural productivity and the negative effects on environmental health, human health, transboundary pest problems, etcetera.

I think it is absolutely crucial to bring the One Health concept and food policy together. If we did that, we wouldn't be thinking about food security primarily from a staple grains aspect; we'd be looking at a much more diverse food system, and we'd be bringing in food safety issues as an integral part of the food policy discussion.

Right now these are all separate discussions, and sometimes in separate ministries. And thinking about it as One Health brings that coordination together. I'm afraid I don't have many good examples of that working yet, but I think that's the future that we need to go towards.

Chair: And hopefully as Australians we can take some leadership in that.

Q: Colin Chartres, The Crawford Fund

Thank you, Prabhu, that was a fantastic talk. Your talk led me to reflect that biosecurity issues are one of many externalities that come from our food production system: the climate change situations, land degradation, and so on. And that we are still, in the West at least, consuming food which is incredibly cheap, and we're not putting aside enough funding to cover those externalities.

You spoke of the importance of prevention in smallholder agriculture where there is very little money, and I thought of the parallel in the COVID vaccination situation. In the West we're having our third – our booster – injections, but some people in the developing world have not had their first injection yet. It's another case of the same thing, where we can control biosecurity at our borders, but

This record has been prepared from a transcript.

we're not doing enough to help other countries prevent diseases and the spread of new diseases to other countries.

So my question is: what models are available in relation to funding not only disease prevention in the smallholder systems, but also the increased knowledge that's required for all consumers in developing and developed countries? And could we consider perhaps having a very small levy at the point of consumption, rather than at the point of production, in our food systems, particularly in Western countries?

A: Prabhu Pingali

I think one of the big limiting factors today is that there's not much consumer awareness of the enormous negative externalities in the current food system. We don't have good enough information on the true costs of the production systems, where you cost out all the externalities involved. The Rockefeller Foundation recently released a report on the true cost of food production in the United States, and it showed that while the monetary cost is around one trillion, the true cost is around three trillion – three times as much, because of the environmental costs and the health costs, etcetera.

That kind of number becomes a really powerful advocacy tool for the policy community, but also broadly for the more educated public to understand why the current system is unsustainable and what can be done about it, and that's where behaviour change comes into play. But I don't think we spend enough time thinking through those issues and trying to quantify those true costs. We've been talking about externalities for decades, but we've never really translated that into policymaking. And so that's one way I would recommend moving forward.

Chair: Excellent. And who did that report, Prabhu?

A: Prabhu Pingali

The Rockefeller Foundation, just a few months ago. I think it came out last July or August. It's called the *True Cost of Food*. So if you just Google 'true cost of food United States', you'll get to that Rockefeller Foundation report. I'd strongly recommend taking a look at that. If it's replicated in several countries it will create that pool of knowledge that we can use for advocacy.

Q: John Fazakerley, The University of Melbourne

I really enjoyed your talk, thank you very much, and agree with so much of it. I want to pick up on the One Health issue, with a rather specific question that you didn't stray into. I'm well aware of diseases that come out of the human transgression into the ecosystem; for example, we go into forests and we get things like chikungunya, or like yellow fever – all the diseases that come out of interfering with ecosystems – and there are a lot of these human zoonoses. Have there been studies on the diseases that come out of natural ecosystems and affect agriculture or horticulture? As we clear the forests, as we clear the lands, are we seeing diseases that come out and affect agriculture, and what is the economic cost of that?

A: Prabhu Pingali

Historically there has been work on things like trypanosomiasis and other vector-borne diseases that have come out because of expansion in irrigation systems, etcetera. But I'm not aware of enough economic assessments of the cost of those diseases and how degradation of these natural ecosystems then creates these vector-borne diseases, and how that affects human health. It's an important area, but I don't think there's been much work on that for several decades now.

Q: David Shearer, Commission on Sustainable Agriculture Intensification (CoSAI)

You were here in 2008 I think, during the phase of globalisation, and at that stage there was some question about the role of the smallholder in our transformed food system. But in the period we're in now, it appears the smallholder farmer will always be a central component of our future food systems. Also, at the time of the Green Revolution, the key factor there was access to innovation. It was a little bit siloed because it was just technology, supported primarily by public extension.

Now I want us to think about the future, and I'm going to promote some work I'm doing, at the moment, for the Commission for Sustainable Ag Intensification. You can Google it and you'll find this research.

We assessed the level of investment in innovation in smallholder systems, and so we determined that there's about $60 billion of investment going into smallholder innovation. But now thinking about your future, which is about environment and social matters, what that study determined was that between 2010 and 2019 only 7% of that innovation investment explicitly called out environmental impact, and less than half of that investment explicitly called out the social objectives that we want to meet: nutrition, livelihood improvement, etcetera. And we also know the important nature between public and private investment to drive innovation.

My question is: how do we drive investment globally that enables smallholders to access innovation, technology, policy, finance, institutional capacity, that allows us to tackle those future issues, so we no longer have 7% of innovation investment going into environment, but we have a much more balanced portfolio for the future of our food system?

A: Prabhu Pingali

There's one way to think about it, and that is as urban populations become more aware of the food that they consume, there's an increased demand for safer food, for better quality food, for better diversity of the food basket, etcetera. That's on the demand side. And on the supply side, much of the food production, and especially in developing countries, will continue to be smallholder production systems that then feed into this urban demand. The process of smallholders connecting into these value chains has always been very complex and complicated. If there are ways in which private sector investment can promote better quality food, safer food, more environmentally sustainable food, then private sector investments in value chains that bring in these types

of foods into urban markets is, I think, probably the best way in which one can influence future food production systems.

That would not only help improve the sustainability at the farm level, and ensure better quality food for urban consumers, but it also becomes a real growth opportunity, and income growth opportunity for small farms, and this will give an opportunity to get beyond staple grains. That means the extension system moving from public extension to more private-sector oriented extension systems. That's the way I would think about it. But, you know, these are all scenarios. We have to see how things evolve over time, and what incentives there are for private sector investments and for small farms to change the way they behave here.

Q: Howard Parry-Husbands, Pollinate and Metamorphosis

I was intrigued by the point you made about the limiting factor being not much consumer awareness of the true cost of production systems. Is there enough collaboration beyond agricultural and food expertise with sociologists, with marketing professionals, with communications experts, to address this significant limiting factor?

A: Prabhu Pingali

I think that right now much of the discussion is very siloed among the different groups, and the agricultural production community doesn't really spend enough time communicating with the consumer groups, etcetera, and the environmental community doesn't really communicate enough with the agricultural production side, the research side or the consumer side. I think one of the issues for the nexus is to create that communication bridge, and to break up those silos. And that can only happen, I think, from the demand side. It can only happen as consumers become more aware and we start to demand higher quality, safer food, more sustainably produced food, etcetera. But we're still a very long way away. It's still a big challenge even in countries like the US. It's going to be a long time before countries like India get onto that same wavelength.

Chair: Thank you all.

Reference

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Future-proofing with advanced and emerging technologies and tools

Dr Rob Horsch

Global Commission on Adaptation at World Resources Institute

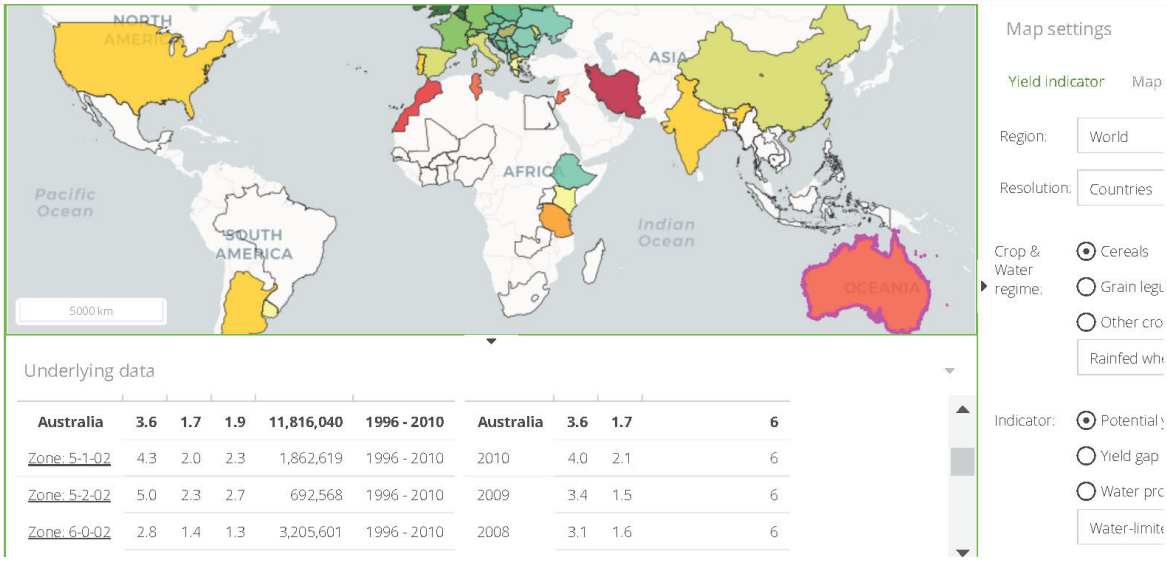
ABSTRACT

Ongoing contributions of agriculture to human health and well-being face major risks. Extreme poverty *per se* and ineffective policies for development, trade and regulations are the largest risk multipliers, with abiotic and biotic stresses being the major risk drivers. Prevention, effective response, and innovation are the key risk mitigation factors. Tools and technology for 1) monitoring, modelling and predicting risk emergence, 2) deploying, tracking and optimising existing solutions, and 3) on-going innovations for better tools and solutions, are keys to future-proofing our agricultural system. I propose focusing on overall water-use efficiency as the normalising basis for quantitative tracking and prioritisation of progress and setbacks. Yeildgap.org is an excellent resource for tracking realised harvest vs water-limited potential harvest. Poor soil fertility in developing countries and pests/pathogens everywhere are the major limitations on agriculture using existing best practices. Soil fertility can be readily solved; the future will be limited primarily by pests and pathogens and increasing abiotic stresses. Recent case studies from Africa illustrate the situation. Maize lethal necrosis virus erupted suddenly in East Africa and exposed a vulnerability in the local seed system which, once understood, was then remedied. Cassava mosaic disease is an on-going and spreading problem that threatens much of Africa's cassava crop. Despite excellent progress in tracking, modelling and development of solutions, it remains a major threat, due to slow progress in deployment of new resistant varieties and cooperation within and across country borders to contain the outbreak. New strains of wheat rust have emerged in eastern Africa and spread around most of the world. Deployment of single resistance genes has led to progressive loss of their effectiveness, complicating efforts to build a more durable resistance package. Molecular efforts to splice together multi-gene packages, and using synthetic biology to create new resistance genes not found in germplasm collections, promise a more robust and durable solution.

I want to start with a normalising factor for looking at just how big are the opportunities to make progress, how big are the risks, how big is the progress we are making, and I propose to use water-use efficiency as the overall basis.

In this talk I refer to nine websites. First, Global Yield Gap Atlas (yieldgap.org), looks at water-use efficiency in a very interesting way. We can click on the atlas, and 'Rainfed wheat', and Australia on the map (Figure 1), and look at the underlying data which show 'yield potential' for the given amount of water that Australia receives, 'yield actual' for the yield Australia actually gets, and 'yield

This record was prepared from the transcript and illustrations of the Zoom presentation.



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Zone: 5-2-02	5.0	2.3	2.7	692,568	1996 - 2010	2009	3.4	1.5	6
Zone: 6-0-02	2.8	1.4	1.3	3,205,601	1996 - 2010	2008	3.1	1.6	6

Figure 1. Data for Australian rainfed wheat at https://www.yieldgap.org/gygaviewer/index.html

gap' for the amount of yield potential that Australia does not realise. According to these projections for rainfed Australian wheat, the realised yield is less than half of the water-limited yield potential, which means there is huge headroom for improving the productivity and efficiency of wheat production – and the same is true essentially for all crops in all countries. I should point out that some or most of the gap is not economically feasible to close, using current technologies.

Before I talk about work aimed at closing the gap, I want to mention work aimed at making the gap *bigger* by raising the ceiling of what is possible. I should say the reason agriculture is water intensive is because plants buy carbon dioxide, paying for it with water, through passive diffusion of water vapour out of stomata. Passive diffusion of carbon dioxide into stomata is how plants get carbon on which to grow. The biochemistry and physiology of photosynthesis determines the exchange rate of water for carbon. The RIPE project (Realising Increased Photosynthetic Efficiency; Figure 2) is looking to make the gap bigger by improving the amount of harvest that is possible for a given amount of water by making carbon dioxide cheaper in terms of water price for plants. A variety of methods were first hypothesised 'in silico' (that is, by computer simulation) and they are now being experimentally pursued. I want to mention partners in Australia in this effort: Jose Barrero, TJ Higgins (our Chair for this session), Tori Clarke, Susanne von Caemmerer, and Dean Price, the last three being at the Australian National University. They are all partners in this, looking at making the gap bigger.

Of course, the other part of this problem is how to make the gap smaller, not by raising the ceiling but by closing the gap between what is actually harvested and

About RIPE (/objectives/our-story)

Our Crops (/objectives/our-crops)

Institutions (/about/institutions)

Objectives (/objectives)

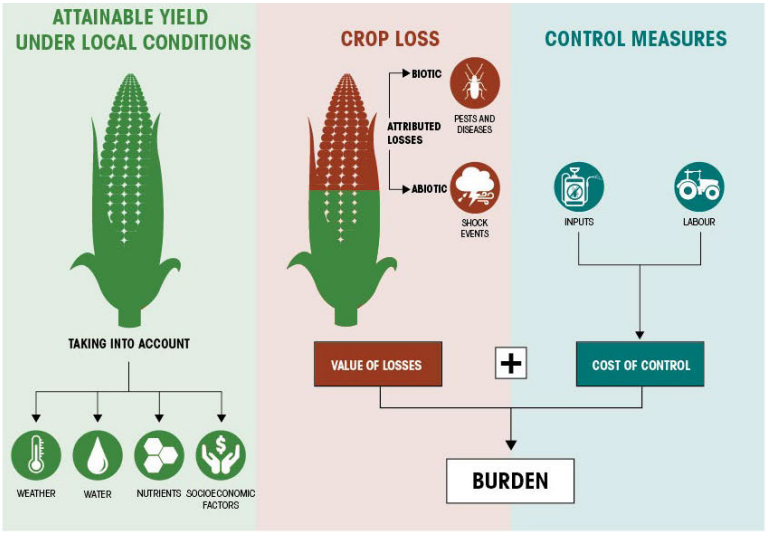
Modeling Photosynthesis (/objectives/modeling-photosynthesis)

Relaxing Photoprotection (/objectives/relaxing-photoprotection)

Modeling Photosynthesis

Photosynthesis—the 170-step natural process in which plants use sunlight and carbon dioxide to grow—is one of the most basic, yet incredibly complex, processes in biology. It is also inefficient. Approximately only 5 percent of the energy from sunlight is converted into plant growth and even less into the parts of the plants that we eat. Scientists speculate that photosynthesis could be transformed if they could find which steps out of the total 170 can be tweaked and modified to make the process more efficient. With the rapid increase in technological advancements, computers can simulate photosynthesis in a real-life environment. These simulations provide a realistic representation of the entire process and can show what happens to plants if variables were to be manipulated, such as light energy distribution by altering the angle of leaves, adding additional cellular machinery, or changes in climate. By using mathematical equations in the computer system, it is possible to see which potential combinations of changes in photosynthesis would lead to the most crop growth and highest yields.

Figure 2. About the RIPE project, at https://ripe.illinois.edu/index.php/objectives/modeling-photosynthesis



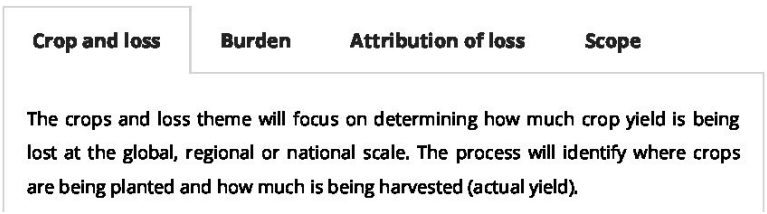


Figure 3. 'The Global Burden of Crop Loss initiative', at https://croploss.org/our-approach

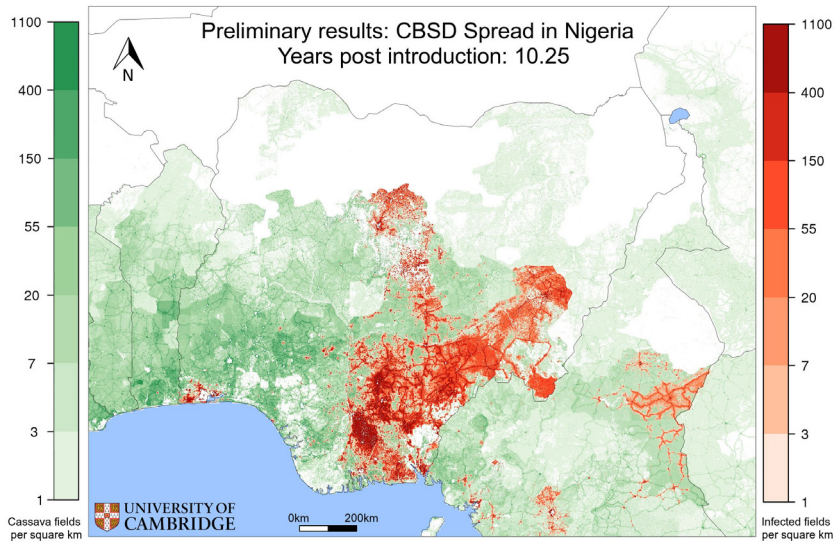


Figure 4. Screen grab from video of a simulated future spread of cassava brown streak disease (CBSD) in Nigeria, at https://plantepidemics.github.io/

what could be harvested. And the group behind croploss.org (Figure 3) is looking at the size of some of these gaps in the global burden of crop loss.

Some stressors are abiotic, and some of them are biotic. I now focus on three examples of biotic stressors that are major contributors to crop losses.

Cassava brown streak disease

My first example is an African virus disease of cassava, and this illustrates the use of technology in both monitoring and predicting and modelling the epidemiology and spread of cassava brown streak disease (CBSD). The video at University of Cambridge webpage https://plantepidemics.github.io/ simulates what the outbreak might look like (Figure 4) when CBSD gets into Nigeria. Currently it is moving westwards from East Africa. There are serious efforts underway to anticipate and combat this spread, as well as technological improvements to invent better ways to control it.

One of the groups working on CBSD is WAVE (Central and West African Virus Epidemiology for Food Security) which was started by Justin Pita. The WAVE Project is described at the WAVE website (https://wave-center.org/).

Another group, the VIRCA (Virus Resistant Cassava for Africa) Plus Program, is working on a biotech solution to the cassava brown streak disease (Figure 5). That work is based at the Donald Danforth Plant Science Centre in St Louis, Missouri, and partners around the world including with the National Crops Resources Research Institute, Uganda, and the Kenya Agricultural Research Institute. They aim to engineer both virus resistance and micronutrient density increases in cassava. Their use of siRNA gene constructions in the lab has been tested in the greenhouse and is now being field tested in Africa, on the way

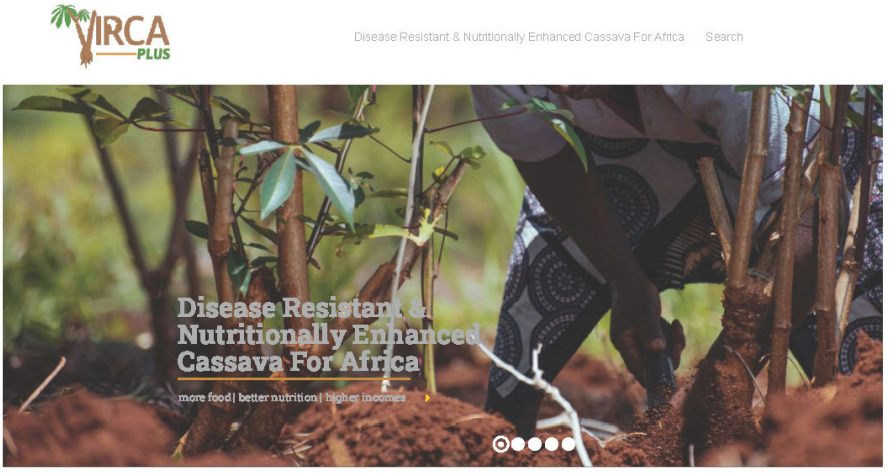


Figure 5. Home page of the VIRCA Plus Program, at https://cassavaplus.org

to being combined with conventionally sourced other virus resistance genes in cassava, and then field tested for final varietal approval before deployment in Kenya and Uganda and other countries. The project has taken more than 20 years to get this far, and it is great to see it now in the field, almost ready for use in Africa.

Wheat rust

My second example is wheat rust, which Prabhu Pingali already mentioned.

The experience involved in the Borlaug Global Rust Initiative at Cornell University spans the whole world (see Figure 6). There are collaborators in Australia who are, and have been, a key part of the effort against wheat rust. This is focused on conventionally sourced resistance genes being bred into modern cultivars, and

Figure 6. 'Experience the BGRI interactive story map' webpage at https://bgri.cornell.edu/about-bgri/

then deployed ahead of the virulent strains of rust. As Prabhu showed, those virulent strains are spreading around the world.

In addition to using the conventionally sourced breeding and doing it faster and deploying it ahead of the waves of new disease, the 2Blades Foundation, of which I am a Board Member, is also looking at stacking genes together. The strategy is to stack up to five resistance genes in a gene package and introduce them into particular wheat varieties (see https://2blades.org/projects-and-technology/projects/1/). Then it will be breedable and heritable as a single locus, making the breeding and combining with other efforts much more possible. Quite a few Australian collaborators are involved in this synthesis effort. And beyond combining and packaging multiple genes in one locus, 2Blades is also working on synthetic genes that build on the knowledge of how the host and pathogens interact: aiming to create genes that will recognise new virulent strains of the fungus. The new genes would be introduced into wheat so it can become resistant – which should be much quicker than going back and looking for something in nature that was there and is not currently being used.

Insect attack on cowpeas

Finally, cowpeas. The success reported at AATF (African Agricultural Technology Foundation) webpage below (Figure 7) includes work of the Chair of this session, TJ Higgins. The project this year (2021) advanced a transgenic Bt cowpea through to good tests in the growth chamber, and successful field tests in Africa. It is on its way to final varietal approval, and then deployment to farmers in Nigeria.

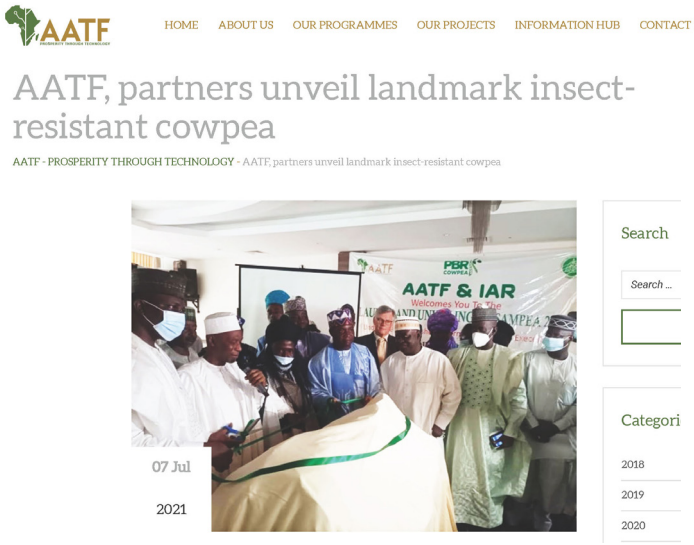


Figure 7. aatf-africa.org/aatf-partners-unveil-landmark-insect-resistant-cowpea/

Dr Rob Horsch recently retired from the Bill & Melinda Gates Foundation which he joined as a deputy director in November 2006 to develop and lead the science and technology initiative of the agricultural development

program. He recruited and managed a team of program officers and other staff that made and managed a large and diverse portfolio of research and development grants aimed at improving the productivity of smallholder farmers by improving the crops that poor farmers raise, and poor consumers eat. He currently serves on the Board of Directors of the Foundation for Food and Agricultural Research and the 2Blades Foundation, and as an Adviser to the Global Commission on Adaptation and to the Global Farmer Network.

Rob is a leader in the effort to create agricultural technologies that help improve yields and incomes for farmers around the world. He joined Monsanto in 1981 and led the company's plant tissue culture and transformation efforts until 1995. In that capacity, he contributed to the development of the Bollgard, Yieldgard, and Roundup Ready traits in broad use today and directed an expanding research group to apply genetic transformation technology to many important crops, including potato, tomato, cotton, soybean, corn and wheat. From 1996 to 2005 he led the company's programs for International Development Partnerships with responsibility to help smallholder farmers in developing countries gain access to better agricultural products and technologies.

Rob received his PhD in Genetics at the University of California, Riverside, in 1979, and then conducted postdoctoral work in plant physiology at the University of Saskatchewan. He has served on the editorial boards of several leading journals in the plant sciences and as an adviser to the National Science Foundation and the Department of Energy. He served as a member of the Millennium Development Goals Hunger Task force and has been active in international agricultural development projects for the past 25 years. He was awarded the 1998 National Medal of Technology by President Clinton for contributions to the development of agricultural biotechnology.

Advanced monitoring techniques

Professor Pablo Zarco-Tejada

Remote Sensing & Precision Agriculture, School of Agriculture and Food & Faculty of Engineering and Information Technology, The University of Melbourne

ABSTRACT

Progress in the last 20 years in airborne-, space- and drone-based imaging spectroscopy has advanced tremendously. These innovations have allowed improved large-scale monitoring of crop physiological processes with unprecedented detail. Successes have been obtained in the context of biotic and abiotic stress detection, particularly with new developments in sensor miniaturisation and physically-driven and artificial intelligence-driven modelling techniques. In 20 years, the spectral detail employed to detect stress has been exceptionally enhanced: cameras and technological imaging devices have moved from gathering data at the 'hundreds of nanometers' spectral scale down to the 'sub-nanometer' resolution, even reaching the Armstrong physical unit. Due to these rapid technological developments, the main focus has shifted recently, moving from a technology push in the last decade to the current algorithm-push to understand better the physiologcal interactions of crops undergoing biotic- and abiotic-induced stress. *Xylella fastidiosa* is currently the major transboundary plant pest, the number one threat for Australia, and the world's most damaging pathogen in terms of socio-economic impact. As with several other pathogens under natural crop conditions, i.e. where the abiotic-induced variability due to water and nutrients co-exists with the pathogen-induced stress, its detection requires advanced remote sensing monitoring technology and algorithms to disentangle the biotic vs abiotic physiological interactions. These advanced methods use high-resolution hyperspectral and thermal imaging cameras onboard drones and piloted aircraft, demonstrating that uncoupling the biotic–abiotic spectral dynamics reduces the uncertainty in the disease detection, reaching accuracies over 90%. Although most currently operated drones are not carrying imaging spectrometers, efforts should be made to enable advanced remote sensing technology and algorithms with low-cost and easy to operate platforms for widespread hyperspectral technologies worldwide. These hyperspectral methods coupled with proper algorithms will advance the early detection of devastating pathogens, to reduce billions of losses worldwide.

This talk is focused on advanced monitoring techniques, particularly for biosecurity and early disease detection. The photo in Figure 1a was taken in October 2013 in southern Italy, and it shows olive trees affected by a pathogen that later was identified officially as a bacterium, *Xylella fastidiosa*. At that time the growers were very worried about those branches that were showing symptoms, with necrotic and defoliating leaves. It was a major issue. By two

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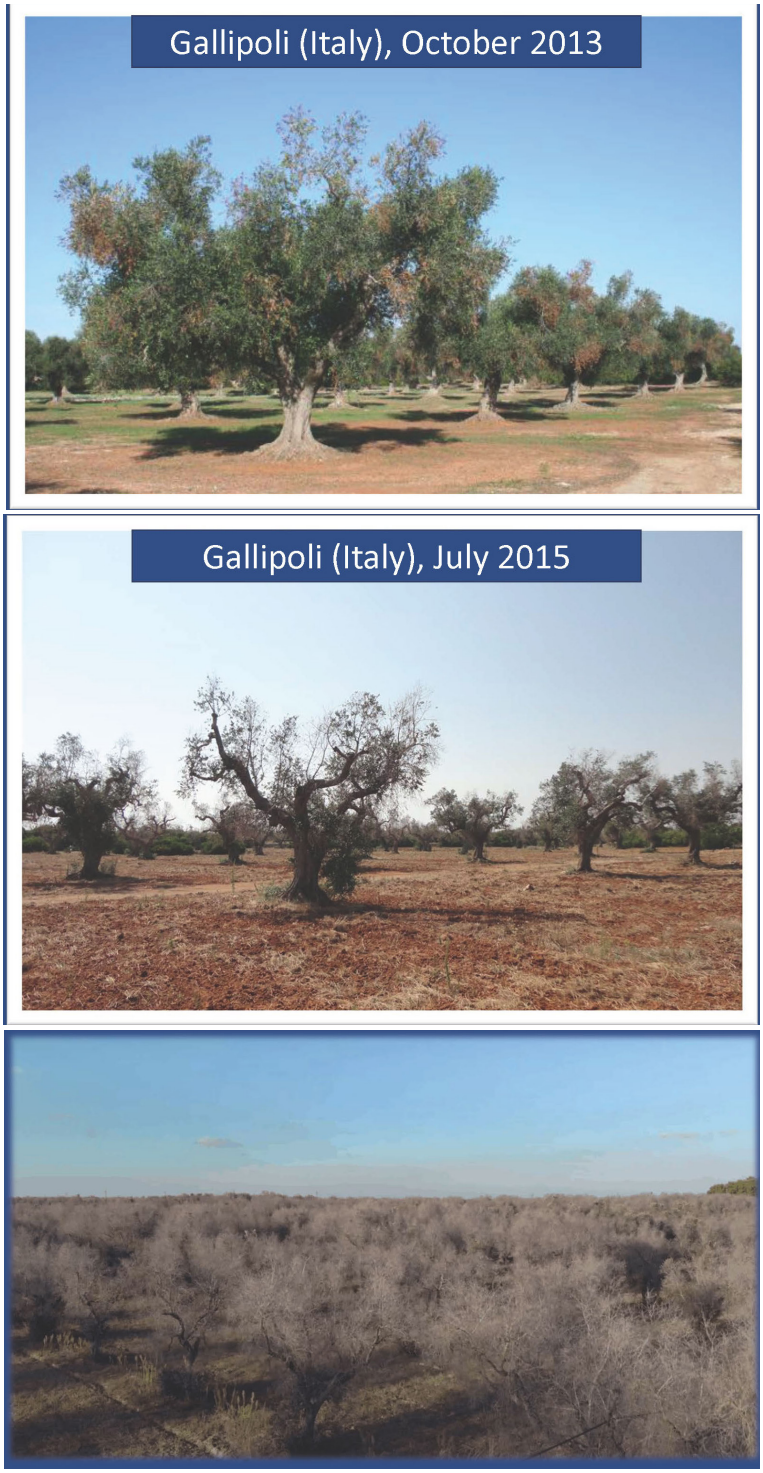

Figures 1a–c (top–bottom). Olive trees affected by *Xylella fastidiosa* in Italy, showing the progress of the infestation over a few years.

years later, the big orchards of the area had been fully devastated (Figure 1b), heavily affected by what – by then – was recognised as *X. fastidiosa* that had come to Italy from the Americas. In fact, the whole area was devastated (Figure 1c), at a cost of billions of euros, because of the bacterium.

Although *X. fastidiosa* was officially identified in 2013, it had been present in the Americas for many years (Figure 2). It was identified officially in Spain, in France, and then in countries in Asia, including Taiwan, and also in Israel, for example. Right now, it is the number one threat worldwide, including for Australia, because it can affect more than 550 plant species and is considered a major transboundary plant pest. Some modelling in Europe (Almeida 2016) estimated that *X. fastidiosa* is capable of causing losses of up to 5.2 billion euros annually in Europe in the olive sector alone – a major threat and impact. *Xylella* infection is now considered a global epidemic.

Back in 2016, academic journals such as *Science* or *Nature* were raising alarm about the potentially large socioeconomic impacts the bacterium could cause, and they were asking whether it was possible to stop it. It was identified very clearly that the development of fast methods for the early detection of the disease across large areas was critical. Therefore, remote sensing was being seen as a very important tool when the objective was to detect *X. fastidiosa* infection in its early stages.

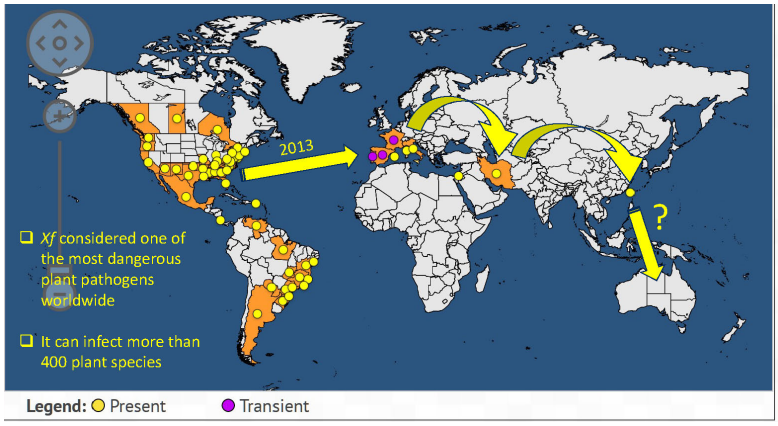

Figure 2. Distribution of *Xylella. fastidiosa* at September 2021.

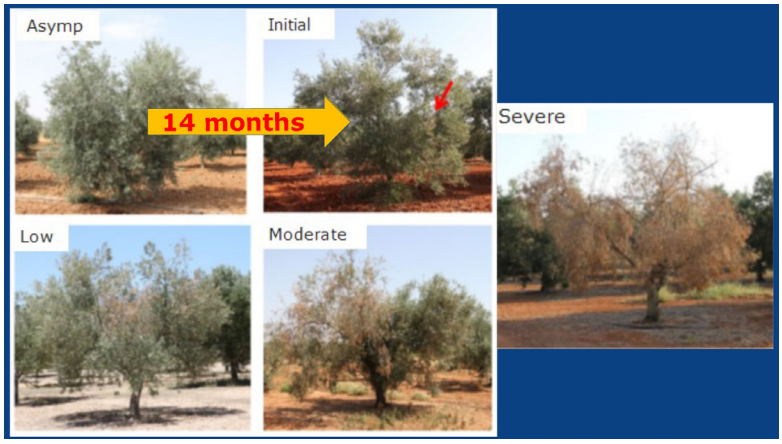

Figure 3. The disease must be detected in its earliest stage, before it becomes visible by eye.

Early detection is critical. At moderate or severe levels of infection we can see it by eye, in the field (Figure 3), but we need to detect the early symptoms of the disease via asymptomatic or pre-visual assessment when the trees are infected and spreading the bacterium but not showing symptoms. In vascular diseases like this one, it could be active for more than a year before the effects become visible, and that is why it is so critical that we have techniques to detect it as early as possible.

Using imaging spectroscopy

The answer is imaging spectroscopy. Instead of getting a few spectral bands using multispectral remote sensing, we obtain hundreds or thousands of spectral bands to form the image, and by using either physically based models or matching learning or deep learning models we can address and identify the physiological changes due to the infection (Figure 4). In a recent paper (Zarco-Tejeda *et al*. 2021) we show that there are specific spectral indicators that are related to pathogens and are specific to a species such as almond or olive for example. We have been obtaining accuracies beyond 90% (Figure 5).

Progress has been made in the last 20 years on assessing hyperspectral and thermal remote sensing for biotic-induced stress, and we have demonstrated this in a number of different pathogen-induced stress situations or conditions – such as with *Xylella fastidiosa*, and with *Verticillium dahliae* which causes Verticillium wilt in olives.

Nevertheless, it is critical that we have the right types of platforms for the imaging, such as drones or piloted aircraft that can carry hyperspectral and thermal technologies when the objective is to carry out this asymptomatic detection. Satellite sensors are very useful at the very large scale, but they are lacking the spectral information that we need for the early detection. They are more useful for assessing the severity of advanced conditions.

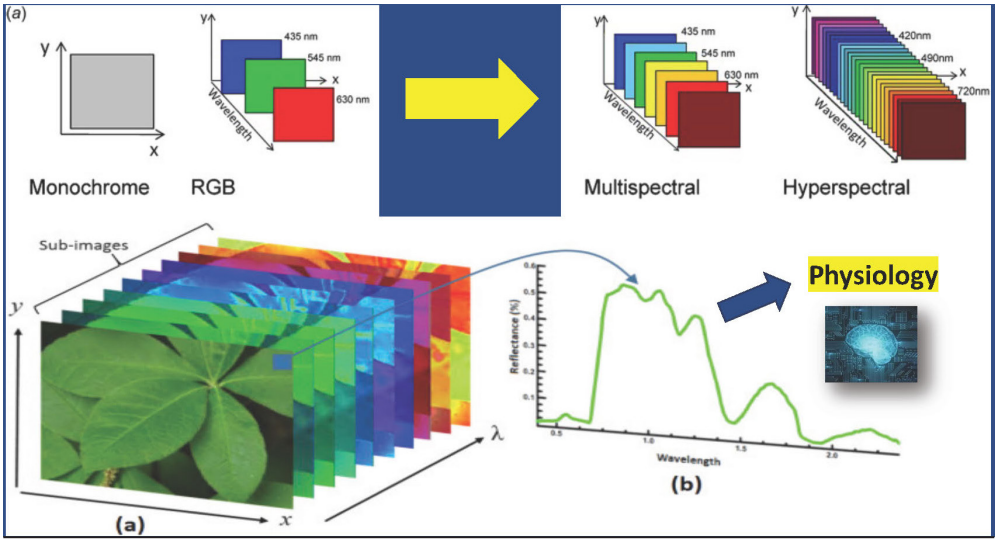

Figure 4. Use of imaging spectroscopy.

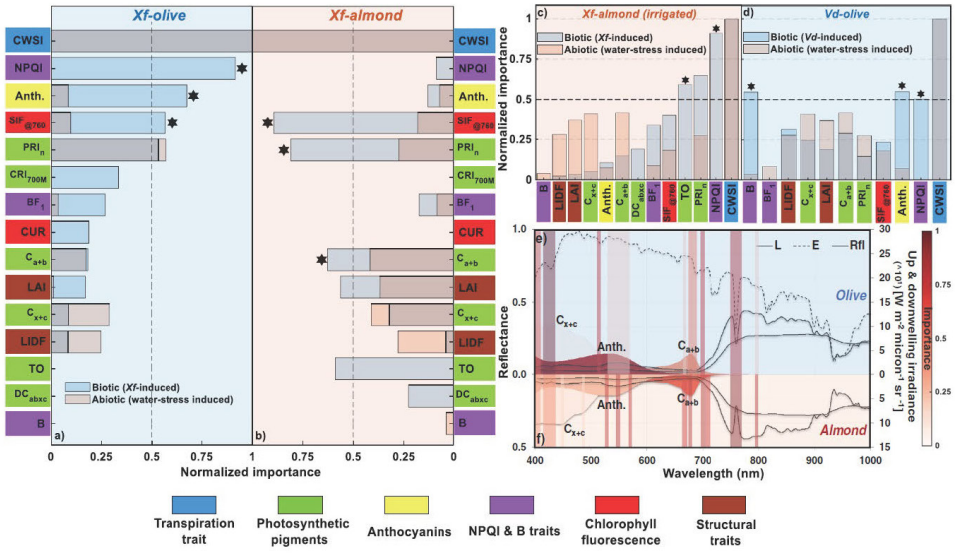

Figure 5. Specific spectral-based RS indicators across species *almond* vs *olive* and across pathogens *Xf* vs *Vd*. Accuracy >92%. *Source:* Zarco-Tejeda *et al.* (2021).

The box below summarises these important take-home messages. We need to avoid limitations that prevent drone technology from carrying hyperspectral imagers. That is a difficulty we are seeing – that is, we have the technology from the remote sensing side, but drones are actually limited from using some of this latest imaging technology to collect data and images that would be useful in the case of particular outbreaks.

Take-home messages

1. Progress has been made in the last 20 years on assessing hyperspectral and thermal remote sensing for biotic-induced stress detection across species (OA>0.8–0.9; *k*>0.6).
2. **Drones** (~hundreds of hectares) and **piloted aircraft** (~thousands of hectares) **should** carry hyperspectral and thermal technology for **asymptomatic** detection.
3. **Satellite** sensors are more suited for **advanced severity** detection and monitoring.
4. Should **avoid limitations** to drone technology carrying hyperspectral imagers.

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Pablo J. Zarco-Tejada is Professor and Associate Dean at The University of Melbourne. He holds degrees across disciplines obtained worldwide, such as Agricultural Engineering (Spain), Remote Sensing (UK), PhD in Earth and Space Science (Canada). He held a Faculty position at the University of California, Davis, USA, becoming later the Director of the Institute for Sustainable Agriculture, National Research Council (CSIC, Spain), and Senior Scientist at the Joint Research Centre (JRC) of the European Commission. Currently, he is Professor in Precision Agriculture and Remote Sensing, leading HyperSens – Hyperspectral Remote Sensing & Precision Agriculture Laboratory. He is author of more than 150 publications and has been recipient of the Highly Cited Researcher awards (2019, 2020 & 2021). He has led research projects worldwide, including capacity building activities for CGIAR in Mexico, Zimbawe and India in the context of remote sensing and unmanned vehicles for plant phenotyping, precision irrigation and biosecurity.

In the field with LAMP

Dr Stacey Lynch

Agriculture Victoria Research, AgriBio, Centre for AgriBioscience

ABSTRACT

Effective biosecurity is underpinned by rapid detection of pathogens within an evidence-based testing framework, and supported by a quality management system. Loop-mediated isothermal amplification (LAMP) is a molecular diagnostics platform that detects the genome of a pathogen. The LAMP enzyme is more resistant to inhibitors, so the pathogen nucleic acid (DNA or RNA) does not need to be purified, enabling detection directly from the sample. This makes LAMP different from other molecular tests, and gives it a robustness that allows LAMP to be used in resource-limited settings, be field-deployable and used as a point-of-care tool. Agriculture Victoria, with the support of colleagues from the Asia–Pacific region including Timor-Leste and Bhutan, have been developing and verifying LAMP assays for foot-and-mouth disease virus (FMDV) and African swine fever virus (ASFV). These two pathogens affect food production systems and animals of cultural importance in the region and – if detected in Australia – within our borders. We are developing an advanced quality management system to support the adoption and implementation of this emerging technology. Specifically, our research is determining the best in-field sample type for FMDV and ASFV, accruing verification data obtained through ongoing quality control and virtual communication, and establishing a proficiency testing program to assess the reagents and operators. The establishment of a sample and data management framework will support confirmatory testing for these significant pathogens, as required.

I am a microbiologist. Our laboratory at Agriculture Victoria develops tools to support biosecurity. Biosecurity is underpinned by the rapid detection of a pathogen.

Loop-mediated isothermal amplification (LAMP) detects the genome of a pathogen. It is adaptable, it uses very specific primers, and it can detect the [genome] of an RNA virus or of a DNA virus or of a pest. It is dynamic, in that we can use it to test different sample types, whether that be clinical material from an animal, or an environmental sample – such as from swabbing the floor of an abattoir, or even from a rope that pigs have played around with (Figure 1). LAMP is fast in detecting the pathogen. In some cases we have made detections within approximately 20 minutes of taking the sample. Agriculture Victoria is working across the state of Victoria to implement and develop LAMP assays to support biosecurity outcomes.

One of the nice things about LAMP is that you can often do the test without actually extracting the nucleic acid from the sample. This makes it quite

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Figure 1. LAMP assays are rapid, adaptable and dynamic, usable with varied pathogen genomes and different sample types in a range of environments.

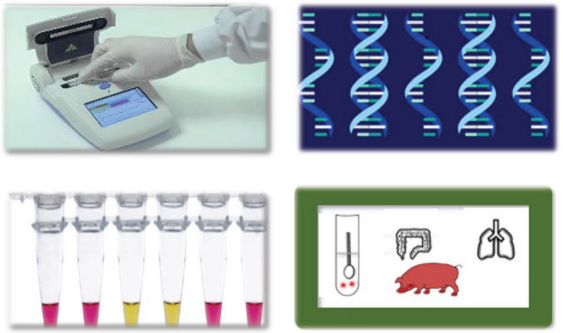

Figure 2. Scientific rigour and assay validation principles provide the foundation of the LAMP assays. Nucleic acid extraction is not required. The assay is optimised for each virus and sample combination. It can be applied where resources are limited, and in the field and as a point-of-care tool.

different from a lot of other types of molecular assays, and it means you do not need additional pieces of scientific equipment to extract nucleic acid. Although the test needs to be optimised for each virus and sample type, this robustness in the enzyme means that the assay can be deployed in settings where resources are limited. To perform and interpret the test, you can take a small machine – which you could hold in your hand – into the field. The assay readout can be adapted to enable detection of positive samples by colorimetric method – and in fact you do not even need the machine when using this detection method; you just need boiling water down to about coffee temperature to stimulate the reaction (Figure 2).

We have been using assay-validation principles to provide a foundation of these LAMP assays for biosecurity outcomes. In this talk I mention two of the pathogens we have targeted and some of the work we have been doing.

First, foot-and-mouth disease (FMD) – a severe, highly contagious viral disease of livestock that disrupts regional and international trade in animals and animal products, causing significant economic impact. Australia estimates that a small FMD outbreak, even if controlled in 3 months, could cost around AUD 7.1 billion; a large 12-month outbreak would cost AUD 16 billion.

Figure 3. Application of an internal positive control in Bhutan for foot-and-mouth disease virus (FMDV) LAMP:

- independent verification of sample quality;
- confirmation of clinical FMDV cases

Statistical analysis confirmed this new RT-LAMP-FMDV test as fit-for-purpose as a herd diagnostic tool, with diagnostic specificity >99% and sensitivity 79% on unextracted field samples (oral swabs).
Source: Bath *et al.* 2020.

We took an established assay for foot-and-mouth disease for LAMP, and we modified it so that we could remove the nucleic-acid-extraction test step. We also developed an internal positive control that could be added to each of the samples, to assess for any inhibitors of the assay in the sample. That removed the chance of having false negatives – which is especially vital for a very important disease.

A team then travelled to Bhutan and independently verified this method (Figure 3). They could confirm clinical cases of foot-and-mouth disease in the field, using oral swabs. Statistical analysis included in Bath *et al*. (2020) demonstrated this was fit-for-purpose as a herd diagnostic test on unextracted oral swabs for FMD.

Within this state, Victoria, we are working with the Office of the Chief Veterinary Officer to train field veterinarians on how to use this LAMP assay. Policy is being worked through to enable this point-of-care testing for FMD by Agriculture Victoria, and meanwhile we have developed a system for training our vets, and giving them very easy, practical, low equipment test kits. In addition to having positive and negative quality controls and an internal quality control, we are also developing proficiency testing panels that can be sent to operators to develop confidence in the use of the assay in the field. Full implementation is currently in development.

Recently we have been working on a second assay, this time for African swine fever virus (ASF), which causes 80–100% mortality in pigs. The virus was detected in Timor-Leste in September 2019. As Agriculture Victoria Research already had a LAMP assay that was being developed in the laboratory, we sent a team to Timor-Leste to work with our colleagues there to assess the diagnostic performance of this assay (Mee *et al*. 2020; Phillips *et al*. 2021). The assay supported a whole-country-prevalence survey of ASF (436 samples, 48 villages), and the work was all completed in Timor by our Timorese colleagues that we had trained. It is important to note that we also are biobanking those positive samples, to send back to the National Reference Laboratory in Australia, and we are providing ongoing test support. That happened just before the COVID

pandemic, and although our team has not been able to go back to Timor-Leste the systems that were put in place, including the provision of reagents and communication, have enabled us to provide ongoing support.

This robust quality platform that has been established can be applied to other targets. Some recent work on a similar LAMP assay for khapra beetle, which is in Papua New Guinea, was recently published by Agriculture Victoria Research in December 2021 (Rako *et al*. 2021) and an assay is also being developed for fall armyworm.

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Australian Centre for Disease Prepardness

Dr Stacey Lynch is a Senior Research Scientist, Agriculture Victoria Research, based at AgriBio, the Centre for AgriBioscience. Her primary focus is to deliver applied scientific outcomes through viral diagnostics and pathogen surveillance. Specific diagnostic and surveillance activities

include the development and implementation of in-field molecular methods for African swine fever virus and foot-and-mouth disease virus, and surveillance activities of avian influenza in wild birds and pathogens in mosquitoes (such as Ross River virus, Murray Valley encephalitis virus and *Mycobacterium ulcerans*). Key areas of research use genomic tools to enhance traditional significant animal investigations and surveillance programs.

Stacey regularly provides lectures in a range of undergraduate and post-graduate courses through the Faculty of Veterinary and Agricultural Sciences, and has co-supervised a number of research students from La Trobe University (School of Applied Systems Biology), The University of Melbourne, The University of Liverpool, and the International Livestock and Research Institute, Ethiopia.

Diagnosis in a fish farmer's backpack

Dr Andrew C. Barnes[1], Suvra Das[1], Oleksandra Silayeva[1], Shaun Wilkinson[2], Fernando Cagua[3], Jerome Delamare-Debouteville[3]

[1]The University of Queensland, Australia; [2]Wilderlab, New Zealand; [3]WorldFish Center, Malaysia

ABSTRACT

Fish underpin future nutritional security, supplying high quality protein, iron, iodine and vitamin A that are critical to childhood development and deficient in many staple foods. In 2018, 54.1 million tonnes of fish were produced by farming, generating US$138.5 billion and directly employing 19.3 million people, mostly in developing nations. With expansion and intensification, disease losses are increasing and are a priority for the FAO sub-committee on aquaculture. In most developing countries, disease mitigation comprises over-stocking to compensate, and use of readily available antibiotics. Indeed 67 different antimicrobials are used in the 11 major producing countries, contributing to the global pool of antimicrobial resistance (AMR). Accurate identification of the causes and sources of infectious disease is essential for implementation of evidence-based treatment, biosecurity and prevention. Pathogen genomics can provide sufficiently detailed information but has, to date, been too expensive and time consuming. Lab-in-a-backpack uses nanopore sequencing technology and low-cost, low-waste sample preparation to generate whole pathogen genome sequence data from diagnostic samples on the farm without laboratory support. Our simplified safe workflow includes a cloud-based identification tool that returns near real-time information about the pathogen using any laptop or smartphone. This enables evidence-based treatment, epidemiological tracing, AMR surveillance and the production of simple low-cost locally produced 'autogenous' vaccines to protect the next crop. These big-data-informed but locally implemented solutions align well with FAO's recently proposed Progressive Management Pathway for Improving Aquaculture Biosecurity, and can deliver real advances in local economy, nutritional security, antimicrobial stewardship and animal welfare.

This talk is about disease diagnosis in a fish farmer's backpack. According to the United Nations, food and nutrition security is achieved if adequate food – in terms of quantity and quality – is accessible for, and utilised by, all individuals at all times to live a happy and healthy life. Fish is a particularly good source of high quality well-utilised protein and it also has high concentrations of iron, vitamin A, and iodine that are critical in childhood development and are deficient in many staple foods. As fisheries are mostly fished to capacity, the increasing demand for fish is being met by aquaculture, one of the fastest growing food production sectors. In 2018, 54.1 million tonnes of fin fish were produced by aquaculture, generating over US$138 billion and directly employing

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19 million people in fin fish aquaculture production. The majority of these were in developing countries.

Disease is the major constraint to aquaculture growth and is a current focus of the FAO COFI Sub-Committee on Aquaculture. In most developing countries mitigation of disease includes stocking more fish to offset the losses, which makes the problem worse, and antibiotic treatments that lead to anti-microbial resistance. This underlines the importance of including aquaculture in a One Health approach to antibiotic stewardship.

Evidence-based disease control is central to reducing antibiotic use. We have all seen the power of genomic sequencing in outbreak management during the current COVID pandemic. Such high-resolution information identifies routes of transmission for biosecurity, informs appropriate treatment, and tells us which strains to include in vaccines. While genomic sequencing costs have fallen dramatically over the last decade, sample preparation is costly and involves toxic chemicals, and next generation sequencers are expensive and require large-scale infrastructure, and the masses of sequencing data need to be analysed to obtain actionable information. This puts the power of genomic sequencing beyond the reach of smallholder farmers in developing nations.

Lab-in-a-backpack

'Lab-in-a-backpack' creates a low-cost workflow for sample processing and genomic sequencing. It can be conducted anywhere, and it does not require expensive equipment or reagents, nor generate any toxic waste.

Our first innovation is a low-cost DNA purification workflow based on a safe household detergent available anywhere in the world. The samples have DNA tags or barcodes added, are pooled with samples collected during the same trip, and then loaded onto a MinION nanopore sequencer. These pocket-size devices are cheap to buy, simple to operate, and do not require lab facilities. Even here at The University of Queensland we do our nanopore sequencing in the office, not the lab. However, the data they generate are fuzzy. It is not possible to get actionable information directly from raw instrument reads.

Our next innovation – from our partners Wilderlab – adds cloud-based machine learning, trained on a custom fish-pathogen database developed by The University of Queensland and WorldFish. The alpha version of the app runs on an Android smartphone. The first few readings from the nanopore instrument are uploaded and return a detailed accurate diagnosis in a few seconds. A simple user interface then provides accurate information in near real-time via any laptop or smartphone, enabling the local fisheries officers to advise the farmers, and for simple custom vaccines to be manufactured using local fermentation capability. They can be used to vaccinate new stock on the farms that have the same bacterial strain types, thereby securing the output of the next crop, preventing spread between farms, and removing the need for antibiotics.

These big data-driven and locally-implemented solutions align with the FAO's recently proposed Progressive Management Pathway for Improving Aquaculture Biosecurity.

Lab-in-a-backpack can provide information that is accessible in real time and be employed directly in defining biosecurity risk, systems-implementation, preparedness and, of course, sustainable health management through vaccination. This will deliver real advances for local economies, nutrition security, human health, and animal welfare.

Thank you to our partners in the Inspire Challenge 2019 Prize, who have built a workflow to put the power of genomic diagnostics into a fish farmer's backpack*.

Dr Andy Barnes obtained his BSc (Hons) in Microbiology from Heriot-Watt University, Edinburgh, and his PhD from the Medical School, The University of Edinburgh. Andy worked for the Scottish Office Agriculture and Fisheries Department and at the Moredun Research Institute, Edinburgh, before joining a small Canadian biotech company, Aqua Health Ltd, specialising in vaccines for aquaculture in 1993. In 1999, Aqua Health was bought by Swiss pharmaceutical giant Novartis and Andy worked in their animal health division for 4 years before beginning an academic career at The University of Queensland. Currently in the School of Biological Sciences, Andy's research and teaching focus on animal health and welfare, including vaccines, diagnostics and healthy feeds for the aquaculture industry, with pure research on immunity and infectious diseases of aquatic animals ranging from reef-building corals, through prawns and oysters, to barramundi, tilapia, stingrays, kingfish, salmon and grouper.

* https://bigdata.cgiar.org/blog-post/meet-the-2019-inspire-challenge-finalists/

Q&A

Chair: Dr TJ Higgins, CSIRO

Panel: Dr Rob Horsch; Professor Pablo Zarco-Tejada; Dr Stacey Lynch; Dr Andrew Barnes

Q: Tony Fischer, The Crawford Fund and CSIRO

This is a question for Rob Horsch. I really enjoyed your optimistic presentation, Rob. There is no doubt the impact and prospects of genetic engineering for pest and disease resistance are massive. But consumer resistance continues, even in the United States in one extreme, and in India where these products are desperately needed. Are we making progress on this front, and how can we improve the rate of progress on this front?

A: Rob Horsch

Thank you, Tony, and I wish I knew the answers. I hope you guys can figure it out. I took my best shot at it, and obviously it was not good enough. The biggest hope I have is that enough products come from enough places benefiting enough people that folks who are upset will move on to bigger problems and realise there are more important things to worry about in the world.

Chair: I could add to that as well, having spent about 30 years talking to people, to decision-makers and others about gene technology. It has been a difficult time. But one of the things that I feel a bit more optimistic about now is the fact that more public sector products are starting to come on the market, which will I think be a little bit more acceptable. For example, the Bt brinjal in Bangladesh, or the beans resistant to bean golden mosaic virus in Brazil, or the resistant cowpea in West Africa. I think these advances will help a little, but I agree with Rob's general point that we do not have the answer to this problem.

A: Rob Horsch

Actually, TJ, I think the public sector involvement and publicly funded projects will help a lot.

Q: Peter Wynn, Charles Sturt University

A question to Andrew. What level of education do you think smallholder farmers will need for adopting your technology, for instance in Pakistan where aquaculture is a big issue? And what are your experiences with the level of education people would need for using the backpack kit effectively?

A: Andrew Barnes

I think it depends on what you are expecting them to do with it. We are still in the fairly early stages of the project, essentially the proof of concept: does it work?, and is it cost-effective? The answers now are 'yes' and 'yes'. You are right: the level of education is an issue. We have done quite a lot of survey work with social scientists on fish farmers' levels of education, separately with the

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Swedish Development Agency, and the levels are quite varied and generally quite low. But this tool is mainly going to be used through the mobile phone app. I was quite surprised to find that everybody seems to have a mobile phone just about wherever you go, and an Internet connection. There are some nice start-ups, for example a little start-up company called 'Farm Inc' that makes chat apps for farmers, where we could offer some oversight and help them through decision-making.

There are a number of levels of potential users for the Lab-in-a-backpack system. For instance, for the farmer, it might tell him that he has a disease in his fish which might mean he should cook those fish when he sells them, to avoid a human health problem; or he has a disease in his fish that is likely to come from contaminated water supply onto his farm, so to try and check on that. At a higher level it will show the local biosecurity officers – in Bangladesh, say – and local fisheries and extension officers that it is an ST283, for example, which causes diarrhoeal problems in people, so to be aware about that. At higher levels still, the system can be used by the government monitoring agency.

It is all cloud-based, so everyone can have access, even at different levels. For the farmer it would be simple day-to-day actionable items that come to him via the smartphone.

Q: Robyn Alders, Australian National University and merino Sheep Farmer

Stacey, I have a question relating to your work with African swine fever in Timor-Leste. I am just wondering how it is going, because you are in the midst of restocking [with disease-free pigs] there, so if you pull this off it is going to be a major achievement and really encourage people in the region.

A: Stacey Lynch

I think the work is going well there. We have been using WhatsApp for a lot of communication while travel has been restricted by COVID-19. The team in Timor sends us the results; we assess the quality control, and make sure that they are supported in interpreting the data. There have been some new detections of ASF; I am not quite sure of the time period, but additional to the surveillance reported in the scientific manuscripts.

Q: Eric Huttner, ACIAR

I think this question would be for Pablo, but maybe for everyone else. The technologies enabling diagnostics are really critical as a first reaction, but then the major biological and research challenge is what actions do you take that are practical for smallholder farmers to address the challenge that you've detected? For example, what do people do in the olive industry when they have received accurate pre-symptomatic diagnosis?

A: Pablo Zarco-Tejada

It is a very relevant question, and a very important issue. In the particular case of this pathogen, *Xylella*, in Europe the main objective of the early detection is to avoid the spread and to limit the potential effects during that period of time – which is so long, sometimes more than a year – between infection and the first symptoms being observed. Every country in Europe has different rules in terms

of surveillance methods, but they all have to agree with the common European laws, so it is quite relevant that every country where there are official outbreaks uses the technology to guide in the assessment.

One aspect that is critical is that farmers, particularly in the case of *Xylella fastidiosa*, did not want to release the information because that would mean eradication, and that would mean that specific actions were taken which were not very well received. And there was an important social resistance to taking those actions. Therefore, using national or European-wide surveillance programs using large-scale remote sensing would allow outbreaks to be identified, and evaluation of quarantine zones – that is, areas to limit in terms of traffic, for example – and then once those areas are monitored, to avoid further spread. So it is quite critical that we have large-scale monitoring methods in place.

Q: David Gale, Plant Health Australia

My question is for Stacey. You mentioned that the LAMP testing is being rolled out, under the Chief Veterinary Officer (CVO), with veterinary staff across Victoria. Are you recording detections as well as absences? And how are you recording all that information so that it can be aggregated in a way that then provides a useful picture more broadly?

A: Stacey Lynch

We are using synthetics at the moment and just running through proficiency testing to set up that data-sharing network. Policy needs to be established also before we can start testing animals for FMD using a point-of-care test. The machines are useful in that you can wirelessly send the data back to the laboratory and they can be interpreted in each case. When you are testing for an EAD [emergency animal disease] it is important to have the backing of the CVO so that if you find your test is positive you have access to further diagnostic support. Also, the data sent to the laboratory could be 'blinded', which we normally do. We record all tests, not just any possible detections.

I just want to make another comment in relation to an earlier question from Robyn Alders. We found in Timor-Leste, when we did the detections for ASF, that pigs in Timor-Leste are quite a sacred animal; they are a specific species and culturally accepted. People are accustomed to seeing the way they look, and so that was one of the things that people were concerned about with a virus that has such high mortality – that if this specific breed is not preserved, other breeds may not be culturally accepted. There is a requirement to identify pigs that could be brought in from an island just near Timor-Leste which would be suitable if they had to replace their own pig populations. It's an example similar to the thinking Pablo mentioned just now.

Q: Ian Naumann, Department of Agriculture, Water and the Environment

For Andrew. Regarding diagnosis of fish diseases, first, how much does a run cost? That is, the cost of identification for one sample? And second, the reference databases that your system runs off – was the compilation of those reference databases a big deal for you, or relatively easy?

A: Andrew Barnes

The running costs: the sample extraction costs 24 cents. For sequencing we are using Flongle cells at present, which are US$90, but because we only need a few reads per sample we can actually barcode (although you are not supposed to) on the Flongle cells. This means we are definitely getting down to a cost per run of $2 or $3. It is still quite expensive, so you wouldn't want to do everything, but it is much cheaper than it was. We may be able to make it cost even less. We are really looking at only the first few reads coming off, going through the database, and coming back with very accurate information.

In terms of the databases, we have tried to be a bit 'Rolls-Royce'. Because we are using machine-learning, we can ask open questions: so rather than querying, 'Have you got this in there?', we can ask, 'What is in here?'. We have tried to create highly curated genomes for most of the strains that we are interested in at present, and that is why it is building slowly, to get it working first on one thing that is difficult, and then build it out. We have built out quite a few species of fish pathogens now where we have the phenotype too, so that we can ask open questions on antimicrobial resistance (AMR), or things associated with transmissibility and aspects that we might not be aware about in the genomes. For example, we could make a database with antimicrobial resistance genes, but that would not cover the full spectrum of antimicrobial resistance or tell us whether the strains are clinically susceptible.

We would actually like to test that, and we have run into problems there in testing fish pathogens because many fish pathogens do not work in standard CLSI (antimicrobial susceptibility) tests. So defining a resistance phenotpye is quite hard. We are starting to work on that now with CLSI to get the testing methods changed.

Yes, usable databases are a big job, but it is a labour of love, an interesting thing, and you find new stuff all the time.

Q: David Shearer, Commission on Sustainable Agriculture Intensification

We must start breaking down the silos. Here, today, we are still having siloed conversations and asking questions specifically. Looking more broadly, these have been fantastic case studies. I think you four should write a paper together where you explain how you have used technology and made it accessible in a particular context: Timor-Leste; the WorldFish example in Bangladesh; etcetera. And we have also heard about the need for policy. For many years, Tony Fischer has been pointing out the importance of policies around gene regulation. Yes, they are very challenging, but they are needed if we are to have sustainable impact. We cannot go on designing policy to create more agricultural subsidies. There is already $700 million spent on agricultural subsidies. How would you four speakers design policy that enables these technologies to be used by smallholder farmers in a cost-effective manner that is not publicly subsidised? That's the challenge.

A: Rob Horsch

It is a very interesting challenge. I can tell you that what has worked has been at a country level, not at a technology level. All the schemes to bring wonderful, cheap, effective technologies to farmers individually work if you subsidise

them. What changes the world is when a country says: We want our agriculture to develop; we are going to support our farmers, and we are going to build in infrastructure. History is full of examples of this happening: it started in Germany and the UK, then across the world to the US, into Asia, and now it is happening in Africa. There the leading country is Ethiopia. Ethiopia said: We want to develop. They started 15 years ago systematically, and two or three years ago Ethiopia surpassed India on average staple crop productivity. That is astounding, and they did it because they decided to do it, not because of a single technological innovation. Then all these new tools can come into action after that first step, and make things more efficient and better. A great question; not a technological answer, I'm afraid.

Q: Luisa Olmo, University of New England

For Stacey. With the increased transparency that this technology allows, I am wondering if there any disadvantages to smallholders, at least in the short term? And could you say if you have encountered that and, if that is a constraint, how that should be managed?

A: Stacey Lynch

In these assays that I described, we are working with the smallholder through the local district veterinary agricultural service within the government, at the moment. From personal experience, I know that if animals are dying, people would like to know what they are dying from, because that is the only way in which you can help prevent, support, and respond. So from the experience we have had, the technology has been generally well regarded.

Chair: I have a question for Rob Horsch, in his role in the Global Farmer Network. I have become aware in West Africa, especially in Burkina Faso and to a lesser extent in Ghana, of the role of farmer federations: how important they are in demanding access to new technologies. I wonder what your experience has been, Rob, in your role as an adviser to the Global Farmer Network, which is much broader than just those two countries I mentioned?

A: Rob Horsch

I discovered it is a marvellous group; it is one hundred per cent farmers. I'm an adviser, and therefore not a member of the group because they are all farmers and their mission is to get the farmers' voices heard politically. They are not lobbyists; they are actual real farmers who make their living by farming; but they organise, they discuss, and then they train, and they have regional groups and country groups all around the world because they are a voice with inherent credibility, who have an interest at stake that almost nobody else has at stake, and yet which is publicly vital to everyone's welfare. I am so glad they found me, and I found them.

Chair: And I can add that quite a few Australians are members of this Global Farmer Network as well.

Thank you, everyone.

View from the private sector: Trust and purpose

Rob Kaan

Corteva Agriscience,
Australia, New Zealand, Japan & Korea

ABSTRACT

Global agriculture is facing many dynamic trends and emerging issues that present both challenges and incredible opportunities for evolution and growth. Key issues such as food security, consumer influence, biosecurity, labour shortage, water utilisation, climate change, deforestation, people talent, sustainability, trust in science/business/technology and smooth trade flow make just a short list of major drivers that require consideration, proactive investment, and decisive action now from many stakeholders to ensure industry success in the long term. The urgency and importance of these trends are different by country, and many trends and issues connect and converge. Developed countries, like Australia, can play a pivotal role in evolving quickly with these trends and leveraging our experience and learnings appropriately to developing nations. I will focus on three key areas and share how the private sector is viewing these in both Australia and developing nations, share examples of how these are being addressed in various countries, and offer suggestions for management of these issues in the future. I will share examples of private–public collaboration that can help address these trends, and touch on the important responsibility of the private sector in embracing Corporate Social Responsibility. Smooth trade flow of agricultural produce is essential to the development of all nations and in meeting global food security challenges. Influences on trade flow are diverse, including political drivers, industry direction, regulatory structures, and food chain stakeholders. Collaboration and transparency between key stakeholders are essential in managing future emerging trends that will impact trade flow. Biosecurity issues continue to impact agricultural production. Recent examples, such as fall armyworm across Asia and the industry response to this, serve as a good case study to assess the importance of multi-stakeholder cross-country collaboration for rapid response to these issues. Technology investment, development and acceptance are essential in agriculture to address current issues and capture future opportunities from within the sector. Technology partnerships with a clear alignment of objectives and a transparent regulatory framework are essential to attract required investment.

It is a privilege to be invited to this event to speak on behalf of the private sector, and to speak to an audience of scientists, industry stakeholders and – most importantly – passionate agriculturalists.

The company I work for is new and you may not be familiar with the name, Corteva. It is only two years old, formed from the merger of three well known

This record has been prepared from a transcript and the slides of the presentation.

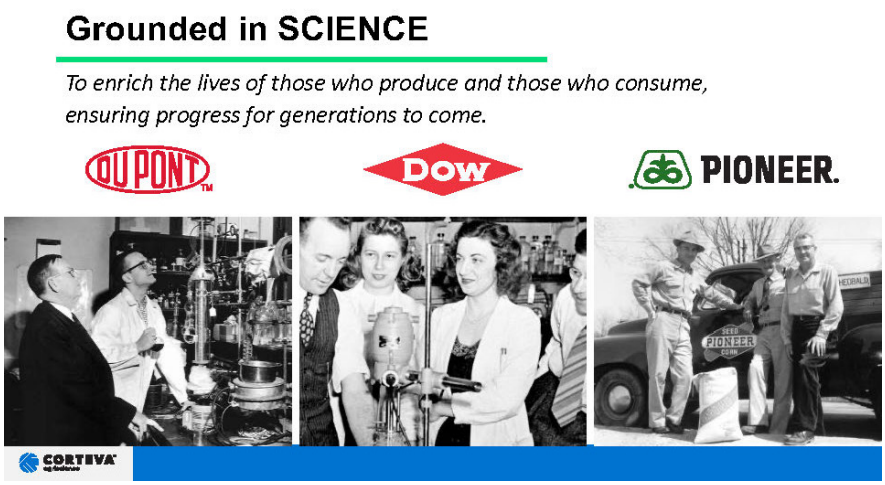

Figure 1. Corteva Agriscience statement of mission and purpose.

American agricultural companies – Du Pont, Dow and Pioneer. Following the merger they spun off three independent individual companies onto Wall Street, and one of those is Corteva Agriscience. This company has the agricultural people, the agricultural assets, the Intellectual Property and the R&D capabilities that came together in the merger. Today we have just over 22,000 people in most countries around the world, working specifically in agriculture. We invest just over US$1.2 billion every year in research and development, and that is broken into three buckets: seed development, whether traditional breeding technologies, new breeding technologies, or trait and biotechnology development; the discovery, development, and commercialisation of new crop protection products; and digital platforms, which many companies like ours are involved in. Figure 1 shows our purpose statement.

I have been asked to talk about issues (Figure 2), many of which we have heard about this morning, Some people think agriculture is homogenous, but it is not: every single sector is different, and we all face different issues in different

Figure 2. Issues noted and managed by agribusinesses.

markets, in different countries, although many of these are linked. I would prefer the image in Figure 2 to show a rainbow rather than storm clouds, because we really should be optimistic and excited about issues – they offer so many opportunities for investment. I hope some of the university students who are attending or watching the conference remotely will look at Figure 2 and think about how much we can do in the future in a really good way, acknowledging that will require great brains, good talent, and a lot of innovative thinking.

In relation to Figure 2, *labour shortage* is one of the biggest challenges we have in agriculture. Even in the most populated countries, like India, agriculture is short of people. I like to visit places like Japan, which to me is like the tip of the spear: they have old farmers, almost no immigration policy, and they are still trying to grow food. However, technology is responding, with automated machinery, new breeding techniques and so on, trying to adapt to the challenges they face. In Australia, technology enables relatively unskilled workers to harvest wheat using expensive equipment on farms, because the harvester is driven by satellites. Doing the job needs very few people. Although labour is a big issue, agriculture is making progress, and it needs to continue to do that, because labour availability is a big problem.

Now let's consider *people talent* (Figure 2), which is a big gap that I think is critically important for our industry. Solving problems of the agriculture industry needs lots of young, energetic, innovative and curious minds. While organisations like 'Picture You in Agriculture' are doing good work, we need to continue to encourage high school and university students into agriculture. It is a great industry to work in, and the challenges you can see in Figure 2 are fundamentally important to all of us.

I want to focus now on *trade flow*, *biosecurity*, and *trust in technology* (Figure 2). From a private sector perspective, these are opportunities: confidence, and then acceptance, and a good regulatory structure with a sustainable value capture will bring sustainable investment for solving these issues.

Smooth trade flow

Trade is a complicated and dynamic area and very important. Smooth trade needs multi-level coordination, from government level to grower level, to understand and manage eight trends that can be grouped under three headings:

- **Political**: trade barriers; protectionism; ideology
- **Food chain**: cross border rules/expectations; secondary regulators
- **Regulators**: MRL harmonisation; Codex; data sharing.

Political *trade barriers* are a familiar issue – sometimes real, sometimes contrived. *Protectionism* still happens, as do nationalistic behaviours. *Ideology* could alternatively be termed 'aspiration'. We are seeing trading blocs or countries starting to influence how other countries produce their food so as to have access to that marketplace. Europe is probably the best example of that; but where countries differ, farming practices and production need to be different, which is good for diversity. Other examples of ideology include attitudes to mulesing and animal welfare.

Looking at ideology from the perspective of sustainable investment, how long will it be before biodiversity, water use efficiency, and carbon emissions become trading principles? That time is probably not very far ahead, and we need to be ready for it. I am not saying those ideologies are a good thing or a bad thing, but we need to get ready because they are in the future. And thinking back to food security, how do developing countries keep pace with this rate of change? They are still working on food security, while we are thinking about farming practices to meet the aspirations of wealthy country blocs. That needs to be addressed.

Under the heading **Food chain**, from the private sector perspective the influence of *secondary regulators* has increased significantly in agriculture. It is part of the reason we have 'consume' on our purpose statement (Figure 1). Through the consolidation of supermarkets and food chains, the food chain now has a strong influence on how food is grown – not just within the country of origin but also in other countries, to be sold within that local market. It is challenging to understand customer need, because it is dynamic and changing quickly, and often it is the supermarkets and the food chains that are driving that customer need. Genetically modified (GM) produce has been affected, as have natural foods and organics, and even how we grow eggs – whether the hens are caged or free range. These are part of the increasing influence of secondary regulators.

Regulators – third heading above – are an area the private sector watches particularly closely. Regulation is very important in agriculture. In relation to food safety, environmental impact, it is critical for agriculture to be a trusted industry. One important example of the regulators in trade is maximum residue levels, MRLs, which give buyers and importers confidence that the food products they are buying have a safe level of product residue. That is very important for long-term investment, and it has been managed by Codex, the global database, for quite some time. However, this is starting to fall apart at the edges. Countries change their MRL limits, and they may be different to those of other countries.

In some cases countries are eliminating MRLs completely for specific products that are important in one geography and not in another. This is adding confusion and complexity for importing–exporting companies, and also causing a great deal of confusion for growers who want to have access to global markets. It is hard for them to keep pace and know exactly which product they can use, and safely, to make sure they do not lose valuable export opportunities.

An example of thinking ahead in this area has started up in New Zealand. In my opinion New Zealanders are very capable in agriculture. I think they are very good at branding, and at agricultural strategy. Figure 3 shows a new organisation, A Lighter Touch, which I think is an insight into the model of the future. It is very new, and I am not making a judgment on whether it will be successful. A Lighter Touch is a partnership between government and industry, with the vision statement 'Agroecological crop production to meet future consumer demands', and a range of organisations are involved. There is a heavy horticulture focus, along with research institutions and some others, including Corteva Agriscience.

We were one of the first private companies to join this partnership, and people ask why a company working with pesticides and GMs wants to be part of this

Figure 3. A Lighter Touch – an organisation exemplifying proactive collaboration.

group. The reason is that it is fundamentally important for us to understand what the consumer will be like in 10 years' time, and this organisation is a think tank of people thinking about exactly what that looks like. It takes us 10 years to discover and commercialise a product, and it costs us a lot of money, so it is very important to us to have really long-term insights into future consumers.

The other thing that this group, I think, is doing well is they are not just thinking about what the consumer needs and wants in the future, and how the grower can actually implement that in New Zealand; they are also trying to design suitable regulatory structures. That is very important for investment from a private sector viewpoint. Not only: Is the customer need understood so the problem can be solved?; but also: Is there a good regulatory structure in place that we can trust, that gives us a pathway to actual investment, then commercialisation?

There are probably more of these types of organisation around the world, and I picked this one as a quick example of the way the private sector needs to think about how to deal with the complexity of trade and how to make long-term assumptions about what the consumer really is interested in.

Biosecurity

Biosecurity is very important and Australia does a good job on it, but we have heard already how challenging it is, especially with fast moving pests and diseases in monocultures. I fully agree that prevention is much better than cure, as other speakers have said, but sometimes we have to cure and sometimes we have to react. That is a fact, particularly with the way we trade products around the world.

Take fall armyworm for example, which spread into India in 2018, South East Asia in 2019, and Australia in 2020. Nowadays it is not so much a biosecurity problem; the big challenge now with fall armyworm (FAW) is its impacts. Particularly in Africa and South East Asia those farmers are very poor, often

self-sufficiency farmers. When their maize crops are damaged and destroyed it is very serious for them. Reaction to, and fixing, that problem needs to happen quickly, and that is why I want to use this example to show partnership and collaboration.

In 2019, government, industry, academia and private companies including Corteva Agriscience collaborated and partnered during a three-day workshop in Hyderabad (Figure 4), organised by USAID (US Agency for International Development). Participants came from Myanmar, Sri Lanka, Nepal, Bangladesh, Thailand, India, Ministries of Agriculture, universities, Crop Life, research institutes. The objectives were simple: first, to get experts together, talk about the problem, talk about the experience, build the farmer programs; and second (particularly important in these smallholder areas), put the outreach into place speedily so those small farmers understand exactly how to treat this problem as quickly as possible.

Some excellent technology has been enabled through this workshop, as well as research on FAW with existing chemistry and also natural chemistry and natural predators. The evolution continues into how we can manage this, and I think this story illustrates how we must remain very vigilant. There will always be another pest and disease, and when they become evident we need to react very quickly.

This workshop was a good example of cross-country, government, public, private sector, all coming together and quickly addressing a problem, and currently FAW numbers have dropped significantly through Asia. Those numbers will come and go, but we think part of that drop is because of that rapid response to the problem in 2019. It feels like a good news story at this point in time, but we do not want to call victory too early.

Figure 4. FAW management was tackled in a workshop in Hyderabad, India, in 2019.

Figure 5. Emerging technologies. Structure and broad support are required to drive investment confidence and consumer trust.

Trust in technology

Technology is fundamentally important to a company like Corteva Agriscience and many others in the private sector, whether they are in agricultural services or other fields. Some of the numerous types of technology are noted in Figure 5, and many of them are designed or in progress to address some of the concerns shown in Figure 2 – and they are making progress and being developed.

One challenge is how to have these adopted by users. That is one of the big barriers, and one of the biggest barriers to investment. Data ownership is a concern (just as we all have our own problems with data security with Google and Facebook). One of the largest challenges for digital platforms is ownership of farmers' data. They have a lot of data, and they need those data to help them make decisions, but there is a clear question about who owns those data, and farmers may ask: What am I giving away by bringing companies in to have a look at my farming history and some of my decisions?

Plant breeding techniques are among those emerging technologies. Corteva is a biotech company; we work with CRISPR-Cas, and it is a real challenge to get acceptance of these technologies. We know we could do great things with these technologies, but the challenge of acceptance is why the consumer is part of our mission statement and our purpose (see Figure 1). Growers are very quick to adopt new technology: if it is good for their farm and good for the environment they will use that product. Science-based regulators will also approve products for use, relatively quickly through their processes, but that is not good enough anymore. The secondary regulators and the consumers must also accept and adopt those technologies. Without those last two steps in the ladder, the first two, unfortunately, will not count. We have seen this and been frustrated by it repeatedly.

As a company we are spending as much time as we can with food companies, and we need to continue to do that as an industry, to try and educate, because when I go to a big retailer and speak about CRISPR-Cas, they have already been

Figure 6.

spoken to by other companies that do not like those technologies. As one of the companies that practises a new technology, we are trailing behind other companies that have negative viewpoints. Influence and education are critically important.

Corporate social responsibility

Corporate social responsibility – CSR – is part of 'trust'. I see a dilemma in a lot of corporate businesses in agriculture (Figure 6) in that want to get involved in more CSR activity but don't know where to start. My company's thinking is that it does not quite have the scale or the influence to really 'make change'. Yet more and more we find that our employees want to get involved in causes. The CEO and the directors support that idea, and our shareholders also will invest in us because we 'do good'. Our employees, especially our younger employees, are coming to us, asking: When can we do more volunteering; when can we go to foodbank again; when can we help out with the climate change initiative? Those types of activities are what drives them to be in the industry, in many ways.

'Shared value' is really important. For a corporation, the old view of shared value is it has to be symbiotic: whoever the company helps, that help needs to be good for them, and the company also wants something in return. And the symbiosis has to be lasting and sustainable, so that when the next CEO takes over, they continue it. In the most basic terms that means that if the company helps you, it will sell more product; that is a very crude symbiotic relationship.

I think the shared value model is changing. I think nowadays that when as corporations we become involved in some other organisations and initiatives, the shared value we get in return is our own employee traction and retention; and that effect is phenomenal. CSR now is not only about selling services, or selling adoption of products: instead, more involvement in CSR and good initiatives in agriculture actually attract more people to our industry and more people to our company. It becomes a differentiator for a company like ours, if we do it well.

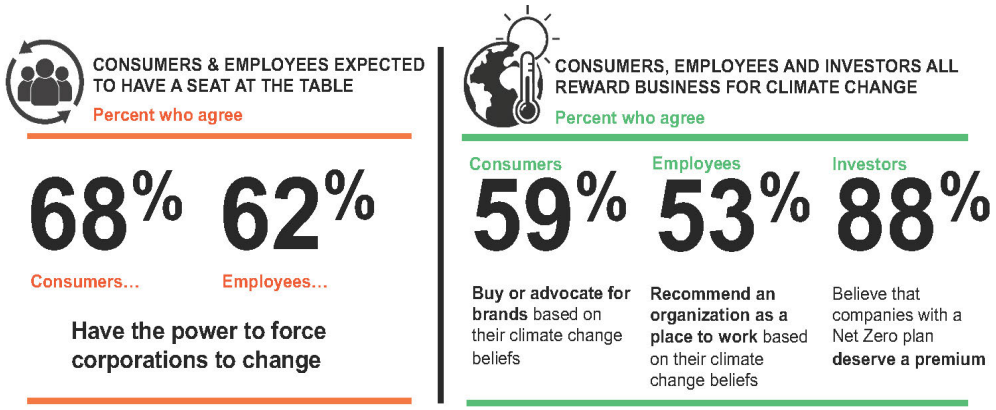

Figure 7. Key stakeholders are a growing influence.
Source: 2021 Edelman Trust Barometer.

Figure 7 shows typical effects of 'key stakeholders' (though this example actually relates to climate change). The Edelman Trust Barometer gives rather negative messages about how trust is declining in the world in the major institutions, but it is very interesting reading. It highlights that consumers and employees are not passive stakeholders; they will not sit by and not vote, either by buying the food that they want to buy or by working with a company that they no longer believe in. As corporations we need to be fully alert and aware of that. Investors are mentioned at the right-hand side of Figure 7, showing it is very important that they also have a say in the corporation's decisions.

Good CSR activities build trust within employees, and attract them and retain them, even in agriculture, which has great purpose in itself before you build

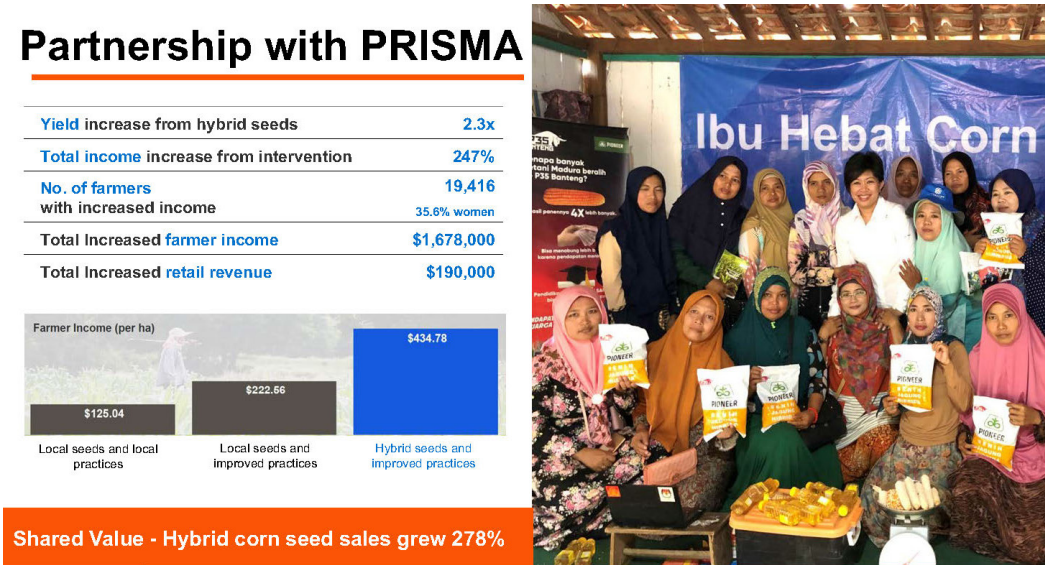

Figure 8. An example of shared value: Corteva's partnership with PRISMA.

other initiatives around that. We think it is also important to start to build this trust with consumers who, as I said above, are one of the biggest barriers to technology adoption for a company like ours. Figure 8 refers to a recent good Australian example of what some organisations in Australia do in other parts of the world. PRISMA is an organisation working with the Indonesians, looking at economic growth in rural Indonesia as farmers move from self-sufficiency to cash-crop farming. It is a classic case of shared value, where PRISMA, working with their teams, bring together the farmers who have a problem that needs a solution and a company like Corteva which can bring in suitable technology – in this case, very simple hybrid corn seed.

It does not stop there, though, because the face you see in the middle of the photo, in the white shirt, is one of our employees, and this is the extra shared value I talked about above. Our employees want to do more and more of this, all the time. Every time we show slides like this they want to know why are we not doing more of this interaction? How can we get involved in this? What can we do to make these benefits more prolific? It is very satisfying to see Australian organisations working with private companies like this example in developing nations, and it reinforces much of the work we are hearing about today.

It is encouraging to me that this conference has invited the private sector to be part of the talks because, as I mentioned, there can be a dilemma for companies – and especially their employees; we want to do good but do not know where to start. Corteva has been fortunate to interact with organisations like Picture You in Agriculture and others that help us in aspects that we think are important but would never be able to do ourselves. We have to find someone to help us support them in what they are doing.

Concluding remarks

I have covered a lot of topics. I was pleased to hear the consistent trend this morning around science-based calm thinking, and I think we are very fortunate to have our Regulator in Australia here. That is a role model to the region, watched very closely by countries and regions like Brazil and South East Asia. In science-based, calm, pragmatic decision-making around agriculture, Australia has much to be proud of. We also have plenty to be excited about: so much opportunity; we should be very optimistic. No doubt there are challenges, and they are complicated and dynamic, but investment is there. We need good people, young minds, and really curious innovators, to be involved.

In conclusion, from a private sector perspective, the identification of the opportunity is not the hard part; the hard part is the structure around that to capture value, and then building trust and acceptance further on.

When I look at some of the trends around the world, especially in trade, I am concerned that they are becoming a little bit more discrete, such as with the secondary regulators and the aspirational ideologies. They are hard to read, and hard to foresee, but their influence is growing. I think we need to be cautious of this, especially when there begins to be a separation between the consumer needs and the realities of scalable food production systems, especially when that starts to block good technology.

I know that has been talked about for 10 years and there is no quick solution, but we truly believe engaging at the ground level with consumers and food companies is a good place to start, and that is where Corteva will be putting in effort.

Currently based in Sydney, Australia, Rob Kaan is responsible for the strategic leadership and commercial activities for the Australia / New Zealand and Japan / Korea business units of Corteva Agriscience. Rob has worked in agricultural businesses since 1998. He spent the first part of his career in commercial roles in Sydney, Perth and regional locations such as Tamworth and Moree, NSW, before relocating to the United States in 2007 to lead global product portfolios. In 2009, Rob relocated to Kuala Lumpa, Malaysia, to lead the SE Asia business units before returning to the United States in 2011 to lead global portfolios for crop protection across global corn and soybean markets until 2016. In these roles Rob has had the opportunity to travel extensively and work with partners and farmers in many agricultural markets around the globe including South America, Asia, Europe, North America and ANZ. He has also worked closely with consultants such as McKinsey on 'Organization Design and Culture' projects both at Dow Chemical and in the creation of Corteva Agriscience. In 2016, Rob returned to Australia to lead local businesses through the Dow Du Pont merger and integration through to the final formation of Corteva Agriscience on June 1, 2019. Rob completed his Master of Business Administration at The University of Western Australia in Perth. He also holds a Bachelor of Science in Agriculture from The University of Sydney. Rob is married and has two children. His hobbies include surfing, skiing, golf, running, reading and guitar.

Q&A

Chair: Andrew Egan, Dept of Foreign Affairs and Trade

Panel: Rob Kaan

Q: Peter Wynn, Charles Sturt University

You said one of the main challenges is adoption, and yet adoption is very much related to extension, or the effectiveness of extension programs, and in many developing countries these are dominated by government organisations. What are the challenges working with and gaining access to farmers, either working around the governments or working with governments in developing countries?

A: Rob Kaan

For many corporations, it's knowing where to start. We obviously have access to farmers in all countries, because we deal directly with them, especially with seed production. But when it comes to looking to help out farmers in difficult areas, or needing production gates, we struggle a little bit with that because, you know, our historical view is very much on production, production, production; it's 'more yield' all the time, which in itself is a good benefit, but doesn't always meet the needs. So that's why I think the PRISMA example is good. We wouldn't have been drawn into that opportunity as a private sector company without being asked to be at the table. That would not have been a segment of the demographic customer that we would have spent time with naturally, as you could imagine. So there needs to be relationship between both sides, but I think identifying the opportunity is not always as obvious to the private sector as it is in the public sector, and that's where we can use a lot of help.

Q: Paul Fox, private consultant

We talk about trust in technology, and in this meeting we have heard about dealing with the sort of views the public might have about GMs. I think that to advise this debate on the nexus we are having, that the agrochemical industry would be better served not by a kind of amnesia, but by some global truth-telling about where the agrochemical industry has got things wrong. We acknowledge that there are products that are supremely important for agriculture, but things like the contamination of agrochemicals with dioxin have happened in the past, and I think they really have to be addressed and not washed under the carpet. They're important to this whole debate about trust.

A: Rob Kaan

I think Corteva had an opportunity four years ago, when the company first merged. You get a great opportunity when you create a new company because you can't shed the past but you can shed legacy, and you can think about a new company, and you can think about a new culture, and you think about moving forward. We went out around the world in 2017 and asked perhaps a thousand consumers around the world: Tell us what you think about the crop protection

This record was prepared from a transcript.

industry. It was a real wake-up call. Not a surprise, but to see the responses consolidated together was very confronting. It made the company think differently about trust and consumers and transparency.

I see most companies very dedicated to trying to do transparency well. I'm not going to say every problem is solved from the past, but in our corporate journey there is now a significant change in the way companies are looking. Recently some companies have just stopped selling products that don't align to that ideology. If we as a company go out and talk about how we want to be an IPM [integrated pest management] company, and we want to have products that do this and do that, and yet in our portfolio we have products that clearly contradict that, we will lose staff. Young people will not work for us.

Q: Dennis Blight, ANU

You mentioned very briefly the role of natural enemies. I wonder if you could just elaborate on that a little? And I should say that I was a former Chief Executive of CABI, where biological control was a mainstream activity on our part. And when I spoke on biological control people often responded about the cane toad, which was introduced as a biological control over the pest of sugarcane and is now encroaching even as far west as the Kimberley. So, could you talk a little bit more about natural enemies and compare and contrast that to chemical control?

A: Rob Kaan

Yes, natural predation is a very important tool, and obviously you've seen it well adopted in Australian cropping systems, especially in horticulture. One of the changes we've seen in our industry, when we look at early screenings of compounds, normally fungicides and insecticides, one of the earliest screenings we look at is how targeted is this product. You look at some key organisms, which might be parasitic wasps, or lady beetles, or spiders, or pollinators, to make very early identification of the characteristics of a product, because the attributes of that are so important to farmers.

Integrated pest management has been around for a long time. We promote IPM a lot. It's talked about in news, but it's not used as widely as it should and could be, and we're in one of the most developed agricultural markets in the world. There are some great companies out there doing really good things with natural predators, heavily supporting really good industries, and I just think that's going to be a continuation, and we'll see more and more crop protection products supporting the use of beneficial insects and predators.

Q: Vivienne Wells, ANU

You talked about the fall armyworm as less of a biosecurity issue and more of a problem for the farmers and the producers in that area, and their resilience, and their reliance on individual systems and their production. Earlier today we heard about prevention, in biosecurity, being helped by diversification in production systems. Should we be looking at multi-use land change practices to diversify income streams and increase farming resilience to biosecurity shocks?

A: Rob Kaan

That's a very good question. I'm not sure I'm the most qualified person in the room to answer it. I think the simple answer is yes, but it's very hard to make that happen because of economic factors. Farmers have to have the freedom to choose what works for their farm, while also thinking about biodiversity within their farm, which is important. I thought someone would call me out when I said fall armyworm is not a biosecurity risk anymore. In my opinion it's 'out of the bag' and now we're more in reaction than prevention. But I would say, yes, of course, the more biodiversity we have, the less spread we'll have of pests and diseases like that.

Q: Fiona Simson, National Farmers' Federation

Thanks so much, Rob. I really enjoyed your presentation and some of the reflections. I'm particularly interested in trust. The National Farmers' Federation has through its 2030 Roadmap engendered a conversation in Australia which is incredibly positive about agriculture, incredibly positive about our future, and has a whole lot of measurables that cascade down from the large headline hundred billion dollar value target that touch on all those sorts of things. When we talk to the private sector, though, and we do work with a number of corporate partners, sometimes it's difficult to get them to work together, because of their brand. I was really interested in the New Zealand example you gave about charting consumers and where we might go. How do farmers, and what role does the private sector play in terms of addressing some of those really big industry-wide issues that may or may not sit quite within their corporate responsibility?

A: Rob Kaan

That is difficult to answer. You mentioned that we don't collaborate very well, and I would agree with that. Some of that is for competitive reasons, but where we collaborate well is in a reactive space, which is the wrong place to work together. For example: This has already happened; now we need to get together, forget about our stripes, and try and solve the problem. But it's too late at that point.

I guess we know our position in the marketplace. We are not the best people to talk about trust. That actually comes from farmers, in our opinion. Farmers are the best advocates for what they do and the products they choose to use, and how important they are.

I think the only way is wider collaboration, and that is why The Lighter Touch organisation caught my eye. Because it's really broad, it takes away the competition of lots of different industry groups sharing ideas and being open about what the future looks like. We need a platform. Up to now, I haven't heard of one in Australia where the private sector and the public sector work together on trust.

But I would agree with you that companies are trying to work one-on-one, whether it's the animal health guys trying to work on animal things, or the crop guys working on genetic modification and the IT people working on big data and

data privacy. There's no collaboration between those different topics, but they are all unfortunately linked together by a general lack of trust in some of those technologies.

Someone talked about CRISPR before. We have a great project with a partner in Japan, working with a university, with High GABA [gamma-aminobutyric acid] tomatoes [genome-edited]. As someone mentioned before I think, the more the public research gets involved in biotech the better. In Japan they don't really like biotech or GM at all; they are very close to their food; so trying to launch a High GABA tomato in Japan is difficult. And I think the strategy has been very cool, and it will be an interesting case study to look back on, say, two years down the track, because they are essentially giving away tomato seeds via a small hardware warehouse. A lot of Japanese grow vegetables in their homes, and they're handing out free samples of this product so that the consumer goes home, grows the tomato; they are not being tricked; they are very open about what it is; but the consumer is at home growing the vegetable, consuming the vegetable, and – you would like to think – with time, actually trusting the technology. It is a very different way to the way we have launched biotech products in the past. We might refer back on it in a year's time and see if it was successful, but I think it is a really interesting way of building trust with the consumer; one that I have not seen attempted before.

Chair: Now just three quick questions, because we have limited time.

Q: Derek Baker, University of New England Centre for Agribusiness

I want to also ask you a question about trust. I'm old enough to remember Soviet Union–USA intercontinental ballistic missile negotiations where agreements would be reached and they would say: Yes, we trust, but we'll verify. Now, I've done a lot of research work over the years on supply chains, particularly in developing countries, involving smallholders, and the more I looked for trust, the less I found it. When you are talking about investing in trust, are we really investing in verification, or are we really investing in trust?

Q: Peter Horne, ACIAR

I am interested in corporate social responsibility. It has a bit of a chequered history: sometimes it has been implemented well, often implemented through a separate part of the company which is just delivering on a social licence to operate. Globally, more companies are seeing that their commercial viability depends upon the commercial viability of smallholders. Do you see a different pathway for CSR in future?

Q: Tanya Skinner, ANU

I am very early in my research career, and I am seeing a gap between fundamental and applied research. There seems to be a big hurdle between very fundamental research like mine, and then getting my research out into field trials, and beyond that the pathways to commercialisation seem quite clouded. I wonder if there's any incentive for the private sector to invest in fundamental research, because obviously that's the pathway to applied technologies? And if there's not, what we can do about that? What sort of collaborations could we be

trying to form so that we are doing research that is a bit more appealing to the private sector?

A: Rob Kaan

I'll answer those in reverse, because the last is freshest in my mind. It's a difficult question to answer because it really depends on the type of research, but I would say, and I'm going to take this from our industry's perspective, that there is no way we can satisfy the needs of what we would like to do in the future through our own discovery and investment pipelines. It's just too limited. So more and more we are looking for early-stage technology to get involved in, and I know every other company in agriculture is doing the same thing, because we take quite a narrow view, to be quite specific on our investments for a return on investment perspective. There are some great seed companies, and The University of Sydney is doing good work trying to point early innovators towards private companies that might be interested in the technology you have. We are swamped at the moment, as no one would be surprised, by biological and natural products. Everyone wants to get into those products, and everyone's got a great idea, and everyone's a bit short on capital and doesn't have a path forward or a distribution network like we have. There are a lot of people coming forward with great ideas, and I would assume that most private companies who have an aligned strategy or a market in what your technology is, would have open ears.

CSR. In my 24 years in the industry, I have not seen any other company where there is such an interest in CSR across all employees. In the old days there was just a statement on the front page of the annual shareholder document; no one really believed it; there were very few people in the organisation who were involved; and that's where it stopped. But I can clearly say now, we have multiple depths of employees, more at lower levels than at higher levels, pushing and wanting to get involved in more and more CSR activities. I think shared value is important. I think it needs to have some sustainability to it. But as I've experienced over probably the last four years, there's a real change in people wanting to get involved. The problem, as I said, is that people don't know where to start. That's the real challenge that I see in corporations at the moment.

Validation versus verification. It's an interesting point. We are the worst people at defending issues because we cite data because we're scientists. We are trying to verify, which is your point, all the time, whereas usually what is needed is an emotive discussion instead. We haven't solved that problem. We are not good at it. I think we are aware that we need to change the direction of the conversation, but I would say we are always verifying, trying to prove what we are doing is good and that we have the data to show that what we are doing is good. That actually doesn't change a lot of mindsets, unfortunately. That has been our experience.

Chair: Thank you, everyone.

Changing and increasing biosecurity risks to food and nutrition security

Professor Andrew Robinson

Centre of Excellence for Biosecurity Risk Analysis (CEBRA),
The University of Melbourne

ABSTRACT

Australia's biosecurity system protects us and the things we care about – including agriculture and the economy, animal and plant health, the environment and social amenity, and human health – from invasive pests. The nature of the risk from invasive pests is constantly changing, and almost invariably increasing, so the biosecurity system becomes ever more important. But what is the system? How does it work, and will it work the same way in the future? What is our role in it – and how can we best support it? Surely, it's all someone else's problem? This overview presentation will review the current and future impacts of emerging biosecurity threats to plant and animal production and human health and biodiversity. The four speakers in this session will pull out trends in the emergence and spread of plant and zoonotic diseases and identify key factors that both promote and reduce disease spread. We will tease out the threats to food security, nutrition and human health that arise from inadequate biosecurity understanding and management, and show how phytosanitary control and best-practice management can materially reduce biosecurity risks for the land-manager and the landscape. The biosecurity system is no longer just AQIS standing steadfast at the border, and perhaps it never was really that simple. But we need to change the way we think about biosecurity as a system of organisations, as a regulatory framework, and as an outcome. The increasing interconnectedness of consumers and international markets means that we are now all stakeholders of and participants in the biosecurity system. Changing trade patterns, changing global alliances, and changing climate all press us to think and act today! How will we get there?

The giant African snail (Figure 1) grows up to a kilogram in weight and is 20 or maybe 30 centimetres in length. An hermaphrodite, it lays 1200 eggs after

Figure 1. Two giant African snails, *Achatina fulica*, cover an adult hand and wrist. *Photo: Scott Burton/AP.*

This record has been prepared from a transcript and the slides of the presentation.

mating, and is highly polyphagous, meaning it eats lots and lots of species of plants. I could add that its slime is highly corrosive and it spits venom 10 metres … but those are not true. However, it is a 'bastard', and we do not want it to get into the country because it is going to eat a lot of our highly valued crops and rainforests. For this talk, this is my example of the threat to biosecurity – the giant African snail.

In the old days I would talk also about zoonoses, familiar to us now. I would talk about bird flu, and swine flu, and Ebola, and mad cow disease, and so on, because to statisticians like me these are really riveting topics. I would finish with the grandparent of pandemic pulchritude, Spanish flu, H1N1, which infected half a billion people, killed 50 million, and laid waste to the world population about a hundred years ago. And I would invite the audience to think what would we do if one of those came around today.

And now we know: we would sit in our homes, and we would Zoom! And we would get vaccinated. ('Grandad, what did you do during the pandemic?' 'I sat at home, and I got vaccinated.')

This new threat, COVID, focuses the mind. It has changed the way we live on the globe and the way we interact. I am predicting that this change is permanent, and that this represents a watershed moment for us to think about what biosecurity means, and what it does for us and what it doesn't do for us, and who it does for and who it doesn't do for, and whether that matters – and if so, why? And I am going to claim that it does, and I am going to claim it is very material. I am going to use this whole exercise of 'what did we do during the pandemic?' as a framework for talking about biosecurity and why I think it matters, and what the key question is.

COVID shows us that the threats against which the biosecurity system is aligned are generational threats, definitional threats. With 500 million people infected, and more than five million people dead, and all of us in our bunkers, it is safe to say that this disease is going to stay with us.

Whether it is a zoonosis or not does not matter. It is a pathogen against which biosecurity could have done a better job protecting us. Not our biosecurity, but somebody's. Biosecurity is before everything we care about. Human health, environmental health, food safety, agricultural exports, conservation biology, our way of life: they are all predicated on biosecurity.

What is biosecurity?

What is biosecurity? This is not a trick question, yet, but I want to convince you that it is an extremely important question to ask, because the answer tells us not only something really important about biosecurity, but it also tells us something really important about ourselves, and it also tells us something really important about what we are doing.

First, why is it important? Threats are here, and threats are continually increasing. Supply chains are incredible organisational operational achievements of multiple multi-layered societies. They provide us with unmeasurable goods

and services, seamlessly and efficiently, but they are also unparalleled vectors for pests and diseases. Every success that we can pin to a supply chain is linked hand-in-hand with a threat. The images in Figure 2 show that there are very few places in the globe that are not connected to somewhere else quite intimately. And this is our vulnerability.

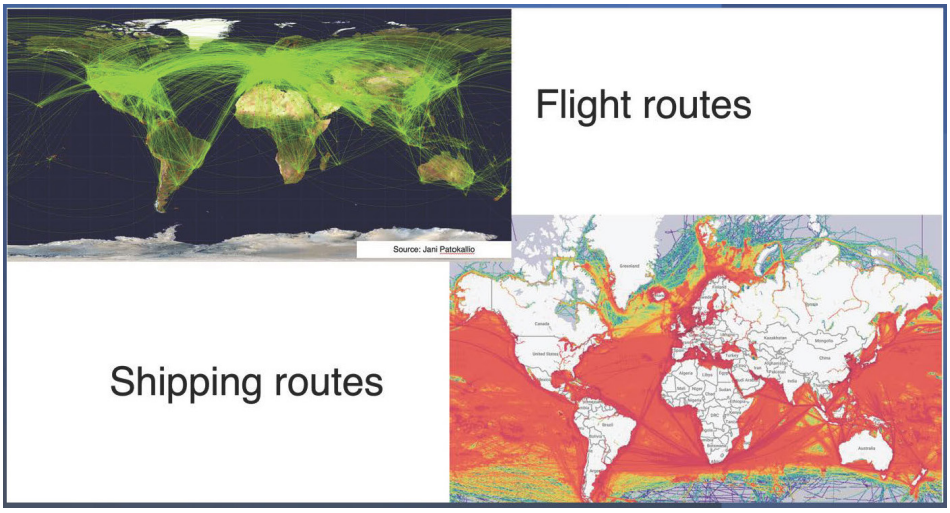

Figure 2.

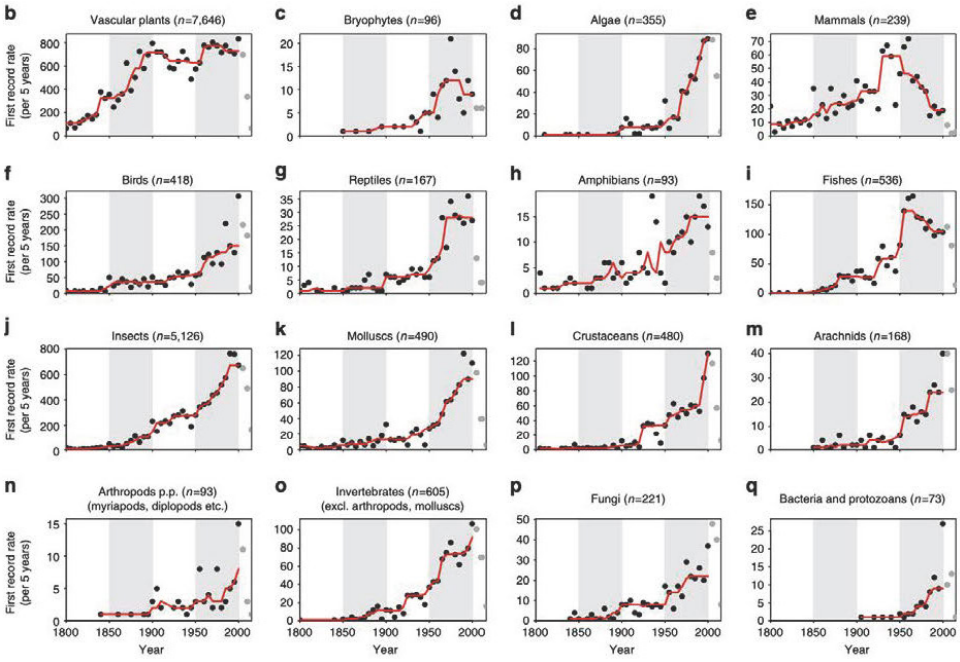

Figure 3. Numbers of various types of pests being intercepted at borders, or detected post-borders. *Source*: Seebens *et al.* (2017).

The vulnerabilities have material impact. The graphs in Figure 3 plot the numbers of different types of pests being intercepted at borders, or detected post-borders, and you'll notice that they are all shaped like hockey sticks; they are all accelerating, and it is all because of what we humans are doing. (Yes, there is some other 'noise' in the graphs: wind-blown or tide-carried stuff here and there, but they do not change the main picture.)

It is us. We are the big biosecurity threat: you and me.

I want to explore this question about biosecurity, and I will give three answers to it. There is a humdrum answer, and a popular answer, and the right answer!

The **humdrum answer**: according to the websites, biosecurity is the suite of activities undertaken by stakeholders to reduce the impacts of invasive species. Impacts of invasive species occur upon plant production, animal production, environmental health, human health, and social amenity, … .

Some of my team of statisticians and I decided that it was time to put a value on the biosecurity system, and in order to do that we had to figure out what are the values that biosecurity protects. We came up with 16 different values, 16 different dimensions of value that we were measuring the system for. Those listed just above are only five of these values, and there are another 11 as well.

The threats to some of those five values (Figure 4) have been pointed out already today. Plant production is affected by fall armyworm – it is here; and *Xylella fastidiosa* (which sounds like a Harry Potter spell!) is quite a material threat as Pablo Zarco-Tejada pointed out earlier. Animal production is impacted or threatened by foot-and-mouth disease, which is not here yet; high pathogenic avian influenza is here all the time. Environmental health is affected by myrtle rust; it is here, but not the bad one; the bad one is still on its way; and *Xylella* again. Human health is affected by COVID, Ebola, SARS. Social amenity is affected by red imported fire ant. And similar lists can be made for the 11 other values as well.

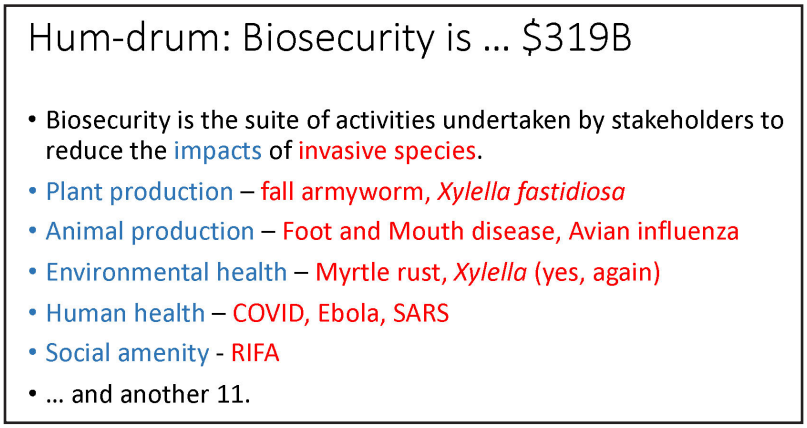

Figure 4. Threats (in red) already known to five (in blue) of 16 values being protected by biosecurity.

Figure 5. Steve Irwin was the face of AQIS advertising about border quarantine.

Therefore, the biosecurity system is starting to sound pretty good, because it is protecting all these amenities from all these threats. It is not giving total protection of course – that is impossible – but it is impeding them. We estimated the value of the biosecurity at around $319 billion over a 50-year timespan, and that the return on investment for biosecurity spend, just at the federal level, is around 30:1, and that the value of the goods and services being protected – just the environmental ones – is $6.5 trillion. This is a very material undertaking!

The problem with the humdrum definition, to my mind, is that it is trying to define the biosecurity system through its actions. That is not quite adequate.

My second definition is **the popular answer**: biosecurity is border quarantine. Many will remember Steve Irwin (Figure 5), the conservationist co-owner of Australia Zoo and a popular TV personality who died in 2006. Steve Irwin told us 20 years ago that if you try to bring stuff across the border you will get caught, and if you get caught there is a 'bloomin' big fine. He was advertising for AQIS [Australian Quarantine and Inspection Service], and it is still on YouTube. Like the Men of the Night's Watch in the more recent *Game of Thrones* television serial, the staff of AQIS were at our borders, protecting everyone from all the ills of other countries.

However, this popular answer is problematic as well. We cannot outsource biosecurity. We can arm the regulators, we can inform the stakeholders, and we can feed and house the scientists and give them regular distemper shots. But it takes more than border protection by AQIS (now renamed) to stop the pests. It takes more than the government. We need to do more.

The next three speakers will give you example after example of how biosecurity relies on a **community focus** and demands a mindset shift, not only from the community but also from the regulators. Irene will tell us about banana pathogen and the technical and behavioural strategies that are necessary to resist it. Chris is going to tell us what we need to do to support livelihoods at the regional level under attack from the fall armyworm; and Tarni is going to share

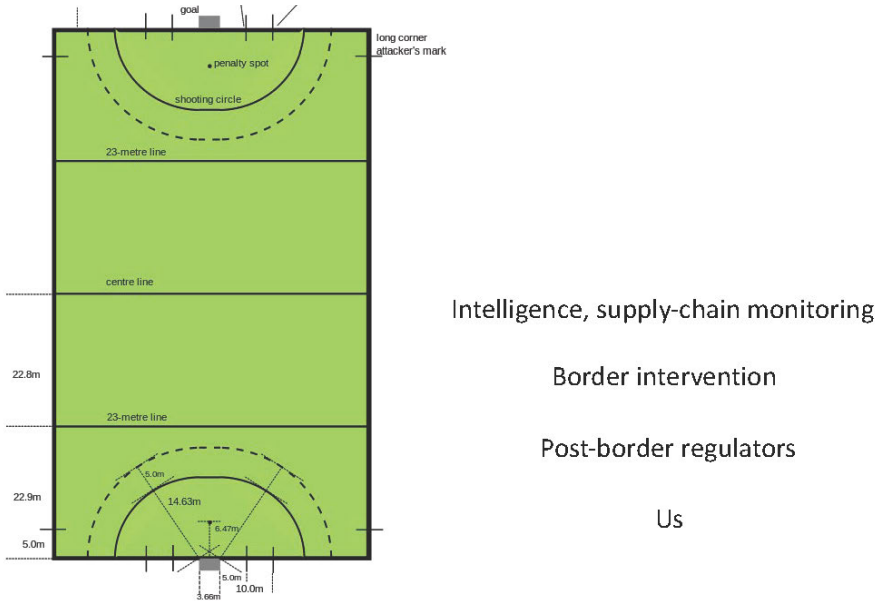

Figure 6. Effective biosecurity illustrated using a hockey field and team as analogy.

key insights into the global response to African swine fever. The common factor in all three presentations is people: people suffering, people planning, people doing things.

If we are going to activate and motivate the biosecurity system, we must get away from thinking there is an AQIS 'security blanket'. We are not protecting the stakeholders; we *are* stakeholders; and we need the stakeholders to understand what their active role needs to be, if they care about it. We assume they do, but we just run on that assumption. And is that right?

The right answer

My third answer is 'the right answer' for the biosecurity system, using the positions of the hockey field (Figure 6) as an analogy – not perfect, but instructive for thinking about the biosecurity system.

- There are the Forwards. In the biosecurity system, they are offshore; they are collecting information; they are helping harden supply chains; they are giving us what we need, to know what the environment is like.
- Then there's the Midfield, which is the Australian border. That is where AQIS (now the Department of Agriculture, Water and the Environment, DAWE) is working, in the midfield.
- The stakeholders, the jurisdictions are the Backs.
- And the Goalie is all of us, everybody.

The reason why this is a good analogy is, first, because we are all on the field. Everybody is 'on the field' in the biosecurity system. This is not you being protected by a system that is external to you. Instead, you are part of it.

Figure 7. All of us need to be engaged in best management practice (BMP) in biosecurity.

The other reason it is a great analogy is that the game does not end when a goal gets scored. You keep on playing. The analogy is not perfect, in that we do not have oranges at half time – or not while we are keeping citrus canker and huanglongbing out of the country! In short, to me, the biosecurity system is like a game of hockey, and we are in the goal. We are the last line of defence: all of us; not somebody else.

We can use that model to inform the activities that a biosecurity system, including us, could undertake in order to improve its performance (Figure 7).

- The Forwards could be tracking and predicting global pest movements:
  'Where are they now?
  Where are they going?
  Let's look at trade pathways; let's look at vulnerabilities; let's look at supply chains; let's make sure that no pest sneaks up on us.'
- The Midfield, DAWE, can manage pathway risks via regulation; not managing consignment risk, because that is impossible. They can be managing pathway risks and verifying such management by selective intervention at the border, because if you try to inspect everything you would simply bring the ports to complete stillness.
- The Defence, this is the states and territories, can study the imminent arrivals. We know that lumpy skin disease is in the region; we know that African horse sickness is in the region – in fact my team recently did a bit of work for the Commonwealth Veterinary Office, and we estimated that the probability that at least one significant animal pathogen threat will arrive in the next five years is about 40%. We have named them, and we can prepare for them, but we need to think about them.
- The Goalies – that is us – we can harden what we control, and we can watch what we can't control. And that is a two-way street. The stories that I have heard of the response of certain regulators to certain pathogens in certain areas in the north have been quite harrowing, and what farmers have gone on record saying I would not disclose again. And that is heartbreaking. It is also incredibly dangerous, because if that is the mindset that we are dealing with, then there's going to be goals scored against us every day. We need to watch out for that.

Biosecurity is all of us!

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Andrew Robinson is Managing Director of the Centre of Excellence for Biosecurity Risk Analysis (CEBRA) and Professor in applied statistics at The University of Melbourne. He has a PhD in Forestry and a Masters in Statistics from the University of Minnesota, and has published four books, 90 research articles, and 50 ACERA/CEBRA technical reports on various aspects of risk analysis and biosecurity. He is an elected member of the International Statistical Institute. He joined The University of Melbourne in 2005 from the University of Idaho, where he was associate professor in forest inventory and forest biometrics. Andrew spends much of his time thinking about biosecurity at national borders, including analysing inspection and interception data using statistical tools, designing and trialling inspection surveillance systems, developing metrics by which regulatory inspectorates can assess their performance, and discussing all of the above with interested parties.

The race to save banana

Irene Kernot

Horticulture, ACIAR

ABSTRACT

Fusarium wilt of banana caused by the soil borne fungus *Fusarium oxysporum* f. sp. *cubense* was first recorded in Australia in 1874, but its spread to Panama in 1890 was the start of the first global epidemic. The disease affected a susceptible variety dominant at the time, Gros Michel. By the 1950s Gros Michel was replaced by a variety resistant to the disease: the Cavendish banana. A silver bullet solution was rapidly adopted around the world. Then in 1967 symptoms of Fusarium wilt appeared on Cavendish in Taiwan. Tropical Race 4, the race that affects Cavendish in any environment, was named in the 1990s. In 2019 it appeared in Colombia, establishing it in every banana-growing region globally. This is a race the disease is winning in turtle-like fashion. Despite this, banana remains an important export and also provides nutrition and livelihood benefits to growers and communities around the tropics. What can we learn from our biosecurity responses to races 1 and 4 to provide a competitive advantage against any future race? Both technical and behavioural strategies are necessary, to be prepared for inevitable change. Solutions must offer hope to growers and smallholders that production can be maintained despite the presence of the disease as the return to business as usual becomes a distant dream.

I am going to tell you a story about when I first encountered Fusarium Tropical Race 4 in Queensland, March 2015. And I am going to tell you a few of the things that I learnt about it on the way. I was working with Queensland Department of Agriculture and Fisheries at that time.

Even though we had prepared and we had worked with ACIAR to research the disease and get to know it in our neighbour countries where it was endemic, the reality of the incursion completely changed the game. Despite the preparation, somehow the simple questions posed by farmers did not have clear or practical solutions: What do I actually have to do to keep my farm clean, and keep growing bananas? I have got the disease on part of my farm; I have always been a banana grower; how do I keep growing bananas?

It was finding practical answers to these questions that began the race to save Cavendish bananas in Far North Queensland.

It is very important to notice that this race is against a very slow-moving opponent that can be stopped ('unless man or flood intervenes Fusarium moves at a tortoise pace', said RH Stover in 1970). As noted by Stover, the main carrier of the disease is humans. The solutions had to address both human and pathogen behaviour – and this is really the key message that I want to share

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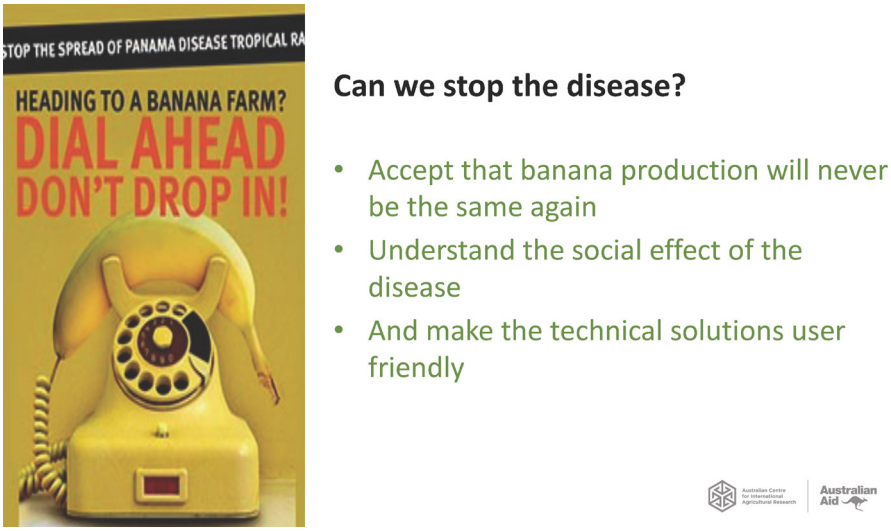

Figure 1. Do not 'drop in' on a banana farmer in Far North Queensland!

about my Fusarium story: the race needs to be run with research looking at the system from a biological, a social, an economic, *and* a policy perspective.

First reactions

Right from the start, the research and regulatory teams worked together with farmers to design the biosecurity barriers, the washdown facilities, and the rules that are the now-universal welcome to commercial banana farming businesses. Researchers fact-checked the many cures proposed (we were overwhelmed by cures!). Researchers also identified effective disinfectants, as well as looking at farm design to manage farm access, ensuring only clean equipment and gumboots could enter and leave farms, and that people could easily comply with the systems proposed.

The banana industry also acknowledged, very early on, that being a banana farmer would never be the same, and that a major part of the solution would involve supporting human behaviour in the response. Queensland campaigns, such as the one shown in Figure 1, were very important: asking everyone not to drop in on a farmer.

The social changes that biosecurity compliance imposed on North Queensland are easy to say but hard to implement. The social impact of not visiting your neighbour, and of having to wash your vehicle every single time you move on or off your farm – it is real! It is like social distancing, but it is forever.

It was critical that research – to control the disease and provide solutions – was multi-disciplinary, bringing social scientists and technical scientists together, supported by the regulators when necessary. The technical solutions were still very important, and the technical solutions are really part of maintaining hope in the system.

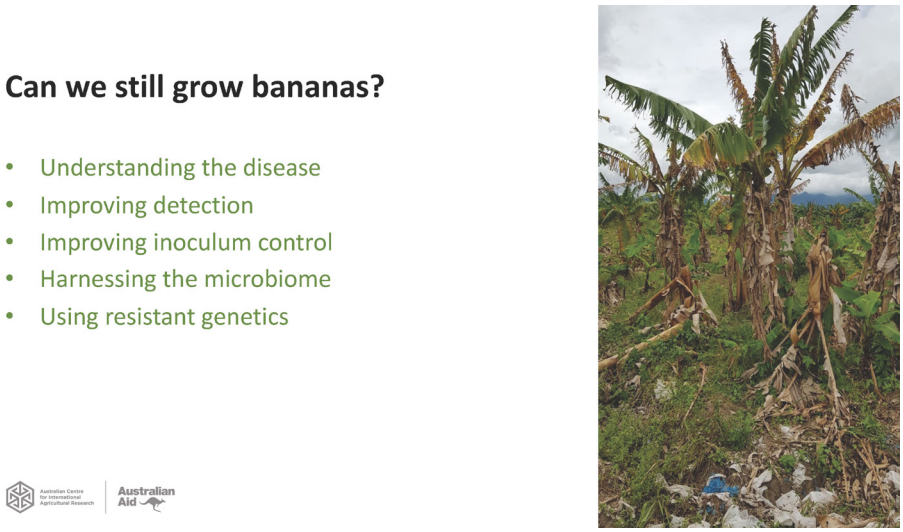

Figure 2.

Technical approaches researched

It is important to maintain hope in a banana-growing future, and so the investment in technical research was ramped up very quickly. It covered many of the research gaps. The improved research improved technical and system efficiencies (Figure 2).

Researched topics included better detection, and the potential for remote and proximal sensing, and managing inoculum build up, including by destroying banana plants using urea rather than by the burning that had previously been practised. Also:

- characterising the banana microbiome, which is one of the really exciting areas of research ACIAR is investing in now;
- understanding how our production system is favouring the pathogen, and rebalancing that system to allow bananas to keep growing through adjustments to management; and
- research to discover and understand and test resistance.

The third of these is where the industry probably had its hopes pinned – that is, on testing resistant varieties that would be able to replace Cavendish, and checking options such as local somaclone selections of Gold Finger. However, although Gold Finger is a banana that we have in Australia and is resistant to Tropical Race 4, it is not able to be marketed successfully. Therefore it has not even been considered as a potential solution.

Can we save banana?

Do you think we can save banana (Figure 3)? I refuse to believe that we will be in a world without bananas. Science is very much the key to that solution, and the research collaboration globally over this time of pandemic has been exciting. Our ACIAR microbiome project is now working with people in the Philippines,

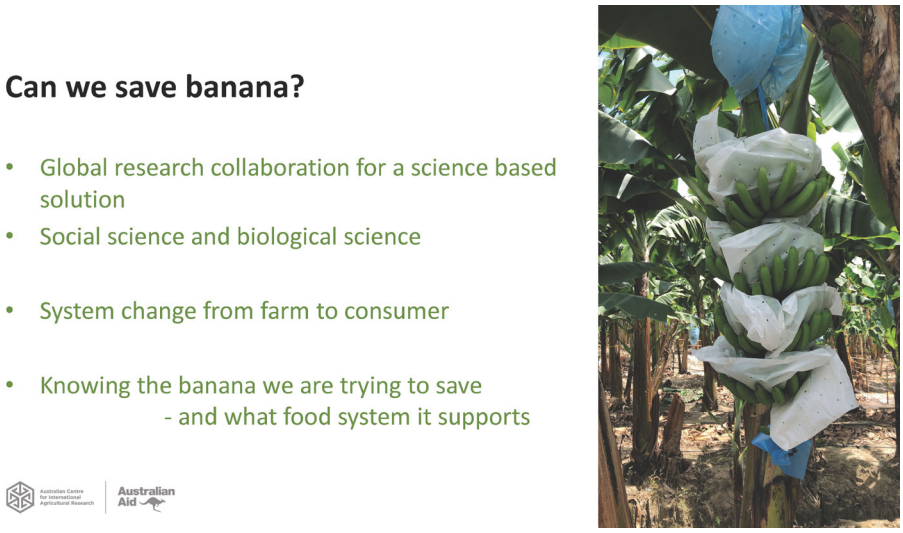

Figure 3.

Laos and Indonesia and Australia, and Malaysia is joining, and we are talking to researchers in China. We are working together. The research must continue to be multi-disciplinary, focusing on biological, social, economic and policy aspects, and it must consider the banana system from the farm through to the consumer, because this is ultimately a food system challenge.

I want to leave you with a last thought: the business that banana supports is worth over US$12 billion in exports per year. It is big, and it is still growing significantly. Banana producers from developing countries are feeding the global north with a cheap, nutritious and universally loved product. Yet that trade, however big, represents much less than a third of total banana production.

We need to put this race to save Cavendish into perspective. Saving banana is not just about saving Cavendish and its role in our food system; it is about keeping bananas on the menu for everyone, and developing tomorrow's system for growing bananas.

Irene Kernot manages the Horticulture research portfolio at ACIAR. Before joining ACIAR, Irene worked in northern Australia as an agronomist in the Northern Territory and in Queensland as an extension horticulturist in tropical fruit systems. In Queensland Irene managed a Tropical Fruit research group that included Market Access and Banana researchers. This gave Irene a solid grounding in the importance of biosecurity and the importance of good science in incursion response and management. In that time the research team supported responses to Panama TR4, black sigatoka and oriental fruit fly as well as to non-biotic damage from cyclones Larry and Yasi.

The battle against fall armyworm

Chris Dale

Agriculture and Food Security Section,
Department of Foreign Affairs and Trade (DFAT)

ABSTRACT

Biosecurity is a shared responsibility. The coordination of biosecurity efforts at a national level has its challenges. The coordination of biosecurity efforts at a global and regional level across geographical, political, and institutional boundaries presents an even greater challenge. This presentation provides an overview of recent collaborative efforts of international organisations, regional plant protection bodies, and technical specialists to coordinate biosecurity initiatives to help countries prevent, prepare for, and respond to biosecurity threats across the Asia Pacific region. Biosecurity pest threats such as the fall armyworm (*Spodoptera frugiperda*) have caused devastating impact upon agricultural sectors at a global level in recent years, and are threatening the biosecurity status of our near neighbour and Pacific island countries as they move via natural and trade pathways through the region. Agricultural production and food trade need to continue for economic and food security reasons but require coordination and collaboration at global, regional and national levels to support local biosecurity systems. Global and regional level biosecurity programs such as the FAO Global Action for Fall Armyworm Control, the ASEAN Action Plan on Fall Armyworm Control, and the DFAT–DAWE Pacific Biosecurity Partnership Program are coordinating the mobilisation of technical, operational, academic, research and communication expertise and resources in a collaborative effort to battle the spread and impact of the fall armyworm across the region. These initiatives are not only providing technical and operational support to biosecurity agencies through the development of regionally and globally consistent fall armyworm resources, but also they are supporting livelihoods at village, grower and commercial levels through implementation of globally harmonised preparedness, response and management initiatives.

This talk is about fall armyworm, which is a shared biosecurity responsibility and a shared opportunity. Biosecurity is a shared responsibility, and the coordination of biosecurity efforts at a national level has its challenges, as I am sure everyone in this room would appreciate. The coordination of biosecurity efforts at regional and global levels across geographical, political, and institutional boundaries presents an even greater challenge. This has been highlighted over recent years with the rapid spread of transboundary pests such as the fall armyworm, and the coordination of prevention, preparedness and response initiatives.

I want to stress the fact that we talk a lot about prevention in relation to biosecurity, but it is very important that we look at preparedness and response as part of that, because a lot of our regional and international stakeholders

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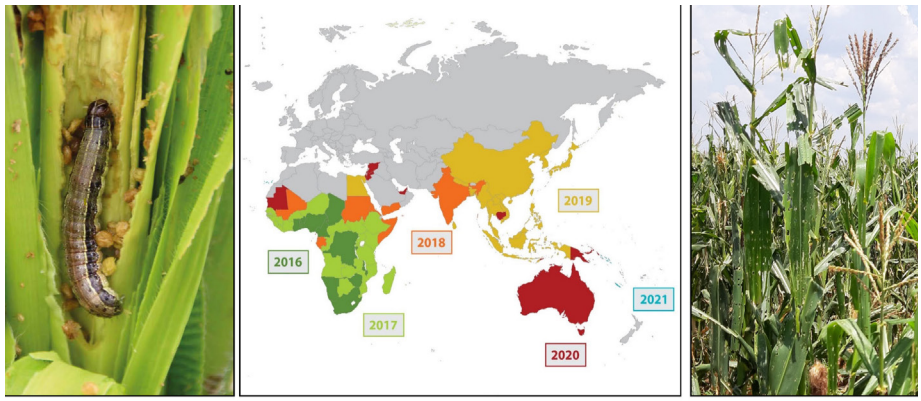


Figure 1. The spread of fall armyworm (*Spodoptera frugiperda*) around the globe.

have the legislative authority and responsibility for preparedness and response initiatives and, ultimately, management initiatives in their countries as well.

The fall armyworm has become a global biosecurity issue, as highlighted already in several of today's presentations. It has been officially reported in 73 countries – most recently in the Solomon Islands and New Caledonia – and it is predicted to continue its spread throughout the Pacific over the coming years, if not months, if it continues its rapid spread. Fall armyworm has also attracted significant attention at national level and international levels across government, industry, and even mainstream media. There is even reference to it being the 'coronavirus of agriculture' (Figure 2).

In Australia, near-Australia and Oceania

At national level in Australia we have a coordinated and collaborative biosecurity system to support our prevention, preparedness, response and management arrangements. Our international biosecurity arrangements have prevented fall

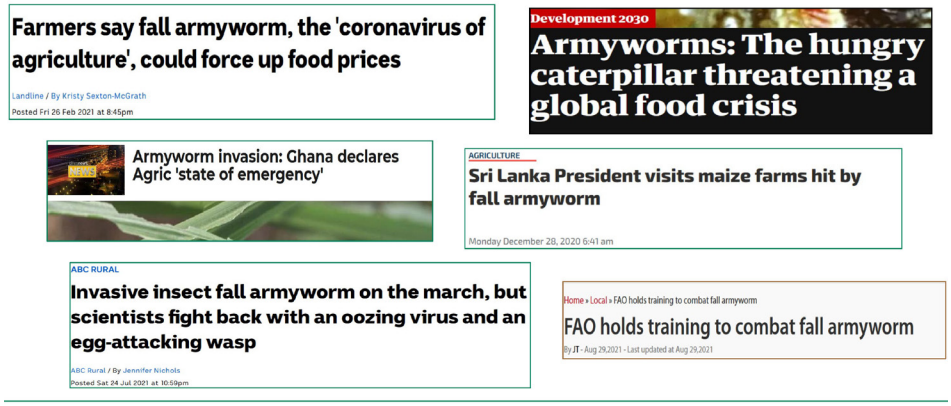


Figure 2. Some headlines about fall armyworm – a global priority pest.

Figure 3. National coordination: FAW prevention, preparedness, response and management involves CABI, DAWE and GRDC and others. See also the GRDC's fall armyworm web portal at https://grdc.com.au/resources-and-publications/resources/fall-armyworm which gives access to a series of podcasts on FAW at https://www.pbri.com.au/pbri-podcasts

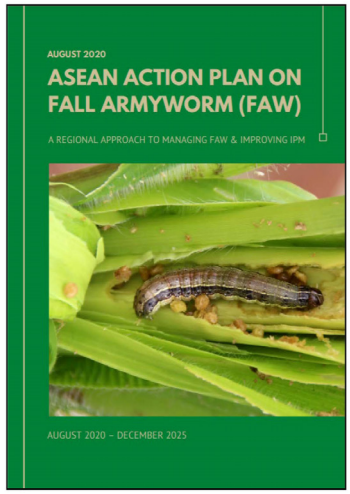
armyworm (FAW) for a number of years through strict border controls of our trade pathways. However, despite our best efforts, our systems were not able to prevent the natural movement of fall armyworm through our risk pathways in northern Australia and ultimately the Torres Strait.

Our collaboration across government, industry and research partners enhanced our preparedness through forecasting, through modelling and response planning, well in advance of fall armyworm being detected in the Torres Strait in early 2020. In fact, they were conducting early warning surveillance and trapping in Timor-Leste well over a year before fall armyworm was actually detected in Australia.

There is national coordination across jurisdictions, industry and research partners and Research & Development Corporations, particularly the Grains Research & Development Corporation (GRDC), and that coordination is now supporting the ongoing fall armyworm management across Australia (Figure 3).

At regional level, particularly in our near neighbours Timor-Leste, Papua New Guinea (PNG) and the Solomon Islands, the concept of the shared responsibility to biosecurity is still evolving. While Australia actively supports our biosecurity counterparts in our near neighbours, there need to be broader multilateral efforts to complement and support those bilateral efforts.

There are regional-level biosecurity programs (Figure 4), such as the ASEAN Action Plan on Fall Armyworm Control, and a Pacific biosecurity partnership program led by the Dept of Agriculture, Water and the Environment (DAWE) and by DFAT; they are coordinating the implementation of technical and operational and academic related activities in a collaborative effort to minimise impacts of fall armyworm across the region. However, more can be done.



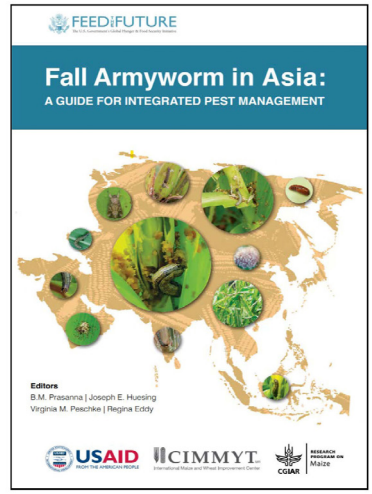


Figure 4. Regional coordination: e.g. the ASEAN Action Plan on Fall Armyworm Control, and PPPO [Pacific Plant Protection Organisation] FAW preparedness.

We have had opportunities through the Department of Agriculture animal and plant biosecurity leads for the Pacific, and we have Sophie Peterson here as the Plant Biosecurity lead for our region, in coordination with our Chief Plant Protection Officer and Chief Veterinary Officer; they are driving a lot of the work throughout our region. It is also important that we actively engage with our Asia and Pacific regional plant protection agencies to coordinate and mobilise these efforts as the regional plant protection bodies.

Global level

At a global level, as we have seen in the maps presented already today, fall armyworm (FAW) is a significant and recognised pest. It has also been recognised by the FAO as a global biosecurity threat, as shown by the establishment of the FAO Global Action for Fall Armyworm Control, which has the direct oversight of the FAO Director-General. That is quite rare for a specific pest risk, particularly in the plant biosecurity and plant protection world. There is also a fall armyworm-specific program within the FAO to address this very important global issue, and that is a significant four-year program (Figure 5).

Australia contributes to these efforts through representation on the FAW technical committees and leadership in the FAW biosecurity Technical Working Group that is one of the seven Technical Working Groups that support the

Figure 5. Global coordination: FAO Global Action for FAW Control 2020–2022. https://www.fao.org/fall-armyworm/global-action/en/

global action. The biosecurity Technical Working Group that I lead within the FAO draws on technical expertise from national plant protection organisations – that is, Australia and Italy and regional plant protection organisations – to provide that global representation. We have representation from CABI, from CSIRO, particularly from a very scientific and technical perspective. Collectively we develop resources, we deliver workshops, we deliver capacity development and capability development initiatives to support the national plant protection officers and the leads in those plant biosecurity agencies. This is not only in the countries where fall armyworm is established, but primarily in the countries still free of fall armyworm, in an effort to try and enhance the preparedness and response capability of those countries that may not have the resources or the technical expertise that we do.

In addition to fall armyworm, Australia is also contributing to regional and international efforts for other global biosecurity pests such as the banana disease TR4 (see Kernot, this conference), and broader biosecurity issues – particularly biosecurity issues relating to climate change which have impacts on plant health. It is very encouraging that effects of climate change have been brought into much of the discussions today.

Biosecurity is a shared responsibility at a national level, and Australia has seen that for a long time. However, biosecurity should also be a shared responsibility at regional and global levels.

Biosecurity is a shared opportunity

Despite the devastation that fall armyworm has caused and will continue to cause as it moves throughout the Pacific region over the coming years, it has provided an opportunity to highlight the global impact of transboundary pests on both developed and developing countries.

Fall armyworm is providing an opportunity and platform to share our learning, our research, our experiences and – as Rob Kaan highlighted in his Private Sector Keynote this morning – it continues to provide an opportunity for Australia and our collective stakeholders to lead by example, both at regional and at international levels.

Biosecurity is a shared responsibility, but we should also see it as a shared opportunity.

Chris Dale is the International Biosecurity Specialist, Agriculture and Food Security Section, Department of Foreign Affairs and Trade, and formerly Assistant Director of Plant Health Surveillance and Diagnostics within the Australian Department of Agriculture, Water, and the Environment (DAWE). Chris has over 20 years of technical and operational experience within the Department, delivering animal and plant biosecurity programs across northern Australia, the Torres Strait, Timor-Leste, PNG, Solomon Islands and South East Asia. Chris is also the Vice Chair of the Implementation and Capacity Development Committee of the International Plant Protection Convention (IPPC) and represents the committee and Australia within the Asia Pacific Plant Protection Commission (APPPC) and the Pacific Plant Protection Organisation (PPPO). Chris is also a member of the FAO Fall Armyworm Technical Committee, Chair of the FAO/IPPC Fall Armyworm Technical Working Group, and technical lead of the DFAT/DAWE International Agricultural Biosecurity Technical Working Group (IAB-TWG), supporting biosecurity preparedness and response initiatives across the Asia Pacific Region.

African swine fever – beyond the numbers

Tarni Cooper
School of Veterinary Science, and Centre for Communication & Social Change, The University of Queensland

ABSTRACT

African swine fever (ASF) is a highly fatal disease of pigs, with no effective treatment or vaccine. Since it emerged in China in 2018 the disease has killed millions of pigs across 13 countries in the Asia Pacific Region where the overwhelming majority of pig-keepers are smallholders. The impact in numbers, such as financial cost to the industry and national protein deficits, is staggering, and the lesser-reported human impacts are profound. This presentation gives an overview of pilot applications of the Socioeconomic and Livelihood Impact Assessment (SELIA) framework to ASF in the Philippines and Timor-Leste. In Timor-Leste, university and government researchers applied spatial group model building techniques to yield insights into the dynamics of ASF impact. With a range of stakeholders, the group prioritised problems associated with ASF and then developed causal-loop diagrams to identify important relationships and identify potential leverage points for intervention. Important features included building trust between farmers and the government veterinary services, strengthening veterinary services, and providing cash grants to farmers conditional on biosecurity investments. In the Philippines, university and government researchers applied a suite of participatory tools with farmers and associated value chain actors to develop a rich understanding of the impact of ASF along value chains. While overwhelmingly negative, the livelihood impacts of ASF were not equal among value chain actors, thus suggesting the need for tailored support. Another important finding for further consideration was around the need for sensitive and safe pig-depopulation practices to reduce the distress of affected farming communities and veterinary staff.

African swine fever (ASF) is a highly contagious viral disease killing up to 100% of pigs in herds and across communities. It is spread by a variety of means – wild and domestic pigs, pork and pork products, and on inanimate objects (fomites) – which means it can spread across the globe very quickly. There is no effective vaccine or treatment. The disease was first described in Africa in the early 1900s. It moved to Europe in the 1950s and has remained there. In 2018 it emerged in China, and since then has spread to 15 countries in Asia and the Pacific, including our very near neighbours Timor-Leste and Papua New Guinea (OIE 2021). In 2019 alone ASF was responsible for a drop of 12% in the global pig herd, partly because 55% of pigs are in China alone – or were before ASF hit. That equated to 11 million tonnes of pork production lost, causing a protein deficit and a mass shift to other livestock protein products (Bruce *et al*. 2021).

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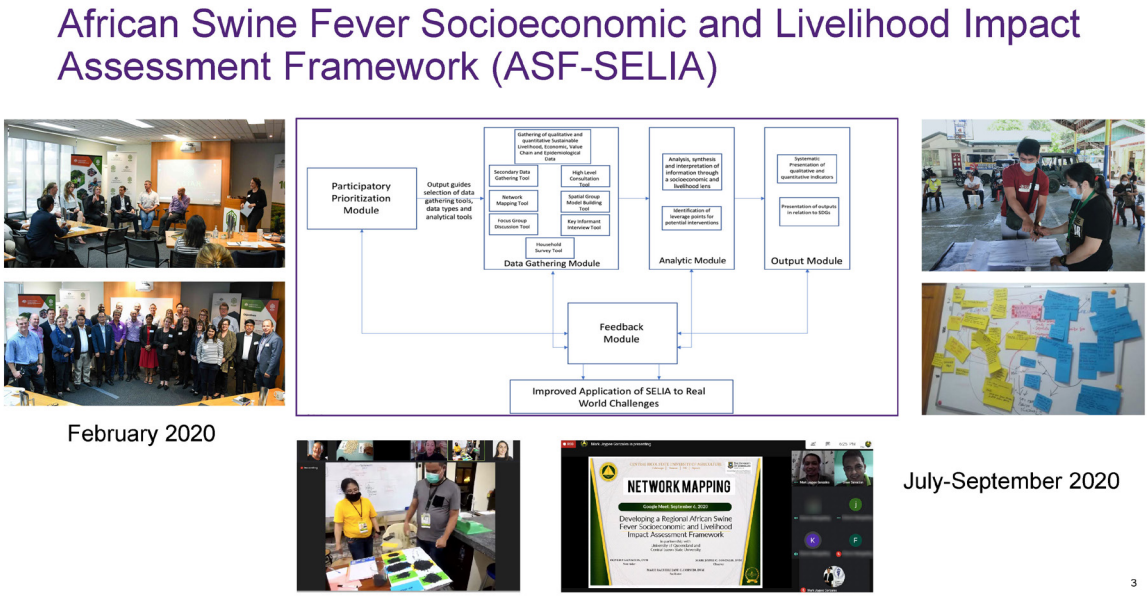

Figure 1. ACIAR project to develop a framework to look beyond numbers of pigs deaths from ASF.

Even though the title of my presentation says 'beyond the numbers', it is clear the numbers in ASF are very large. It is a very significant disease in a growing number of countries. Our research, led by Dr Dominic Smith and funded by ACIAR, involved developing a Socioeconomic and Livelihood Impact Assessment (SELIA) framework to look beyond those numbers; to look at the broader impacts of ASF and other livestock diseases (Smith & Cooper 2021).

The project started in 2020, and we were able to have one meeting in Canberra with many people from different organisations who formed a Community of Practice to help brainstorm and workshop the SELIA framework (Figure 1), but very quickly we had to move our collaborative efforts online and become adaptive to the local situation in the field.

Pilot studies: Timor-Leste

This morning Stacey Lynch touched on how important pigs are in Timor-Leste. They are important for ceremonies, for religious practices, for funerals, for selling to pay for education and health care (Figure 2). This drives the value of live pigs up very high. Seventy per cent of households in Timor-Leste kept pigs in the last published census, which was before ASF hit – or US$160 million-worth of pigs in Timor-Leste, and US$1000-worth per pig-keeping household. This is a huge amount in a country where more than 70% of people live on less than US$3.20 a day (Smith *et al*. 2019). We worked with the International Livestock Research Institute (ILRI) to partner with people involved in the value chain to explore what would be likely to occur when ASF hit communities, and then to look for leverage points for intervention (Berends *et al*. 2021).

Impact of ASF in Timor-Leste

- The ceremonial and cultural importance of pigs in Timor-Leste cannot be overstated
- Value of national pig herd was more than USD 160 million
- ASF is estimated to have killed 150,000 head of pigs to date
- Spatial Group Model Building with value chain actors revealed complex impact pathways
- Potential leverage points identified:
  i. Build trust between small-scale pig farmers and veterinarian technicians
  ii. Strengthen services available from the Ministry (MAF)
  iii. Provide start-up loans/cash grants to small-scale pig farmers conditional on application of farm biosecurity practices

Community members load their pig, worth about USD 600 and roofing materials onto a truck, both to be used in their clan's Uma Lulik (Sacred House) ceremony.

Figure 2.

Three high-potential leverage points were identified. One of those was the dynamic of trust that veterinary and livestock technicians had with pig owners. It was seen that if the livestock workers could improve their engagement with farmers – which partly depended on resourcing by the Ministry of Agriculture and Fisheries – then trust would increase through that relationship building. That would lead to an increase in reporting of animal health issues and of cases of ASF, which would mean that action could be taken – so long as it was resourced – thus increasing the trust even more as mortality decreased and pigs were protected.

Just this weekend, Dr Joanita Bendita da Costa Jong, the Director of the Veterinary Directorate in Timor-Leste, told me that the Market Development Facility (MDF) from Australia has been supporting a lot of farmer engagement campaigns in Timor-Leste, and they are seeing a real increase in that trusting relationship around biosecurity and African swine fever.

Dr Tamsin Barnes from The University of Queensland has also completed a study on basic biosecurity interventions that could be implemented on smallholder farms to potentially decrease the incidence of ASF (Barnes *et al*. 2020).

Another leverage point was identified in relation to resource-poor farmers buying new pigs. The poorest farmers were unable to restock with pigs once ASF went through because the ceremonial demand for pigs remained high when supply was low, so the price of live pigs 'had gone through the roof'. Dr Joanita said that the restocking campaign (which Professor Robyn Alders asked Dr Stacey Lynch about in this morning's Q&A for Session 2) is going very well. They are breeding pigs in areas free of ASF to pass on at no cost to smallholder farmers, the poorest farmers, after they have enhanced their biosecurity practices and undergone training.

Impact of ASF in the Philippines

https://www.abc.net.au/news/2020-11-12/typhoon-vamco-hits-typhoon-ravaged-north-east-philippines/12878932

- Financial losses to the sector have been enormous – but not equal
- Impacts of livestock disease are superimposed over a complex vulnerability context
- The psychosocial impacts of ASF depopulation campaigns were immense

- Two proposed areas of intervention for further study:

1. Tailored support to align with degree and direction of ASF impact
2. Improved communication and a One Welfare approach to ASF control

5

Figure 3.

This will be a revolving system: once the farmers get back on their feet, they will give pigs back into that restocking system. So far there have just been some treatable skin diseases reported. The Government of Victoria has been giving support for any veterinary concerns that they have. This system is looking promising.

Pilot studies: the Philippines

The Philippines is a very different context (Figure 3). There are larger farms there. The financial losses to the sector have been enormous, but not equal. The larger farms have had more of a buffer, allowing them to rebound. They have also been better at biosecurity and able to be flexible and reduce the incidence of ASF. Communities have differed in vulnerability context, with some communities we spoke to having had typhoons, superimposed over the top of ASF, putting them under great strain. And having COVID-19 and ASF at the same time has also put these farmers under pressure. This has been described as a 'double punch' (Neubauer 2020).

Professor Pingali earlier today said that during the COVID-19 pandemic the problem is not so much a lack of food across the globe; it is access. This is where we need to support smallholders, because even though larger farms are rebounding – and China's pork production is increasing hugely – there are millions of smallholders that have gone out of business because of ASF. It is a very complex situation.

As a research team, we were taken aback by the immensity of the psychosocial impacts of ASF in the Philippines. Echoing the findings of ethnographers in the UK in relation to foot-and-mouth disease (Mort *et al*. 2008), farmers in the Philippines are used to seeing their properties as places of life and of breeding; they build relationships with their livestock. Some farmers were describing their

pigs as 'family'. Their forefathers had built up the genetics in their breeding stock over generations, and they had been passed down by family members. Now they were seeing these pigs slaughtered in huge numbers. They were hearing gunshots. Their accounts were very harrowing descriptions of what they went through.

The veterinary and animal health staff that we spoke to were feeling traumatised too, because they were having to conduct mass depopulation campaigns to control ASF in communities – sometimes in their own communities. We also spoke to people who had been ostracised, and whose personal security had been threatened at times.

In this case we proposed two areas of further research (intervention was not possible within this small pilot trial). One area is to tailor support according to need; that is, recognising that ASF does not affect all groups equally. The other area is to improve communication and consider a 'One Welfare' approach to depopulation campaigns. In this, the welfare of humans involved is considered alongside the welfare of pigs and humane practices (Cooper *et al*. 2022).

An encouraging initiative that I have seen is that the UN Food and Agriculture Organization (FAO) under Dr Mary-Louise Penrith has started online training for veterinary staff to learn how to use context-appropriate control measures for ASF. Mass depopulation campaigns do not always work, and sometimes they do more harm than good.

The next step for this work is that the Socioeconomic and Livelihood Impact Assessment Framework (SELIA) that we developed during the project is going to be applied via Dr Dominic Smith and myself and the Griffith Asia Institute as part of the Bill & Melinda Gates-funded Global Burden of Animal Disease (GBAD) program, in a sub-project led by Dr Dianne Mayberry at CSIRO.

Some publications are listed below. I wish I had time to acknowledge all the people who collaborated with us. The people I most want to thank are the field staff who, despite the challenges posed by COVID, managed to contribute so much to this research.

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Tarni Cooper is a veterinarian experienced in One Health and social research with smallholder livestock farmers in South East Asia and East Africa. Tarni has collaborated on a range of ACIAR-funded research for development initiatives including 'Developing a Regional ASF Socioeconomic and Livelihood Impact Assessment Framework'. She is currently contributing to the FAO-led Global Pool of Expertise on ASF. In 2013–14 Tarni was an Australian Youth Ambassador for Development (now AVP) in Kenya, and in 2016 she was a Crawford Fund in Queensland Postgraduate Awardee. Tarni is completing her PhD at The University of Queensland with the International Livestock Research Institute in Vietnam. Tarni is a Queensland representative of the RAID network and a volunteer with the Kyeema Foundation.

Q&A

Chair: Dr Robyn Cleland, Dept of Agriculture, Water and the Environment (DAWE)

Panel: Professor Andrew Robinson; Irene Kernot; Chris Dale; Tarni Cooper

Q: John Fazakerley, The University of Melbourne

I enjoyed those presentations. Thank you. I am thinking about [*Game of Thrones*] 'The Night's Watch' and 'The Wall' and all the pathogens coming across from the north. It is all very well keeping them out, but when they get here, how well is Australia prepared? For example, we have fewer high containment laboratories than in most other countries. We have fewer facilities to deal with actually characterising these pathogens. That is a very different issue, and one that we haven't actually touched upon, and I do wonder how well Australia is prepared for that?

A: Andrew Robinson

Exactly right, thank you, that is exactly right. A broader point, that I wanted to encourage us towards, is that thinking about the biosecurity system as a wall, or as AQIS at the border, is a disempowering model, and that we collectively need to take responsibility for the end-to-end activities. That includes appropriately resourcing science onshore, and ensuring that we have the best possible chance to defeat pathogens when they arrive. Thank you. I firmly agree.

Chair: Chris, do you want to contribute?

A: Chris Dale

Thank you for the question. Although I no longer work within the Department of Agriculture, Water and the Environment, I can speak to the work that has happened in the plant biosecurity space over a number of years. We do have a list of national priority pests, and for those pests a whole suite of prevention, preparedness, response initiatives, including surveillance diagnostics response. There's a unit within the Plant Biosecurity or Plant Health Policy Branch specifically designated for plant health and plant biosecurity preparedness. So there is that capability. It is an evolving process, obviously, as new and emerging plant pests are found, and being able to keep up with the surveillance and the diagnostics protocols.

From a departmental perspective, in relation to containment and the necessary infrastructure, that is a multi-jurisdictional responsibility as well. However, to echo Andrew's point, it is a shared responsibility in terms of that preparedness, and we draw on not only the government and the NPPO, National Plant Protection Organisations, but also institutions, scientific research, the Research & Development Corporations, to support a lot of that.

This record has been prepared from a transcript.

Chair: Tarni [on video link], would you like to comment from an animal perspective? The question was: given the incursion of all of these biosecurity issues, does Australia have enough capacity, particularly for dealing with high-risk pathogens such as avian influenza, African swine fever, or indeed foot-and-mouth disease?

A: Tarni Cooper

There has been massive ramping up. The issue with ASF is that probably our highest risk exposure route is through pork products. There were some alarming statistics at the beginning of the ASF outbreak in China where huge numbers, many kilos, I can't remember the exact numbers, of products coming into our airports for receipt by the general public had to be destroyed. Sniffer dogs were trained. I was very surprised at the time that sniffer dogs were not always deployed in Darwin Airport. I like to think that dogs are there more, now, because we also have a lot of movement and trade going on through the islands in the north as well.

ASF is very resistant to heat and a range of treatments, so it can easily be brought in: some salami that someone sent from overseas, for example. It probably got into Timor-Leste because of people swill feeding – that is, feeding their pigs on pork that was contaminated with this virus. I am not a member of the Government, so I can't say whether we have the capacity, but we have certainly done very well so far. We haven't had any incursion. So 'hats off' to the hard work of the Government.

Chair: Those of you in this room can see I have a biosecurity detector dog [soft toy] sitting up here on the table to remind us of their important work. I am not sure that we have dogs in Darwin at the moment. They are a limited resource that we try and deploy to the most needy area, and I think at the moment they are looking after brown marmorated stink bug.

Q: Phoebe Readford, Australian Centre for Disease Preparedness

This is for you, Tarni, and in relation to the question that Robyn asked Stacey earlier today. You mentioned that Timor-Leste is getting ready to restock some of the areas that have been affected by African swine fever, and we know how difficult it is to get rid of ASF, and how long it lasts in the environment. As a social scientist rather than a veterinarian, what are your thoughts on the risks and dangers of restocking those areas, particularly in terms of the impact on those smallholder farmers experiencing ASF yet again, and also in terms of the impact that then has on the trust that that government has spent a lot of time building up; and knowing that we don't have a vaccine for ASF at the moment? Are we prepared for that, or are we assisting the Timorese Government in being prepared for that?

A: Tarni Cooper

It is a great question, and I think you essentially answered it yourself. The concern definitely will be that these households don't have strong enough defences against ASF. We talk about, you know, the poorest farmers receiving these pigs, but in reality that there is no developed commercial sector in Timor-Leste. It is very different context to the Philippines. Pigs just don't have a safety

'bubble' around them; a lot of them are free-roaming still. I haven't heard yet via Dr Joanita about how they are hoping to overcome some of those challenges. I definitely agree that there's a real risk that any trust built will be dismantled, or the good work that has occurred through these extension activities will be undermined.

Also, there's the risk of the surrounding pigs being impacted as well, with ripple effects through the community. Dr Joanita said the pigs are coming from safe areas to safe areas, so there's a need to make sure, using tests such as these LAMP tests discussed earlier in this conference. We are trying to form a safe ring from an epidemiological perspective – a safe area where there are also movement controls.

But the challenges are enormous, so it will be very important to keep alert and keep talking to communities through the process.

Chair: Thank you to everyone.

Unpacking the nexus in a changing world – the relationship between biosecurity, trade, health and environment

Nicola Hinder PSM

Exports and Veterinary Services,
Department of Agriculture, Water and the Environment (DAWE)

ABSTRACT

International trade in agricultural and food commodities is essential to global food and nutrition security. Trade is enhanced by systems-based and science-based approaches to regulation that address risks to animal and plant biosecurity, zoonotic disease, food safety and nutrition. The World Trade Organization Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) recognises the 'three sisters' – the Codex Alimentarius Commission (Codex), the World Organisation for Animal Health (OIE), and the International Plant Protection Convention (IPPC) – as the international standard-setting bodies squarely at the centre of this nexus between biosecurity, health and trade. The standards set by these bodies are integral to maintaining a transparent rules-based trading environment and reducing risk for those operating in the increasingly connected global value chain. I will explore how the work of the three sisters intersect to influence food import and export systems, continuing to adapt in a changing world, and I will discuss Australia's crucial role in promoting science-based standards and guidance that facilitate trade in safe food, with a focus on the important role Australia plays in contributing to the work of Codex.

This talk is about our international standard-setting, our day-to-day engagement, our technical market access, our biosecurity, human health, the environment – and how all these roles interact, and how all that facilitates trade.

My normal day-job is the Head of the Exports and Veterinary Services Division at the Department of Agriculture, Water and the Environment, but at the moment I have immense pleasure to be Acting as the Deputy Secretary responsible for the Agricultural Trade Group. These are both extraordinary roles, and I am absolutely committed to them.

The teams I work with are responsible for the regulation of exporting industries, as well as trade negotiations, technical market access, multilateral engagement, and tackling non-tariff barriers including through the World Trade Organization; also, international standard-setting and export reforms that drive digital products and services to deliver benefits to exporters and the broader Australian community. My roles fit right in the centre of the nexus of animal and plant health, biosecurity, trade, human health and the environment.

This record has been prepared from a transcript and the slides of the presentation.

Today I will outline Australia's important role in promoting systems and science-based approaches to regulation: they address risk in animal and plant biosecurity, zoonotic disease, food safety, nutrition, all of which underpin biosecurity and underpin trade.

My focus is specifically on the work of Codex, the Codex Alimentarius Commission. This work is absolutely critical in promoting the development and adoption of international food safety standards that facilitate the fair and free trade in safe food. Our work in Codex touches every single one of us around the world. Everyone eats; everyone consumes; everyone is affected; and yet that particular side of our work often appears to be quite dry and a little bit bureaucratic, so today I want to put some light and colour behind it all.

Three standard-setting bodies

I will quickly introduce the standard-setting bodies (Figure 1), which we refer to as the 'three sisters' because that shows how interconnected they are:

- the World Organisation for Animal Health (OIE),
- the International Plant Protection Convention (IPPC), and
- Codex.

Together the three sisters are responsible for setting standards, guidelines, and recommendations that cover, respectively, animal health, plant health, and food safety. These organisations have been around for a very long time: since 1924 for the OIE, 1952 for IPPC, and 1963 for Codex. It was in 1995 with the establishment of the WTO, the World Trade Organization, that they were enshrined in the Agreement on the Application of Sanitary and Phytosanitary Measures, the SPS Agreement (Figure 1). They are referenced in that agreement as the organisations responsible for developing standards to which countries are encouraged to comply to harmonise their national measures. Anything that

The Agreement on the Application of Sanitary and Phytosanitary Measures (the SPS Agreement) enshrines the three sisters as the organisations responsible for developing standards to which countries are encouraged to harmonise their national measures

Figure 1. The 'three sisters' and the SPS Agreement.

is more stringent than those national measures requires scientific justification. That is very important.

It is the position of the three sisters in our most central trade framework that makes our involvement in the standard-setting process so very important. Further, certification of all food must address animal and plant health, as well as food safety. The standards that are developed by these bodies are tied together, and they work together to design our food import and our export systems.

Australia has a long history of active participation across the fora and activities of the three sisters. Dr Gabrielle Vivian-Smith, Australia's Chief Plant Protection Officer, leads Australia's delegation to the IPPC (Figure 2). In the IPPC, Australia actively participates as an individual contracting party; we are there in our own right, and as well we act as part of South Pacific Region in the Commission on Phytosanitary Measures. We also have representatives and members in all the subsidiary bodies of the Standards Committee, the Implementation and Capacity Development Committee, and many of the technical panels and working groups.

We have equally strong focus in the OIE governance structures. Australia's Chief Veterinary Officer, Dr Mark Schipp, leads the Australian delegation to the OIE, and Dr Schipp also held the role of the OIE presidency from 2011 to 2021, and he will continue on the OIE Council after 2021. Dr Schipp is also a member of the Regional Core Group for Asia and the Pacific, and that focuses specially on enhancing communication and coordination in our region. Australia also has members on two of the four OIE Specialist Commissions: that is, the Scientific Commission for Animal Diseases, and the Aquatic Animal Health Standards Commission, of which Australia holds the presidency.

I am trying to build a picture to show how influential we are in these three sisters, and how important that work is.

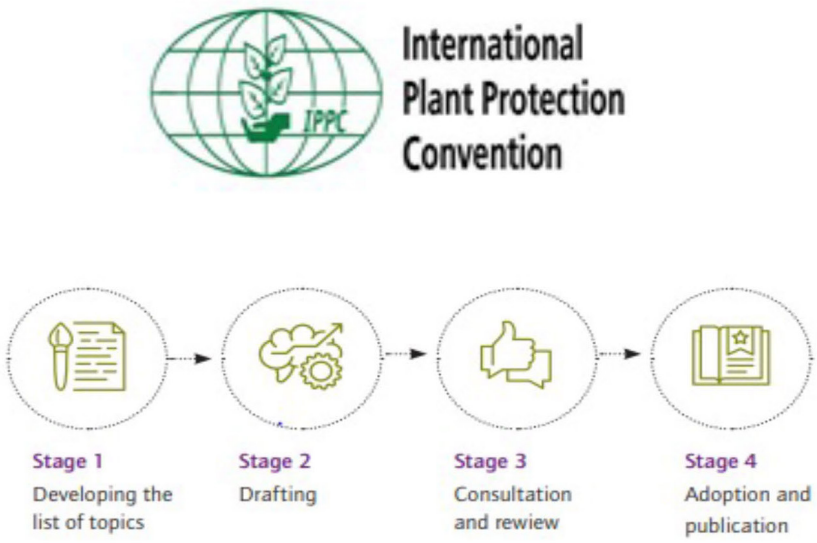

Figure 2. Role of the IPPC.

CODEX ALIMENTARIUS | Food and Agriculture Organization of the United Nations | World Health Organization

Codex Alimentarius Commission		
CAC	Codex Alimentarius Commission	Active
Executive Committee		
CCEXEC	Executive Committee of the Codex Alimentarius Commission	Active
General Subject Committees		
CCCF	Codex Committee on Contaminants in Foods	Active
CCFA	Codex Committee on Food Additives	Active
CCFH	Codex Committee on Food Hygiene	Active
CCFICS	Codex Committee on Food Import and Export Inspection and Certification Systems	Active
CCFL	Codex Committee on Food Labelling	Active
CCGP	Codex Committee on General Principles	Active
CCMAS	Codex Committee on Methods of Analysis and Sampling	Active
CCNFSDU	Codex Committee on Nutrition and Foods for Special Dietary Uses	Active
CCPR	Codex Committee on Pesticide Residues	Active
CCRVDF	Codex Committee on Residues of Veterinary Drugs in Foods	Active
Commodity Committees		
CCFFP	Codex Committee on Fish and Fishery Products	Active
CCFFV	Codex Committee on Fresh Fruits and Vegetables	Active
CCFO	Codex Committee on Fats and Oils	Active
CCSCH	Codex Committee on Spices and Culinary Herbs	Active
ad hoc Intergovernmental Task Forces		
TFAMR	Ad hoc Codex Intergovernmental Task Force on Antimicrobial Resistance	Active
FAO/WHO Coordinating Committees		
CCAFRICA	FAO/WHO Coordinating Committee for Africa	Active
CCASIA	FAO/WHO Coordinating Committee for Asia	Active
CCEURO	FAO/WHO Coordinating Committee for Europe	Active
CCLAC	FAO/WHO Coordinating Committee for Latin America and the Caribbean	Active
CCNASWP	FAO/WHO Coordinating Committee for North America and South West Pacific	Active
CCNE	FAO/WHO Coordinating Committee for Near East	Active

Figure 3. Australia is involved in 22 committees of Codex.

In my current role I am actively engaged in Codex: I lead the Australian delegation to the Codex Alimentarius Commission. Team Codex Australia comprises representatives from the Department of Agriculture, Water and the Environment; we also have senior representation from FSANZ (Food Standards Australia New Zealand), as well as a number of colleagues who are co-opted into a huge range of working groups – which cover subjects as diverse as food nutrition, the labelling of food and non-food products, food hygiene, residues of veterinary drugs, and residues of pesticides and other chemicals – as well as numerous subject-specific working groups.

Figure 3 shows the list of Commission Subcommittees, specific commodity committees and other working groups that Australia actively leads and promotes; they underpin all our standards on food. Participating across this spectrum gives Australia a unique opportunity to contribute to and influence the development of the text in international standards, implementation material, and a range of other policy documents at each point of its development cycle. It also means that we can work very hard in our region to participate in the development of these materials so that they are reflective of the positions of all, and not just the positions of major trading partners.

Over the past almost two years we have continued to participate in the fora virtually, to make sure that the development of these important standards and texts is not delayed, and also that Australia's perspectives and needs continue to be promoted and included in the development process.

Australia's value in these roles

Australia really does need to be 'at the table'. We are a balanced and a pragmatic voice that promotes science and risk-based standards, not only in

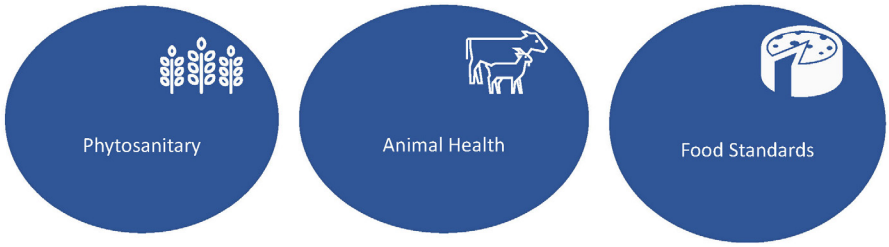

Figure 4. Australia's participation across this spectrum is important.

food safety but also in animal and in plant health (Figure 4). And I know that the perception in the international community at these bodies is that we actually *are* a balanced and pragmatic voice, and that we deliver benefits that genuinely do contribute to the international community.

We play a really important role collaborating with like-minded trading partners to counter the efforts by some countries to promote the development of standards that are overly prescriptive or hazard-based, or that mimic their own national control measures. Those control measures could be informed by political or other domestic considerations that constitute factors other than science, and that do not take account of the unique environments and production systems of all other countries.

At a technical level I often reflect with colleagues across the Department that we really do 'punch well above our weight' in each of the three sisters. A challenge, however, is translating our technical influence into spheres that are sometimes quite confronting, and at times even geopolitical. This is where I am immensely keen to be able to continue our work with Su McCluskey in her role as Special Representative for Australian Agriculture.

Australia has continued to make headway over the course of the pandemic, despite the challenges that COVID-19 has presented not only in terms of regulating trade but also in preventing physical meetings with trading partners.

- In phytosanitary matters we have been able to adopt standards related to the use of third parties in regulatory systems; these will help countries use non-government entities in a way that facilitates trade and protects plant health. Australia also has gained approval for a number of international phytosanitary treatments for the Mediterranean fruit fly and the Queensland fruit fly. Australia is one of the few countries that is affected by fruit fly, so the approval is of obvious importance to our fruit exporters, and as well to countries that import Australian product.
- In matters of animal health, Australia's voice has been important in tackling serious emerging problems. In one of the next three case studies today we shall hear about antimicrobial resistance, where global solutions must encompass the needs of a very diverse range of stakeholders. Australia has also worked very hard in the OIE processes for recognising official diseases status, and the effect of this is two-fold. It improves the credibility of the OIE's official diseases recognition system, and it helps Australia maintain our favourable disease status – thereby supporting Australian exports.

- In terms of food standards, Australia has been instrumental in progressing principles and guidelines for the assessment of voluntary third-party assurance programs, as well as in guidance on paperless use of electronic certificates. What that means in practice is that we are developing process and guidance at an international level that will remove the need for paper certification accompanying export health certificates. For those who are engaged in exports, that requirement is a huge burden – both on the Department, to be able to make sure that the systems are operating effectively, and also because it makes no sense in a digital modern age to have paper certificates traversing the globe when we can exchange certificates electronically in such a secure way.

The importance of Australia's participation in Codex

Australia has a particularly close connection to the Codex Committee on Food Import and Export Inspection and Certification Systems (CCFICS, Figure 5). It is among the most influential of the Codex committees, and one that has been chaired by Australia for a significant period of time. I am the incoming Chair.

The work of this committee, I think, well illustrates the importance of Australia's participation in Codex. CCFICS develops principles and guidelines for food import and export inspection and certification systems, with a view to being able to harmonise those systems across all trading partners around the world. The texts developed by CCFICS, and then adopted by Codex, set the benchmark for global food trade. There is no prescriptive 'one size fits all' approach. Instead it provides the basis on which all countries can model their food control systems to achieve the same outcomes.

All the texts cover principles central to the trade in food, such as guidelines for the use of quality assurance systems, and to promote the recognition of these systems in facilitating the trade in food. And they have served us well, but the committee still has a huge and quite demanding agenda ahead of us in order to make sure that Australia's food exports and food safety systems remain 'ahead of the curve' in a rapidly changing environment.

There is a conception that the international standard-setting process is incredibly 'dry' and proceeds at an absolutely glacial pace, and that is absolutely true ... but – there is always a 'but' when we talk about this – consensus building takes time, and with more than 200 member parties of Codex, with dramatically different food safety systems and approaches, you can understand why sometimes progress is slow.

However, sustained effort provides great benefits in the long term, for consumers, industry and governments. And given that it does take some time to achieve consensus on science-based and risk-based standards, it is even more important that the committee is forward-looking early on, and that we address emerging risks and trends, and are responsive to changes in our operating environment. I am proud to say that we are. It is not a stagnant space. We know, and indeed have experienced, situations where there is a vacuum of guidance in the potential for countries to go it alone and implement measures that are

Figure 5. CCFICS.

not science- or risk-based, and for those countries to then expect their trading partner to mirror those measures. It is not a helpful place to be.

As Chair, Australia hosted the 25th session of CCFICS, and it was the first time in the history of Codex that we held virtual sessions. Despite the limitations of operating virtually we progressed a huge amount of very important work that in the longer term is really going to assist countries modernising their approach to the way that the trade in food is regulated, as well as ensuring that inspection certifications systems adapt and keep up with that change.

We have now experienced and implemented remote technologies to conduct audit and verification guidance, and because of that, from the Australian experience, we are driving the development in Codex of guidance on remote audit and verification for food regulatory frameworks. We are sharing that information with our colleagues in biosecurity as well so that we are keeping pace with each other. These are going to be extremely important about facilitating the acceptance of these new ways of regulating across the globe.

We have embraced electronic certification exchanges to do away with paper (Figure 6) and, as I mentioned earlier, we have been instrumental in having this guidance put forward and nominated at Codex last November. That will enable more streamlined and secure exchanges of information between trading partners. Australia also negotiated the most forward-leaning and expansive paperless trade arrangement with a significant trading partner early this year (2021). And we are hammering hard at the moment to move to completely paperless trade with another significant partner in 2022, which again I am hoping will deliver significant financial and non-financial benefits to exporters in some food sectors.

The committee is also taking forward new work to develop guidance on the prevention and control of food fraud (Figure 6), which is becoming increasingly sophisticated, with lots of criminal networks operating; it is a significant threat to consumer health.

Figure 6. Standard-setting bodies are at the forefront of addressing emerging issues and adapting to change.

There are also new food and certification production systems emerging, such as seaweed or cell-based meats, and insect protein, which may become more staple parts of our diet in the future. They all have unique food safety risks, as well as biosecurity risks. Through Codex, Australia is actively working on those.

The uptake of Codex texts is voluntary, so the committee's efforts do not stop at the point of getting the standards adopted and then published by Codex Alimentarius. We do not just silo ourselves in Codex either; we are engaging internationally and within the Department, consistently working from a solid scientific basis to counter trade-restrictive measures in a huge range of fora. We work across government and with trading partners to promote uptake of the standards, and this can happen multilaterally within our regional agreements, and it can also be through thematic sessions at the World Trade Organization. We also work in a strategic food safety dialogue with the food safety regulators of like-minded trading partners, to make sure that we both share information, and then rapidly deal with emerging issues.

Recently, the Government committed additional resources to stepping up Australia's leadership in the agricultural international food policy discussions and to enhance our capacity to influence in multilateral institutions. Through the Global Agricultural Leadership Initiative and Su McCluskey, in 2022 the committee will be focusing efforts to increase the uptake of the international standards that we, as Team Australia, have been trying to drive.

In summary

In Australia we really do punch above our weight.

We play a very key role in shaping international standards and guidance, so that they address risks to animal and plant biosecurity, zoonotic disease, food safety, and nutrition in a way that is transparent, systems-based, science-based and risk-based.

Our work in the three sisters is central to facilitating fair and safe trade in agricultural and food products, by maintaining a transparent and rules-based trading environment that promotes global food safety and security.

The increasingly connected global value chain, evolving consumer trends, and new technologies all present challenges and opportunities that we continue to engage with closely, to make sure that our systems keep pace and adapt appropriately.

This work does take time, but when it is done well and done right it implements and underpins trade that benefits us all.

Nicola Hinder PSM is the First Assistant Secretary of the Exports and Veterinary Services Division of the Department of Agriculture, Water and the Environment (DAWE). Ms Hinder's responsibilities include technical market access negotiations underpinning the export of a wide variety of agricultural goods from Australia. In addition, Ms Hinder's role includes the management of operational staff based throughout Australia, including in remote and regional communities, providing export certification and assurance functions. Ms Hinder is also the Australian Delegation Head for the Codex Alimentarius Commission – the international food safety standards-setting agency established by the United Nations Food and Agriculture Organization and the World Health Organization. Ms Hinder has undertaken a broad range of roles across government, including (for DAWE) biosecurity, corporate, emergency management and international trade, and has served the Australian Government on postings to the European Union and India. In 2019, Ms Hinder received a Public Service Medal for services to Biosecurity and Trade.

Global collaboration: International Plant Sentinel Network

David Gale[1] and Katherine O'Donnell[2]

[1]Data Management & Surveillance Communities, Plant Health Australia; [2]Seed Conservation & Plant Health, Botanic Gardens Conservation International

ABSTRACT

Invertebrate and pathogen pests present a significant risk to global plant health, and this threat is ever rising due to the growing global trade of plant material and, increasingly, as evidence suggests that climate change is influencing pest establishment in new locations. Sentinel plants within botanic gardens and arboreta can play a vital role in providing information on future and/or unknown threats. The objective of the International Plant Sentinel Network (IPSN) is to act as an early warning system to recognise new and emerging pest and pathogen risks, through the development of national and international partnerships between plant protection scientists and botanic gardens and arboreta. There are currently 71 members of IPSN. They include the Australian National Botanic Gardens (Canberra), Kings Park and Botanic Garden (Perth), Royal Botanic Gardens Victoria, National Arboretum Canberra, Royal Botanic Garden Sydney, Royal Tasmanian Botanical Gardens, and the Botanic Gardens and State Herbarium of South Australia. As part of the project 'Establishing a Program of Plant Pest Surveillance in Australian Botanic Gardens and Arboreta', which is funded through the Australian Government's Agricultural Competitiveness White Paper – the Government's plan for stronger farmers and a stronger economy – Plant Health Australia has had the opportunity to develop connections with the IPSN to build capacity and knowledge, locally and abroad.

This brief talk outlines the opportunities which exist through the International Plant Sentinel Network for collaboration in the context of the biosecurity, health, trade nexus as it impacts food security and nutrition.

Two organisations I shall frequently refer to are Plant Health Australia, and Botanic Gardens Conservation International. Plant Health Australia is the national coordinator of the government–industry partnership for plant biosecurity in Australia. It is a not-for-profit member-based company, and works in partnership with industry, governments, researchers and others to facilitate and manage improvements in biosecurity policy and practice across Australia's plant industries. The other organisation, Botanic Gardens Conservation International (BGCI), is a worldwide botanic garden networking organisation, established in 1987 with headquarters in the Royal Botanic Gardens, Kew, UK, and offices in the USA, Kenya, Singapore and China.

This record has been prepared from a transcript of the presentation.

The International Plant Sentinel Network (IPSN) is a global network of botanic gardens, arboreta, plant health institutes and National Plant Protection Organisations, coordinated by BGCI. The IPSN provides an early warning system for threats from new and emerging insect pests and pathogens.

How?

Plants growing outside their native range can be monitored for damage by pests or pathogens that are native or naturalised to the host country. Information can then be collated on the risks these organisms could pose if introduced into the plants' native range. And as we have heard already today, with global trade continuing to increase, there is increasing likelihood of moving insect pests and pathogens around the world on host material or as hitchhikers.

There are over 3000 botanic gardens worldwide. They have a broad geographical and climatic range, and contain about 30% of the known plant species. They also have a wealth of expertise in the staff who know their living collections 'inside out'. The gardens hold native and non-native species of plants, and contain pests and pathogens native and naturalised to the host country of the botanic gardens. Of these 3000 botanic gardens, 71 are members of the IPSN, including the Australian National Botanic Gardens here in Canberra, Kings Park and Botanic Garden in Perth, the Royal Botanic Gardens Victoria, the National Arboretum here in Canberra, the Royal Botanic Garden Sydney, Royal Tasmanian Botanical Gardens, and the Botanic Gardens and State Herbarium of South Australia.

Australia's contributions to the IPSN

IPSN member gardens in Australia are undertaking surveillance on five host plants, as part of a project funded by the UK Department for Environment, Food and Rural Affairs. They record, using a plant health checker (proforma), any insect pests or pathogens that are affecting the host species. The same logic could be applied to host species being grown in Australian botanic gardens that have their origins in a food insecure country, or where Australian natives have been grown as part of development projects: eucalyptus plantations, for example. In both those cases there is an opportunity to exchange information on the pest threats – that is, insect pests or pathogens – that could potentially impact those species.

Also, in a different approach to this surveillance, Plant Health Australia is running a project called 'Establishing a Program of Plant Pest Surveillance in Australian Botanic Gardens and Arboreta', which is funded through the Australian Government's *Agricultural Competitiveness White Paper* (2015) 'Stronger Farmers; Stronger Economy'.

In this project, botanic gardens have been looking for five pests on potentially susceptible host species. The five pests are: brown marmorated stink bug; rose rosette virus; myrtle rust; stigmina leaf spot, and polyphagous shot hole borer. Rather than looking at the host, we are looking for the pest irrespective of the host. This is still potentially useful in an international context because we might find a new strain of myrtle rust, for example.

There are opportunities through this process as well. Although in our project we are looking for early detection using botanic gardens as sentinels, there may be opportunities to find the next pest that could impact one of these crops or one of these species overseas.

Thinking ahead

International trade is continuing to increase, and as a consequence there is an increased risk of moving insect pests and pathogens around the world quite quickly. Through engagement with botanic gardens, both in Australia and globally, there is an opportunity to get a 'heads-up' on what the next big pest threat might be, based on the species that are there. Thinking ahead by incorporating botanic gardens into projects, there is an opportunity for mutual development of skills and knowledge on insect pests and pathogens, for the benefit of Australia and partner countries.

Reference

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David Gale is currently the Manager, Data Management and Surveillance Communities, at Plant Health Australia (PHA) where, amongst other things, he has recently been managing a Department of Agriculture, Water and the Environment funded project working with Australian botanic gardens to improve national plant pest surveillance outcomes. The networks of staff and Friends of botanic gardens developed through this project also connect into the International Plant Sentinel Network (IPSN) to contribute to collaborative efforts to conduct plant pest surveillance across many countries. Prior to working at PHA David completed a Master of Philosophy undertaking a project investigating the way in which certain composts act to ameliorate acid sulphate soils in Vietnam's Mekong Delta. David was a Crawford Fund Conference Scholar in 2012 and a Crawford Fund IRRI scholarship awardee in 2013. David is an ACT RAID events representative, and the RAID representative to the ACT Crawford Committee.

From field to lab

Dr Jay Anderson

Centre for Organics Research, Southern Cross University

ABSTRACT

The Crawford Fund has supported a long-running program providing plant pathology and entomology support for smallholder farmers and provincial and district staff in southern Lao PDR. The program has involved over 32 volunteers, mentors and students covering 55 cash crops involved in poverty alleviation. The program has focused on identifying the key pests and diseases while working directly with the farmers to develop appropriate management practices. We endeavour to empower government advisers to work with farmers to alleviate poverty, for example through the production of high value horticulture crops. Activities have included workshops, establishment of small diagnostic laboratories, and the development of pest and disease checklists and extension materials. Benefits also flow to Australia, with volunteers and mentors gaining exposure to pests and diseases not present in Australia, and the opportunity to build professional networks. This case study describes the 'field to lab' approach that has characterised this program and made it successful. Dr Anderson visited Savannakhet and Champasak provinces in February and March 2019 as a volunteer with the Australian Volunteer Program. She worked with local government advisers to visit smallholder farmers and survey the leaf diseases that affect bananas in southern Lao PDR. In-field training for identification of banana leaf diseases was undertaken. Samples were taken to the laboratory for preliminary identification, providing the opportunity for training in specific techniques for working with banana leaf pathogens. Samples were sent to colleagues in internationally recognised laboratories for formal identification, making use of specialised resources not present in Lao PDR. During COVID, ongoing support for the identification of pest and diseases and their management has been through the use of social media such as WhatsApp which link the network of past volunteers, mentors and Lao counterparts.

This talk is about my six week volunteer stint in Lao PDR in 2019, looking at leaf spot pathogens of banana. Since 2009, the Crawford Fund has had a program in southern Lao PDR, working with local smallholder farmers and provincial and district staff to identify pest and disease issues and develop control measures to specifically suit each location. The program has involved 32 volunteers, mentors, and students, and it has covered 55 cash crops that were important in alleviating poverty. The Crawford Fund has also been involved in the development of two laboratories – one in Pakse and one in Savannakhet – and also a glasshouse in Savannakhet.

Bananas in Lao PDR are extremely important: the fruit and flowers of local varieties such as Kuay Nam are consumed, and leaves are used as food

This record has been prepared from a transcript and the slides of the Zoom presentation.

Figure 1. Banana in Lao PDR.

wrappings. Banana leaves are also culturally significant, because they are involved in the manufacturing of offerings. Bananas are important sources of cash, both being traded domestically and also for export. The bananas on the back of the motorbike in Figure 1 are some Kuay Nam bound for Vietnam. There are also large Cavendish plantations which are foreign-owned concessions and significant from a biosecurity point of view.

Banana disease issues are not well documented, apart from Fusarium wilt. A bit of work has been done on pests (Vansilalom 2016). The focus of my work was leaf spot diseases: the leaf spot pathogens are quite important because of the cultural uses of the leaves.

The project

In a survey of banana leaf disease, I and my colleagues from the Provincial Agriculture and Forestry Office in the south of the country went out to quite a few locations. We surveyed villages and smallholder plantations and looked mainly for banana freckle and banana leaf streak, collecting leaf samples and also noting anything else of concern, such as the occurrence of banana weevil borer (bottom right in Figure 2).

As I mentioned, two laboratories have been set up: entomology and pathology laboratories in Pakse and Savannakhet. However, they cannot handle the

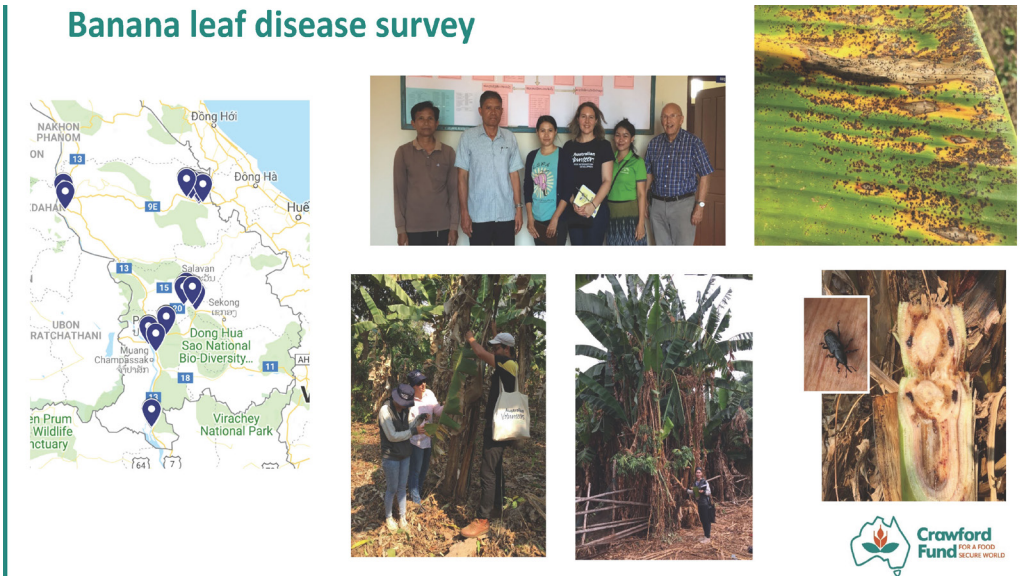

Figure 2. Banana leaf disease survey.

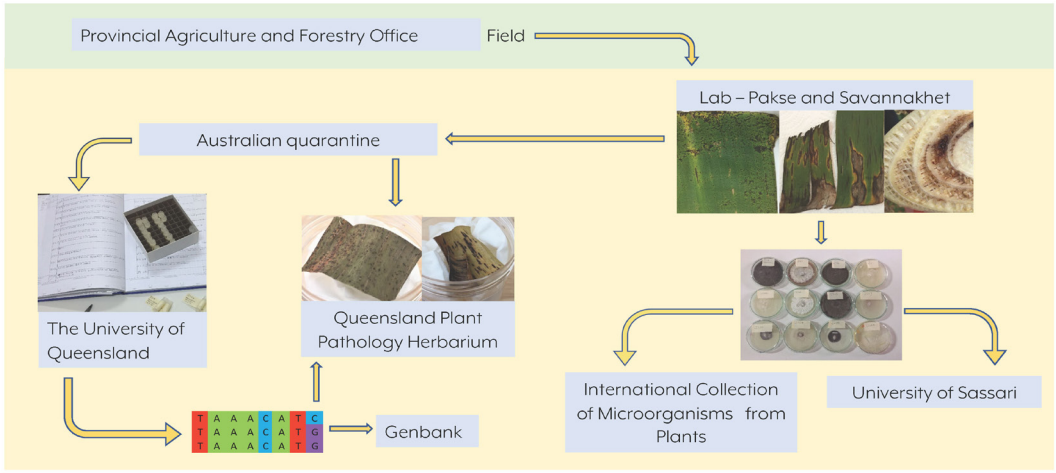

Figure 3. From the field to the lab.

processing of all the samples, and so we drew on our international network to identify the pathogens that were present. After our team had collected samples, we brought them back to the laboratories in Pakse and Savannakhet (Figure 3). The photos at top right in Figure 3 show, on the left, leaf samples with banana freckle. A number of fungal pathogens can cause those symptoms. Similarly, the symptoms of leaf streak can be caused by a number of fungal pathogens.

Those fungi are quite slow growing, and therefore instead of trying to grow them in the laboratory in Laos we prepared them for returning to Australia under Australian quarantine. We dried the specimens, gamma radiated them,

- Growers – no major change to practices
- Verifiable records of freckle pathogens and leaf streak pathogens present
- Lao colleagues - skills

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First report of *Phyllosticta* spp. associated with banana freckle disease in southern Lao PDR

Jay M. Anderson[1] · Cecilia O'Dwyer[2] · Sengphet Phanthavong[3] · Kaisone Sengsoulichan[4] · Andre Drenth[2] · Somlit Vilavong[3] · Lester W. Burgess[5]

Crawford Fund FOR A FOOD SECURE WORLD

Figure 4. Outcomes of the project.

and then lodged them in the Queensland Plant Pathology Herbarium as voucher specimens. We also prepared samples in solutions that inactivate the pathogens but preserve the DNA, and we brought those back to The University of Queensland where we could use sequencing to identify the fungi present. The data we generated were matched up with the specimens that we had sent to the Queensland Plant Pathology Herbarium, and also submitted to GenBank. We also did some isolations in the lab, and we had duplicate collections in case of losses. One of those went to the International Collection of Microorganisms from Plants (ICMP) in New Zealand, and the other went to the University of Sassari in Italy. ICMP have recently sent us back some DNA to work with and do further confirmation.

Outcomes

For the smallholder farmers, the project did not lead to any changes. They have a system that suits them: occasional de-leafing gets rid of their banana leaf spot issues. It is a low input system that allows them time to earn off-farm income and to spend time with the family, but still brings in needed cash. We gave out some advice for management of the banana weevil borer: it was a cultural control technique that did not cost the farmers any extra money.

For the Australian and Lao researchers and extension officers, the project led to capacity building, and we have contributed verifiable records of the freckle pathogens and leaf streak pathogens (Figure 4). That information is publicly available and internationally available, contributing to scientific knowledge with a good scientific basis. We have also published that work (Anderson *et al*. 2021). I think it is very important for us to help our Lao colleagues have the opportunity to publish and be recognised.

Acknowledgements

From Figure 5 you can see how big a network we have been able to draw on to do this work, and people who have helped. In particular I would like to

Figure 5. Acknowledgements.

acknowledge Professor Lester Burgess and the other volunteers who have worked before me to set up the laboratories, and also the Crawford Fund for funding the laboratories and the banana leaf survey.

Dr Juliane Henderson (The University of Queensland; Biosecurity Queensland), Ms Kathy Grice (Queensland Dept of Agriculture and Fisheries) and Dr Madaline Healey (University of the Sunshine Coast) provided me with some tips and tricks for working with banana diseases, banana pathogens, and also about life in Laos.

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Anderson J., O'Dwyer C., Sengphet Phanthavong, *et al.* (2021) First report of *Phyllosticta* spp. associated with banana freckle disease in southern Lao PDR. *Australasian Plant Disease Notes* **16**, article no. 29. DOI: https://doi.org/10.1007/s13314-021-00442-y

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Dr Jay Anderson is a Senior Research Fellow at the Centre for Organics Research at Southern Cross University. She is a plant pathologist focused on integrated disease management of tropical and subtropical horticultural crops. Jay has worked in government, university, private enterprise and in an industry representative body, and in all these roles, her work focused on practical solutions for farmers. Jay volunteered through the Australian Volunteer Program with the Crawford Fund's long-term program in Lao PDR where she was able to use her pathology skills to work with colleagues studying banana leaf diseases in the south of the country. She considers it a career highlight to meet smallholder farmers and share her knowledge with Lao colleagues, learning so much from them and her Australian counterparts. A short video interview on this experience is at https://www.youtube.com/watch?v=EZJTj7b6LJ4

Curbing antimicrobial resistance

Dr Walter Okelo

CSIRO Land and Water

ABSTRACT

The discovery of antimicrobial agents for treatment of diseases in humans, animals and plants was one of the most significant events of the 20th century. Notwithstanding their importance, acquired resistance has become increasingly evident and this pattern has followed the introduction of each new antimicrobial agent. Antimicrobial resistance (AMR) has not only led to unwarranted mortality rates in humans, but also presents a major economic burden to farmers, governments and the rest of society. Hence, the alarming worldwide escalation of AMR poses a serious threat to public health, agricultural production and food security, and can cause major disruption globally. Whilst there has been progress in understanding the causes of AMR, there is a dearth of knowledge on how to empirically mitigate it using the One Health approach in low resource settings. Furthermore, the occurrence of AMR in the Pacific region is poorly understood. Using Fiji as a case study and through the Enhancing the Management of Antimicrobial Resistance (EMAR) project, we illustrate how systems thinking can be applied in the context of AMR. We also describe the impact of AMR on agricultural systems, and demonstrate how we are tackling the problem of resistance in Fiji to improve health, agricultural production, and ecosystem outcomes in a sustainable and cost-effective manner. We envisage that the approach used in Fiji, including the lessons learnt, will be scaled out to other low resource settings to reduce the spread of AMR.

Antimicrobial resistance (AMR) adds to the already long list of biosecurity threats that have been discussed today. It is a problem that involves the complex interaction of microorganisms, people, animals and the environment. It will cause 10 million deaths by 2050, surpassing cancer and diabetes as the major cause of mortality. Antimicrobial resistance will also cause many disruptions in health care, livestock production and the global economy (Figure 1). For

Figure 1. The global problem of AMR.

This record has been prepared from a transcript and the slides of the presentation.

example, in the Western Pacific region alone it is estimated that AMR will cost $1.35 trillion over the next 10 years. Therefore the spread of AMR, just like the COVID-19 pandemic, presents a major economic burden to most governments and communities in most countries of the world, requiring it to be mitigated as a regional and global public good. That means all countries in a region, and globally, need to come together to tackle the problem. No country can tackle this problem alone.

Since the COVID-19 pandemic began there is greater recognition that human, animal and environment systems are only as strong as the weakest link. But how do we strengthen such systems to tackle problems such as AMR and COVID-19?

The One Health approach, which has been mentioned throughout this conference, is a very important operational mechanism for bringing together agri-food systems, health systems and ecosystems, to optimise the health of people, animals and the environment. From an economic perspective, a One Health approach is also a good mechanism for reducing the negative externality of AMR, resulting in the optimal use of antibiotics – rather than overuse, which is the major cause of problem.

Therefore, from an economic point of view, we need to make sure that we optimise and get the best value from using antibiotics in human health as well as in animal health.

The causes of antimicrobial resistance are well known, but in developing countries the One Health approach has not been applied as a way of mitigating the problem (Figure 2). Suitable resources are limited in developing countries,

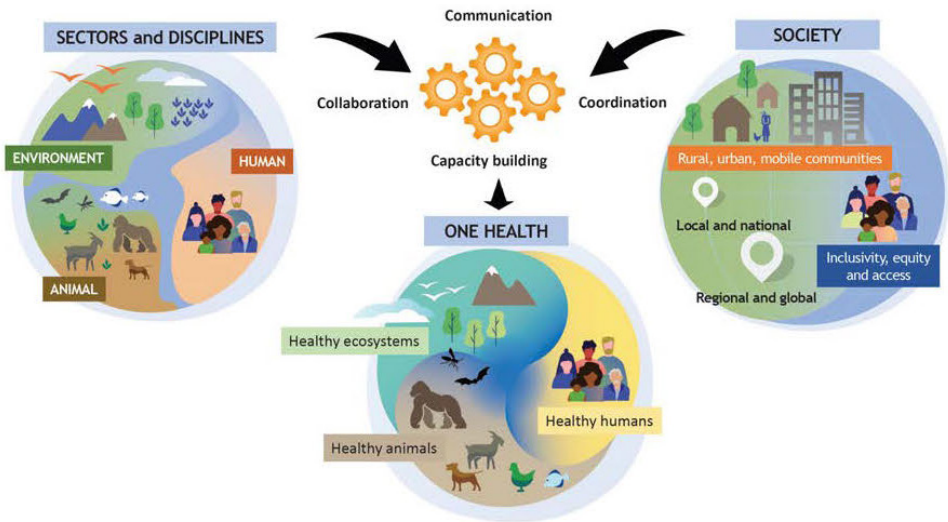

Figure 2. Systems thinking: One Health approach.

* One Health approach provides an operational mechanism for bringing agrifood systems, health systems and ecosystems together to optimise health of people, animals and ecosystems.

* There is insufficient knowledge on how to mitigate AMR using the required One Health approach in low resource settings.

* How do we develop an integrated surveillance system and a business case for each sector to participate in the management of AMR, given the limited resources in developing countries?

so the question arises: How do we build a business case for each sector to participate in the management of antimicrobial resistance, when each sector has its own roles and expectations? (Figure 2).

The project: Fiji

To answer this question we first conducted a scoping study which was funded by ACIAR and the Indo-Pacific Centre for Health Security (an Australian Government Health Security initiative) between 2018 and 2019. We found that Fiji is the best place to tackle the problem of AMR, because it has a National Antimicrobial Resistance Committee, commonly known as NARC, which is a multisectoral platform for coordinating AMR activities. The study also showed the need to enhance research and lab capacity, and the need to strengthen animal health systems, among other needs.

Consequently, working with the NARC members we co-designed a project known as Enhancing the Management of Antimicrobial Resistance (EMAR). All the stakeholders came together to develop the project to tackle some of the challenges that were identified during the scoping study (Figure 3).

As part of the project design we incorporated the One Health approach into what we call the Driver Pressure State Impact Responses Framework. This framework is commonly used in the environmental sciences to tackle emerging or complex issues such as climate change. That is, we are trying to bring that framework into the management of antimicrobial resistance. Such an application has been proposed previously but has not been done before.

Specifically, it means that some of the project activities in the livestock sector will include economic analysis of the impact of AMR, sample collection, lab capacity building, and conducting surveys on farmers' knowledge, attitudes and practices towards antimicrobial use.

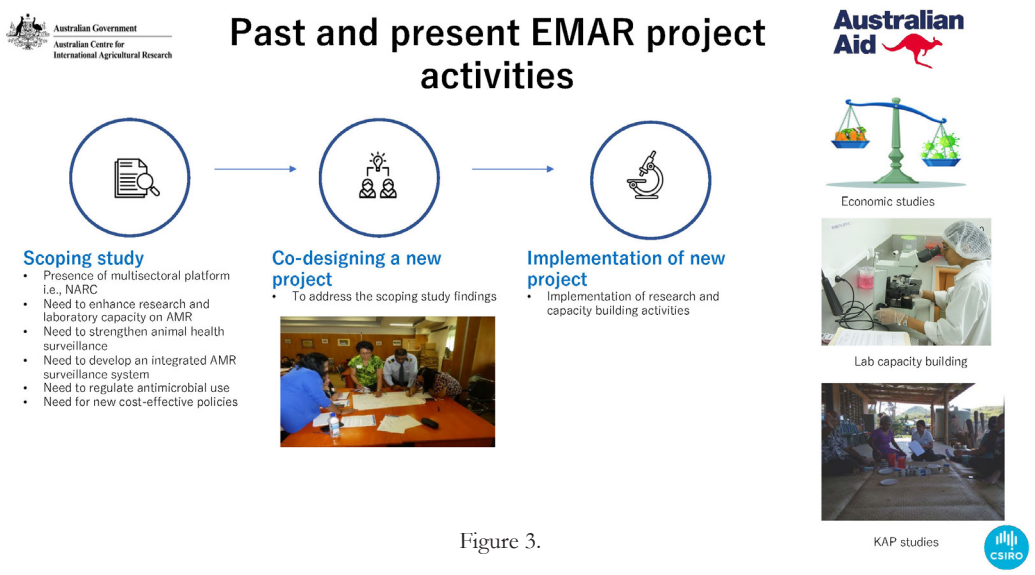

Figure 3.

Outcomes so far, and acknowledgements

So far this project has increased lab and research capacity in Fiji, particularly in the animal health sector where there had been very little or no investment in the past. For example, for the first time, the Fiji National University staff are conducting their research through our project. We have also improved the regulations around antimicrobial use, among other outcomes (Figure 4).

Our aim is to improve food security, health outcomes, and water quality, as stipulated in Fiji's National Development Plan. It is important that we communicate what we are doing and that we link it up with what the Fiji Government is trying to achieve, so that the Fiji Government wants to be part of this project.

In Fiji we have learned that multisectoral platforms and strong partnerships, capturing the interest of each sector, and providing economic evidence, are all essential factors in tackling acquired resistance, as well as developing the business case for each sector and strengthening Fiji's human, animal and environment systems. We envisage that the approach used and lessons learnt in Fiji will be scaled out to other low resource settings to reduce the impacts of acquired resistance, plus other zoonotic diseases, in the Pacifc region including Australia.

I would like to thank our partners, including (Figure 4) University of Technology Sydney, University of South Australia, Fiji National University, The University of the South Pacific, the Fiji Ministry of Agriculture and the Fiji Ministry of Health & Medical Services, and the many, many, many other stakeholders that we are working with in Fiji.

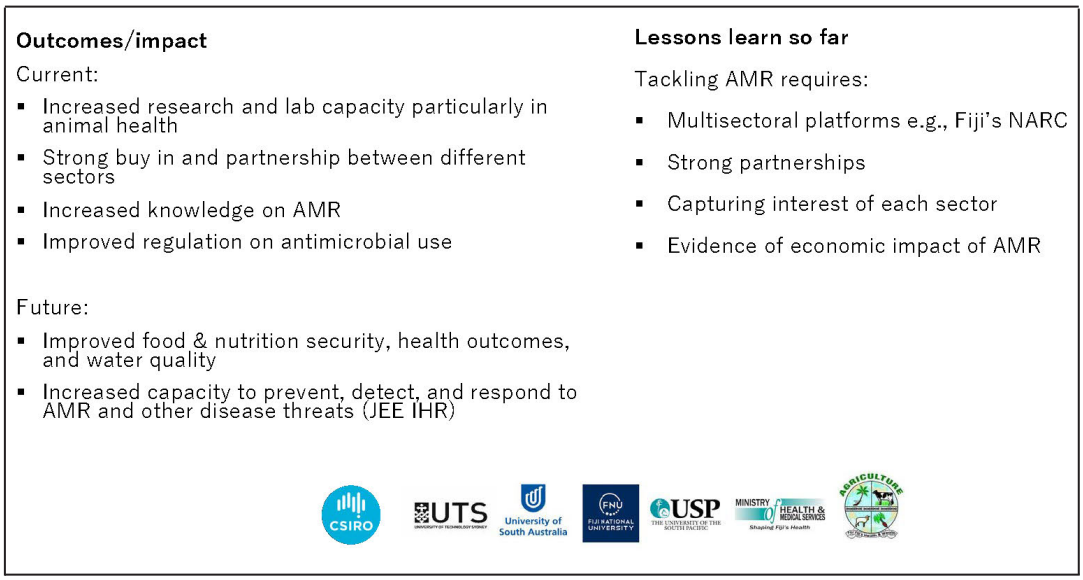

Figure 4. Outcomes/impacts and lessons learnt, and the logos of the partner organisations involved.

Dr Walter Okelo is a research scientist at the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and his current research involves quantifying economic impact of biosecurity risks at the human–animal–environment interface. Also, Walter currently leads an interdisciplinary project focusing on sustainable management of antimicrobial resistance in Fiji, among other projects. Walter's research interests include biosecurity economics, resource economics, disaster risk management, One Health, and techno-economics. Walter holds a PhD in economics from The University of Edinburgh and postgraduate certificates in applied econometrics and epidemiology (from Utrecht University) and health economics (from the World Bank). Walter is a veterinarian by background and has over six years' experience in designing and evaluating biosecurity projects in Asia, Africa, Australia and the Pacific region. Walter is a Commonwealth Scholar and enjoys nature and playing basketball.

Q&A

Chair: Cathie Warburton, Grains Research & Development Corporation

Panel: Nicola Hinder PSM; David Gale; Dr Jay Anderson; Dr Walter Okelo

Q: Peter Wynn, Charles Sturt University.

A question for Nicola. With Codex, you have got a large group of countries that cover the whole spectrum of economic development, from the underdeveloped to the most developed. Do you ever have to make compromises to accommodate some of the relatively poorly developed technologies in the underdeveloped countries when you are developing your different standards, so that perhaps the can of tomatoes I buy from Australia is the same as the can of tomatoes I buy from any one of the underdeveloped economies?

A: Nicola Hinder

That's a really good question, and I would like to flip it around by saying there are two approaches. In relation to Australia's engagement in Codex, one thing we are very mindful of as well is our own biosecurity standards, and what that would mean for trade in food products or other commodities that would come to Australia. In Codex, though, I would say that there is never a concession. I would say that it is more of a compromise. One of the benefits that is behind Codex is that it is a consensus-based organisation, and that means that we manage to both consider and then work through a wide variety of views. Ultimately the standards that we set are non-binding. What they do, though, is provide the benchmark for international food safety standards and for countries to lift to, to be able to meet those standards, and at times countries also exceed those standards because of their own requirements, either around biosecurity or their own natural food systems.

In the entire time that I've been engaged with Codex in various forms on and off over the last 20 years, I have not yet seen an example where consensus on the standard has been unable to be reached … with the exception of the meeting that is happening this evening, where we are actually reconvening at Codex because we were not able to reach agreement on the use of a particular veterinary medicine and its application in food. And that is where I say that there are never concessions given in order to be able to develop a standard, but there is agreement there around having it be, if we can, a consensus-based approach. And the reason why I draw that out is because, as I referenced in the speech, the trade in food is huge, and when we are talking food we are not just talking muesli bars or cereal packets or highly processed food products. Anything that is exported as a commodity product from agriculture effectively is food.

But as more and more trading partners become more and more developed, and as there are geopolitical tensions and others that arise, we are seeing

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some trading partners setting their own national standards and attempting to be able to bring those into the Codex sphere. And that is why it is particularly important for Australia to be engaged in Codex, as much as it is important for us to be engaged in the work of our other two sisters, because we do have a very balanced and a very pragmatic approach, and we can work hard to be able to bring about consensus where there may not be acceptance of views, and it may not be the middle road, but it is certainly not the extremity either.

Q: Carol Quashie-Williams, Department of Agriculture, Water and the Environment

Two questions. For Nicola: Is there an environmental sister? And for David: is there an animal sentinel group that uses zoos, the zoo network?

A: Nicola Hinder

Is there an environmental sister? Absolutely. There are a range of what I would call environmental sisters that operate across the environment, both in terms of protecting natural resources, and in terms of furthering global standards. I think everyone has also seen our engagement, including on the climate sisters that operate as part of COP [Conference of the Parties to the UN Framework Convention on Climate Change], etcetera, etcetera.

One of the big benefits about the amalgamation of Agriculture, Water and the Environment as one Department now is that we are really bringing together a consensus-based approach to how we actually manage our natural resource environment; so that it's not only our agricultural and food production systems, but also our environment and our management practices.

A: David Gale

You asked if there is a sentinel network for zoos. That is a fascinating question that I do not know the answer to, I'm sorry.

A: Nicola Hinder

I cannot answer for zoos, but I think Helen Scott-Orr would be able to nod at me if I say that there is a consensus- and ability-based approach across both the zoos and the natural environments, working with the State Governments. For example, there is the Sentinel Hive Program, which is operating in the far north of Australia, where beehives are being monitored for the incursions of foreign pests coming with bees; there's the Sentinel Herd Program; there is also environment, and there are also management programs that operate in zoos. But it has been quite some time since I was involved in those matters, so I'm not certain.

Q: Howard Parry-Husbands, Pollinate and Metamorphosis

I am very encouraged to see so many mentions of systems thinking, co-design and systems approaches and the core beliefs to the work we do, and Dr Okelo's insight, which is that human and environmental systems are only as strong as the weakest link. My question is to the panel: is there enough collaboration across departments, between scientists and communicators, between nations? And also, what should be done to improve collaboration and co-design?

A: Walter Okelo

That is a good question, for everyone. I think it is very important to make sure that we do not only invest in one system which may not work. We need to think broadly; we need to think where these problems are coming from; and at the centre of it all we also need to think of the people who are affected, because they are the people who are bearing the burden. So I think it is very important that we take the systems approach, and also that we add a bit of economics into it, because at the end of the day someone has to pay.

A: Nicola Hinder

I like to think of it as a cheesecake. There are layers that go towards management, and there are layers that go towards communication and control and coordination. I think that across government collectively we have always been good, but I think we are getting much better at joining up and making sure that all the voices are heard and that positions are formed. And when I talk about a cheesecake approach, I think about some of the things that we have just done recently in trade: going down to the local government level, and then all the way out to a huge range of producers that we have never had to engage with before.

I think communication and coordination are always going to be the key, and I look at some of the underpinning documents that we have in our animal health and plant health management sphere: the EADRA [Emergency Animal Disease Response Agreement], the EPPRD [Emergency Plant Pest Response Deed] and the NEBRA [National Environmental Biosecurity Response Agreement]; how we go to respond to animal and plant pest and diseases when they are found, bringing everyone together; a common source of funding; agreed response arrangements. These mean that the communication and coordination do not have to happen at the start of a response, because everyone knows exactly what we are doing.

It is the same, I think, with the work that Andrew Robinson (who gave the overview to Session 4 today) is doing in CEBRA, the Centre of Excellence and Biosecurity Risk Analysis: that forward-looking approach; being able to make sure that we have done the modelling, we have decided on the approach, we have got the sign up for everyone that is engaged. I am certainly not going to say that there is always going to be great communication, because sometimes communication fails, but the commitment to communication is absolutely there.

Q: Luisa Olmo, University of New England

My question is for Jay. Based on your experience working in Laos for six weeks, how important do you think the role of diagnostics is in some of these systems in Laos, when it seems that sometimes you can make recommendations based just on what you think? What are your thoughts on that?

A: Jay Anderson

I think it is very important that we can diagnose things correctly. I think it is important also that we do it in a way that makes sure we are transferring back those skills to our colleagues who are going to remain in country. And that is what I was trying to do: that is, we can't always do everything straightaway

at that moment, but we can make sure that we say we think this is what the situation is and that this is the best way of managing it, and we will bring you further information, and make sure we empower our colleagues there to be able to do that.

In that pest and disease program that the Crawford Fund have run in Lao PDR since 2009, pest lists have been developed for important vegetable crops. When you go into these laboratories you see images on the wall, and you see the English word and you see the Lao word; these kinds of educational things.

Yes I think diagnostics are very important. But also, sometimes, one can talk about general measures that are important. For example, for some leaf spot pathogens it is not important to know exactly what the pathogen species is. Knowing the species helps us in terms of our biosecurity, because there are species there that we don't want in Australia. But a lot of general mechanisms for control on-farm are similar, and for the growers it is important that you explain the lifecycle and why it is important to de-leaf.

There are two different types of banana weevil borer. That fact doesn't make much difference to the farmer, but we can say to them that as soon as you harvest your bunch you should chop up the pseudo stem, so it will break down quickly and then you won't have a problem. That is the kind of information we need to get to our colleagues, so that they are able to carry that advice on after we leave.

Chair: Thank you to everyone.

Conference synthesis

Dr Helen Scott-Orr AM PSM

The Crawford Fund NSW

At today's conference, it has been an absolute privilege to hear the speakers and the quality of the debate that they have engendered around this very complex topic.

The scene was clearly set by Su McCluskey, our very first speaker, who discussed the drivers for Australia to get more involved in the area of standard-setting, and to be able to maintain and strengthen our exports to the rest of the world. That is very important.

Then we had a really profound and complex address from Prabhu Pingali about food system transformations and biosecurity threats. He described how the global food system has been transformed in the last 60 years, with major changes and different threats coming through about every 20 years, and biosecurity threats rising with globalisation. He posed that differnt food systems around the world create both problems and solutions, challenging us to work together to find those solutions. COVID has proved overall food system resilience, but it varies greatly between areas. Smallholder resilience in developing countries will be quite different from resilience in more developed countries. Particularly, we must look to strengthen diversified and mixed farming systems rather than monocultures, while strengthening biosecurity.

Prabhu also discussed the need for value chain and societal investments. He considered the difficulty of raising consumer awareness of the externalities of food production. Possibly we are paying only a third as much for our food as we really should if we were costing in all the externalities, and it is not clear how such costing could be done. The pull from consumers was very much emphasised, with increasing demands to address biosecurity and climate resilience issues. This, of course, links with the trade nexus.

Next we heard from Rob Horsch about future-proofing our agriculture and our food systems with advanced and emerging technologies and tools. Rob skated over a terrific variety of areas with the key websites he displayed and mentioned. These sites basically summarise the massive increases in data availability and management, and the power of big data now, which we can all draw on and examine, to challenge our assumptions and try to inform broader thinking about the particular areas that we might be involved with.

Three case studies followed.

- Pablo Zarco-Tejada talked about remote sensing and hyperspectral imaging, with the example of the terrible pest *Xylella fastidiosa* that is menacing the olive groves of Europe, if not the world, and the way that early infestation

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This is an edited transcript.

of olive trees could be detected. Early detection is critical for better control, and this new technology shows great promise.

- Stacey Lynch discussed LAMP – Loop-mediated isothermal amplification – a very powerful surveillance technology that allows investigators to find a pathogen's genome in the field, using small portable equipment. LAMP enables surveillance that could not be done otherwise in many situations, such as:

  – for foot-and-mouth disease prevalence in Bhutan using oral swabs and being able to get test results 20 minutes after taking the sample, with high sensitivity and specificity;

  – for African swine fever in Timor-Leste; and

  – for khapra beetles in imported cargo entering Australia.

- Andrew Barnes spoke about the fish-farmer backpack that, again, can rapidly diagnose genomes of disease-causing bacteria in fish farms. Normally the farmer would reach for antibiotics, and with overuse of antibiotics comes AMR (antimicrobial resistance). However, with proper sequencing of the pathogen in the field, customised vaccines can be developed locally and used instead of antibiotics. This gives a more precise response, supports fish farming, and also delays or prevents the onset of AMR, which is terribly important to us.

In the third session, Rob Kaan from Corteva Agriscience spoke about the role of the private sector in this nexus area, and how public and private sectors must work together in a complementary way. Various issues and threats are being managed by companies supplying chemicals and seeds to agriculture and working across the whole crop protection and digital platform. A strong, reliable and transparent regulatory framework is needed to underpin the use of chemical products, to avoid consumer resistance. Corporate social responsibility is profoundly important: these chemical companies must be seen to be, and actually be, doing good in the areas they are working in. The best young people will only be attracted to work in firms that take on that responsibility, work with trusted public bodies, and do not solely chase quick profits, as shown by the Edelman Trust Barometer – a powerful monitor. For example, chemical companies consulted extensively with FAO to determine appropriate roles of pesticides in responses to recent invasions by fall armyworm in different systems around the world.

After lunch, Andrew Robinson gave an impassioned talk about the need for shared responsibility for biosecurity. That thinking has in recent years become a mantra in Australia and New Zealand, where they say ‘We have five million biosecurity officers in New Zealand’; in other words, their total population. Agriculture, fishing and similar fields of work are predominant in New Zealand, whereas five million in Australia is not even the population of Melbourne or Sydney. Although it is harder to sell the concept of shared responsibility right across a country like Australia, it is terribly important to do so.

Three case studies followed.

- Irene Kernot spoke about managing Panama disease in bananas: the need, once it is diagnosed, to work out what to do about it. It is very distressing to find a serious new pathogen, control of which will require destruction of the host crop, or the host animals if it is an animal pathogen. It can be emotionally and economically devasting for farmers and also for government or industry officials or others who have to implement that process. There is a need to work with farmers and look at the practicalities of the operational biosecurity they have to apply on-farm to prevent disease spread and protect other people, very often at their own expense. And, of course, compensation arrangements need to be worked out as well.
- Chris Dale talked about fall armyworm again: about preparedness and response and management, and not just prevention. We had heard about prevention in the morning session, and prevention obviously is the optimum if you can do it; but we must get the preparedness right. There are some principles of inclusivity and collaboration which are easy to say but hard to put into practice because you need to get the right stakeholders for every system, every crop, and you need to get the right control measures for the different pests and diseases.
- Tarni Cooper discussed the socioeconomic and livelihood assessment of African swine fever (ASF) and its impact on Timor-Leste, where all the pigs are very valuable because of their cultural importance there. African swine fever is also a huge issue in the Philippines where there have been much bigger economic losses, and also profound cultural and social impacts across both small and large producers of pigs. Mass depopulation is really still the only solution, followed by extremely good biosecurity. Again, that is easy to say, and terribly hard to do in a smallholder situation. There is no vaccine yet for African swine fever.

The final session was about standard-setting, and how we can manage that. Nicola Hinder brought the discussion back to Su McCluskey's opening comments: the need for rigorous, transparent standards that are feasible and not artificial trade barriers. Nicola explained very clearly the processes by which Australia works hard within the international sphere – to everyone's benefit in the long term, and certainly to Australia's benefit – to set these defensible standards. They need to be more transparent, but also strong enough to provide protection both for us and for other countries, should they choose, to implement properly against invasions of pests and diseases where possible. Nicola talked about the work of Codex and also OIE and the IPPC which are absolutely critical to this process. It makes me proud to be Australian when you see what we are doing in that standard-setting area.

Three case studies of international collaborative networks followed.

- David Gale spoke about the International Plant Sentinel Network – a lovely creative network that links botanical gardens around the world and all those people who are passionate about their plant collections. They are the obvious group to be monitoring and checking for pests and diseases. Different gardens have different sentinel crops to look at and watch over, for different pests: a very creative response to one problem.

- Jay Anderson described the long-standing Crawford Fund plant biosecurity program in Lao PDR championed by Lester Burgess. He has had young volunteers going there, working with Lao people who did not understand the diseases and did not speak much English. Lester has also linked these people with 54 or more e-mentors around the world who are specialists on different plant diseases and insects. He has developed whole networks via WhatsApp and other software, so that the local Lao people can be connected with experts, who may be in New Zealand or Sardinia, and who are thrilled to receive a new specimen or a new image that might add to global information. Then information goes back to Laos to help them manage the disease or pest there. Some local teams have now delivered scientific papers to international journals and to the Australasian Plant Pathology Network Conference a couple of weeks ago. The Australian volunteer program and some ACIAR programs are helping develop that program as well.
- Walter Okelo talked about curbing antimicrobial resistance (AMR) through a One Health approach. It is incredibly difficult to mitigate AMR in a low resource setting, and therefore he is applying a very collaborative approach, working with Fiji as a first trial, with a view to expanding the learnings to other countries in the future. Antimicrobial resistance is a very big biosecurity problem that we shall be confronting in the future, so the work Walter outlined is looking over the horizon, and getting on the front foot with new systems.

Overall, today we have heard about projects that require tremendous imagination, persistence and resilience in the scientific community to keep them all going, in spite of COVID.

This very positive and encouraging conference allows allows us to see how our food systems will, we hope, be able to withstand the biosecurity challenges of the future.

Dr Helen Scott-Orr AM PSM is a former Australian Government Inspector-General of Biosecurity; and Executive Director Research, Advisory and Education; NSW Chief Veterinary Officer; and Director, Brucellosis and Tuberculosis Eradication with NSW Agriculture. She led veterinary capacity-building projects in Indonesia on zoonotic disease control, especially rabies, anthrax, brucellosis and leptospirosis. Helen is a Fellow of the Australian Institute of Company Directors and served on the boards of Animal Health Australia and the Cooperative Research Centres for Invasive Animals, Weeds, Beef, Sheep, Cotton and Rice.

Closing comments

Dr Colin Chartres

The Crawford Fund

It is great to see many young people in-person at the conference today. In pre-COVID years the conference audience would include 40 or 50 young aspiring scientists from our Scholar Program. That program was set up because there are continually new issues and problems in agriculture and food security, and we need an enthusiastic cadre of younger people who can follow in the footsteps of people like our speakers, tackling some of these problems that are not going to go away. The Crawford Fund supports this through the activities of the RAID Network and also the ACIAR program called Nextgen which is looking at curricular materials for schools to encourage young people to go into careers in agriculture and international agriculture. Engaging with youth is critical to the future of agriculture.

From today's presentations I have come away with two messages about the future. One message that we heard is that Malthus is wrong. John Anderson pointed out that for 10 years we have managed to feed ourselves quite well across the whole of the globe. I would qualify that by saying there are problems of access and affordability in some countries, and the equally big problems of malnutrition and overnutrition which are integral to agriculture and health. But if that is the case, and we still have the science to keep up with population growth until it (we hope) levels out, then two big issues are confronting us.

– One issue is around One Health and the links between agriculture, environment and health. Walter Okelo pointed out the importance of a One Health approach against antimicrobial resistance, and I think, in terms of tackling future zoonoses and other pests and diseases, that One Health is going to be very critical, and something we all need to think about.

– The other issue is the overall impact that agriculture is having on all of us, and on our environment. Several speakers mentioned this, including Prabhu Pingali: particularly the impact agriculture has on greenhouse gas production – producing I think 18 or 20% of our emissions. Biosecurity is vitally impacted in both a good and a bad sense by agriculture. Land clearing is causing tremendous damage to biodiversity, not only in Australia but also elsewhere. And agriculture interacts with water scarcity. These are some of the challenges we shall have to grapple with in the future: the impact of agriculture on our whole environment, and on our health.

The other message I have received from this conference is that we all need to be involved in this. We cannot just be scientists sitting in our offices or laboratories

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This record has been prepared from a transcript.

thinking about the nexus and saying it is all doom and gloom. I liked the analogy of us all being goalkeepers: the farmers, and the scientists, the community and policymakers and regulators, all working together to prevent biosecurity issues.

We have to make sure that the challenges we have heard about today are not just issues we talk about in our small groups, our 'silos', but that we talk about them right across the community.

Some interesting thoughts, which we will certainly take forward to our next conference.

Finally, a very big thank you to Cathy Reade and her team who have organised this conference through its various false starts, culminating at last in this actual meeting which has run so smoothly, both last evening and today.

Dr Colin Chartres is the Chief Executive Officer of the Crawford Fund and 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. From 2002 to 2004 he was part of CSIRO Land and Water, where he was involved in business development and international science linkages. Colin has 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 he is an Honorary Professor in the Crawford School of Public Policy at Australian National University.

Conference participants, in-person and online

* indicates Crawford Fund Scholars for 2021

Abbott, Angus	Plant Health Australia
Ackland, Ebony	ACIAR
Agaid, Timothy	Chop Inc.
Akbari, Mona	Department of Agriculture, Water and the Environment
Alagcan, Mai	ACIAR
Alders AO, Robyn	Development Policy Centre, Australian National University
Allen, John	CSIRO – Australian Centre for Disease Preparedness
Amaefula, Adanma	National Root Crops Research Institute (Nigeria)
*Anagnostis, Mikali	The University of Sydney
Anderson, Jay	Southern Cross University
Anderson AO, John	The Crawford Fund
Andrew, Neil	The Crawford Fund
Ariani, Miranti	Indonesian Agricultural Environment Research Institute/ Gadjah Mada University
*Armati, Eleanor	The University of Sydney
Armstrong, Tristan	Department of Foreign Affairs and Trade
Arnold AO, Lynn	The Crawford Fund
Ash, Gavin	University of Southern Queensland
Ashhurst, Robbie	James Ruse Agricultural High School
*Austin, Anneliese	Bees for Sustainable Livelihoods
Ayodele, Oluwatobi	Osun Rural Access and Mobility Project (Nigeria)
Bacic, Tony	La Trobe Institute for Agriculture and Food
Baker, Derek	University of New England Centre for Agribusiness
Band, Pip	Band Consulting
Bansal, Nidhi	The University of Queensland – School of Agriculture and Food Sciences
Barkla, Bronwyn	Southern Cross University
Barnes, Andrew	The University of Queensland
Barrero, Jose	CSIRO Agriculture and Food
Basford, Kaye	The Crawford Fund
*Bates, Amy	Charles Sturt University
Beattie, Keira	Department of Agriculture, Water and the Environment
Bett, Bosibori	RAID
Biddle, Julianne	ACIAR

1 The acronyms ACIAR, ANU, CSIRO, QAAFI and RAID are expanded on page 145.

Birrell, Nicole	International Maize and Wheat Improvement Center (CIMMYT)
Blackburn, John	Institute for Integrated Economic Research Australia Ltd
Blight AO, Denis	ANU – School of History
Blumenthal, Martin	NSW Department of Primary Industries
Bolin, Jessica	University of the Sunshine Coast
Bouterakos, Maree	World Food Programme
Boyd, Davina	Murdoch University
Boyd, Lynette	University of the Sunshine Coast
Breen, Joshua	ACIAR
Byron, Neil	Alluvium – NCEconomics
Carmichael, Alison	Department of Agriculture, Water and the Environment
Cavanagh, Stacy	The University of Sydney
Chartres, Colin	The Crawford Fund
Cheng, Paul	The University of Melbourne
*Chew, Woon Ling	La Trobe University
Chia, Victoria	World Food Prize Foundation
*Christophers, Ayla	The University of Adelaide
*Chudleigh, Billy	The University of Melbourne
Claessens, Michael	Canberra Region Food Collaborative
Cleland, Robyn	Department of Agriculture, Water and the Environment
Coffey, Shaun	The Crawford Fund
Colvin, Alison	University of New England
Cooke, Hannah	Department of Industry, Tourism and Trade (Northern Territory)
*Cooper, Lucy	University of Tasmania
Cooper, Tarni	The University of Queensland
Cotton, Rebecca	RAID
Courville, Sasha	ACIAR
Crimp, Steven	ANU – Fenner School of Environment and Society
Cruz, Eric	Australian Pesticides and Veterinary Medicines Authority
Cummins, Cathryn	Department of Agriculture, Water and the Environment
*Cuthbertson, Scarlett	The University of Melbourne
Dale, Christopher	Department of Agriculture, Water and the Environment
Dalton, John	Dalton NRM
Dart, Peter	The University of Queensland
Datt, Nitesh	Biosecurity Authority of Fiji
Dean, Eleanor	ACIAR

Dibley, Kathy	CSIRO Agriculture and Food
Dixon, John	The University of Queensland / ANU
Doerflinger, Fran	The New Zealand Institute for Plant and Food Research Limited
Donaldson, Amy	Department of Agriculture, Water and the Environment
Downard, Fleur	Department of Agriculture, Water and the Environment
Drenth, Andre	The University of Queensland
*Dunne, Angus	Mulloon Consulting
*Ebert, Hannah	The University of Melbourne
Edgar, Robert	The Crawford Fund Victoria Committee
Egan, Andrew	Department of Foreign Affairs and Trade
Escobar, Andrea	Soydoy Foundation
Esham, Mohamed	Sabaragamuwa University of Sri Lanka
Evans, Jessica	Department of Foreign Affairs and Trade
Falvey, Lindsay	ACIAR
Faulkner, Sue	The Crawford Fund
Fazakerley, John	The University of Melbourne – Faculty of Veterinary and Agricultural Sciences
Fearnley, Jessica	RAID
Fernandes, Leandra	Griffith University
Field, Damien	The University of Sydney
Finlay, Eliza	Department of Agriculture, Water and the Environment
Fischer AM, Tony	CSIRO Agriculture and Food
Fischer, Gemma	Gemma Fischer Photography
Ford, Rebecca	Griffith University
Fox, Paul	globalEDGE
Fraser, Greg	Protected Cropping Australia
Gale, David	Plant Health Australia
Gallo, Andrea	La Trobe Institute for Agriculture and Food
Garnett, Helen	The Crawford Fund
Gaynor, Suzie	ACIAR
Genova, Christian	The New Zealand Institute for Plant and Food Research Limited
Geraghty-Dusan, Francette	Indo-Pacific Centre for Health Security
Glen, Morag	University of Tasmania – Tasmanian Institute of Agriculture
Gorea, Emmanuel	Papua New Guinea Oil Palm Research Association
Graham, Scott	Barker College
Gregson AM, Tony	The Crawford Fund

Griffin, Traci	Agriculture Victoria
Hall, Howard	ACIAR
Hanifah, Vyta	Indonesian Agency for Agricultural Research & Development, Indonesian Ministry of Agriculture
Hanks, Jenny	The University of Melbourne
Hassan, Azeez T	Federal University of Agriculture, Abeokuta (Nigeria)
Healey, Madaline	University of the Sunshine Coast
Herrald-Woods, Elyse	Department of Agriculture, Water and the Environment
Higgins, TJ	CSIRO
Hinder PSM, Nicola	Department of Agriculture, Water and the Environment
Hinds, Lyn	CSIRO Health and Biosecurity
Hitchcock, Bobbie	Department of Agriculture, Water and the Environment
Hoang, Huong	Thai Nguyen University of Agriculture and Forestry
*Hone, Holly	Agriculture Victoria Research
Hongsathilath, Sabaidee Mayouly	Provincial Agriculture and Forestry Service Savannakhet (Laos)
Hopeq, Tammy	CQUniversity, Queensland
Horn, Peter	ACIAR
Horsch, Rob	Global Commission on Adaptation, World Resources Institute
Horsey, Bridget	University of the Sunshine Coast
*House, Jenny	Charles Darwin University
Howley, Carmel	agresearch (New Zealand)
Humphries, Camilla	RAID
Huttner, Eric	ACIAR
Huynh, Trinh	University of the Sunshine Coast
Iga, Doreen	ACIAR
Irwin, Sonia	Department of Agriculture, Water and the Environment
*Isu, Faruq	Southern Farming Systems
Ives, Stephen	University of Tasmania
Jackson, Tamara	ACIAR
Jayasekara, Preethinie	University of New England
Jenson, Ian	Meat & Livestock Australia
Johnson, Laura	Department of Agriculture, Water and the Environment
Johnston, Robyn	ACIAR
Johnstone (McKenzie), Tara	University of the Sunshine Coast
Jones, Ruby	ACIAR
Kaan, Robert	Corteva Agriscience
Kafle, Arun	University of South Australia

Kalibata, Agnes	Alliance for a Green Revolution in Africa
Kamau, Mumbi	Department of Agriculture, Water and the Environment
Kanchana-Udomkan, Chat	Griffith University
*Kay, Phil	University of Tasmania – Tasmanian Institute of Agriculture
KC, Diwakar	Griffith University
Keating, Brian	The University of Queensland
Kelly, Jennifer	CSIRO
Kenny, Christina	University of New England
Kerin AM, John	The Crawford Fund
Kernot, Irene	ACIAR
*Khan, Waleed	University of Tasmania
Kibet, Abraham	Climate Smart Agriculture Youth Network
Krishnan, Mahima	The University of Adelaide
Kumar, Hemendra	Meb
Novembre, Ana Dionisia da Luz Coelho	University of Sao Paulo – ESALQ (Escola Superior de Agricultura Luiz de Queiroz)
Lamberton, Emily	Department of Agriculture, Water and the Environment
Langfield, Thomas	Department of Agriculture, Water and the Environment
Langford, Kate	CSIRO
Lawn, Bob	The Crawford Fund
Lawson, Simon	University of the Sunshine Coast
Le, Duy	NSW Department of Primary Industries
Le, Sang	University of New England
*Lee, Jordan	The University of Queensland – QAAFI
Lemerle, Deirdre	The Crawford Fund
Lewis, Bill	The Crawford Fund
Li, Yin	CSIRO
Liang, Xia	The University of Melbourne
Liehr, Eoin	University of New England
Lochner, Kayla	University of New South Wales / RAID
Logan, Emma	Department of Agriculture, Water and the Environment
Lountain, Sophie	University of South Australia
Lynch, Stacey	Agriculture Victoria Research
Lynn, Fiona	Department of Foreign Affairs and Trade
MacDonald, Heather	Education Partnerships
Maske, Mahesh	Borlaug Institute for South Asia (BISA)
Mayberry, Dianne	CSIRO
McCawley, Peter	ANU

McCluskey, Su	ACIAR
McGill, David	The University of Melbourne
McGregor, Robert	Department of Foreign Affairs and Trade
McNeill, Annie	The Crawford Fund
Mendham, Neville	The Crawford Fund
*Mercer, Clarence	NSW Department of Primary Industries
Mganga, Kevin	South Eastern Kenya University
Mienmany, Soytavanh	ANU – Fenner School of Environment and Society
*Miller, Troy	Flinders University
Milligan, Ann	ENRiT: Environment & Natural Resources in Text
Mills, Amy	University of the Sunshine Coast
Moata, Melinda R.S.	State Agricultural Polytechnic of Kupang (Indonesia)
Molero, Sally	RAID
Molesworth, Anika	Climate Wise Agriculture
Morrison, Sabrina	The University of Queensland
*Mullot, Larissa	The Crawford Fund
Munidasa, Sineka	The University of Melbourne
Nakamura, Michelle	ACIAR
Nath, Onkar	The University of Queensland – QAAFI
Naumann, Ian	Department of Agriculture, Water and the Environment
Ndufeiya-Kumasi, Lauritta	University of Benin (Nigeria)
Nelson, Sam	GrainGrowers
Neupane, Ram	Agriculture and Forestry University (Nepal)
Nguyen Van, Kien	Plant Resources Center (PRC) (Vietnam)
Nguyen, Van	Institute of Animal Sciences of South Vietnam
Nielsen, Belinda	ACIAR
Nil, Khin Zaw Tun	FCA Finn Church Aid
*Noga, Sekondeko Ronnie	James Cook University
*Norman, Michael	CSIRO
Nuradin Abdi, Nuradin	Haramaya University (Ethiopia)
Nurberg, Ian	The Crawford Fund
O'Dwyer, Cecilia	The University of Queensland
*Ohl, Melanie	CQUniversity, Queensland
Okello, Anna	ACIAR
Okelo, Walter	CSIRO
Oliver, Tanya	Department of Agriculture, Water and the Environment
Olmo, Luisa	University of New England
O'Mullan, Cathy	CQUniversity, Queensland

Onyango, Patricia	International Centre for Tropical Agriculture (CIAT)
*Oude-Egberink, Isabelle	Biosecurity SA
Palaniappan, Gomathy	The University of Queensland – School of Agriculture and Food Sciences
Paradice, Sarah	The Crawford Fund
Parry-Husbands, Howard	Pollinate
Pasiona, Sonny	University of the Philippines Los Baños
Patil, Raj	Department of Agriculture, Water and the Environment
Paul, Tania	The Crawford Fund
Penrose, Beth	University of Tasmania – Tasmanian Institute of Agriculture
Percival, Chris	Department of Agriculture, Water and the Environment
Peterson, Sophie	Department of Agriculture, Water and the Environment
Pethybridge, Heidi	CSIRO Oceans and Atmosphere
Pettersen, Claudia	University of the Sunshine Coast
*Pfeifer, Hayley	The University of Adelaide
Pham, Anh	RAID
Phan, Jana	RAID
Phengphachanh, Sa Bai Dee Bounma	Rice Research Center
Philpot, Danette	Texas A&M University
Phongoudome, Chanhsamone	National Agriculture and Forestry Research Institute (Laos)
Phongoudome, Phonepakay	Forestry Research Center
Pingali, Prabhu	Tata-Cornell Institute for Agriculture and Nutrition
Pogson, Barry	ANU
Proctor, Murray	SEEK Development
Quashie-Williams, Carol	Department of Agriculture, Water and the Environment
Radcliffe AM, John	The Crawford Fund
Rahiria, Florence	Pacific Community–SPC
*Rajan Babu Sheela, Raj Kishore	University of Tasmania
Ramsay, Malcolm	The Crawford Fund
*Ramsay, William	Australian Centre for Pacific Islands Research
Ramsden, Jessica	Elanco Australasia
Raneri, Jessica	ACIAR
*Ray, Jane	The University of Queensland
Rayamajhi, Kamana	Nepal Agricultural Research Council
Reade, Cathy	The Crawford Fund
Readford, Phoebe	CSIRO – Australian Centre for Disease Preparedness

Reeves, Timothy	The Crawford Fund
Rehman, Ata-ur	Charles Sturt University
Reid AO, Margaret	The Crawford Fund
Ribeiro, Camila	Forest Research Institute
*Rima, Sharmin	ANU
Rincon Florez, Vivian	The University of Queensland QAAFI – Centre for Horticultural Science
Robinson, Andrew	The University of Melbourne – Centre of Excellence for Biosecurity Risk Analysis
Rodger, Stephen	Department of Agriculture, Water and the Environment
Rodney Harris, Rachael	ANU – Fenner School of Environment and Society
Ross, Ben	Department of Agriculture, Water and the Environment
Rupesinghe, Tharindri	Market Development Facility (Sri Lanka)
*Russell, Alex	The University of Melbourne
Samdrup, Tshering	The University of Western Australia
Saqlain, Daud	Human Appeal – Pakistan
Schrobback, Peggy	CSIRO
Scobie, Michael	University of Southern Queensland
Scott-Orr AM PSM, Helen	The Crawford Fund
Sedowo, Matthew	Charles Sturt University
Sekulic, Gregory	CropLife Australia
Shafi, Sadiah	SKUAST Kashmir (Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir), India
Shearer, David	Commission on Sustainable Agriculture Intensification (CoSAI)
Sheldrake AM, Richard	The Crawford Fund
Shine, Jody	Department of Foreign Affairs And Trade
Simmons, Luke	Department of Foreign Affairs and Trade
Simson, Fiona	ACIAR
Singh, Kanika	The University of Sydney
Singh, Shweta	The University of Queensland – School of Agriculture and Food Sciences
Sinn, Michelle	Department of Agriculture and Fisheries, Queensland
*Skinner, Tanya	ANU
Smith, Millicent	The University of Queensland – School of Agriculture and Food Sciences
Smith, Monica	University of the Sunshine Coast
Stacey, Samuel	Cultivate Communications
Starasts, Ann	University of Southern Queensland

Stark, Greta	The University of Adelaide
Steel, Elya	RAID
Stone, Sally	CABI (Centre for Agriculture and Bioscience International)
Sullivan, Abbey	University of the Sunshine Coast
Supian, Suhaina	Malaysian Agricultural Research and Development Institute (MARDI)
Sushil, Zaynel	CSIRO
Suttie, Annika	CSIRO
Sweetingham, Mark	The Crawford Fund
Tariq, Hafiz Ahmed Hassan	UVAS (University of Veterinary & Animal Sciences), Lahore (Pakistan)
*Taylor, Demi	Charles Sturt University
Taylor AO, Michael	The Crawford Fund
Taylor, Paul	The University of Melbourne
Tenkouano, Abdou	CORAF (West and Central African Council for Agricultural Research and Development), Dakar (Senegal)
*Thomas, Isabelle	The University of Adelaide
Thompson, Adam	Department of Agriculture, Water and the Environment
Thorp, Grant	Plant & Food Research Australia
Tran-Nguyen, Lucy	Department of Industry, Tourism and Trade (Northern Territory)
Umberger, Wendy	ACIAR
*Van Den Nieuwenhuizen, Erin	Department of Primary Industries
Van Haeften, Shanice	RAID Network
Van Wensveen, Monica	Department of Foreign Affairs and Trade /CSIRO
Vial, Leigh	ACIAR
Vithanage, Upul Yasantha	ANU
Walker, Dan	ACIAR
Walsh, James	ACIAR
*Wang, Pinhui	ANU
Warner, Richard	The Crawford Fund
Watson, Liam	Department of Agriculture, Water and the Environment
Webb, Michael	CSIRO
Weir, Glen	The Crawford Fund Committee
Wellawatta, Ayesha	ANU
*Wellington, Michael	ANU
Whittle, John	Self Employed
Wickes PSM, Roger	The Crawford Fund
Williams, Megan	RAID

*Wilson, Salome	ANU
Wiyati, Rusmi	STIPAP (Indonesia)
Wood, Mellissa	CSIRO
Woodiwiss, Olivia	Pinion Advisory
Woods, Beth	ACIAR
Wynn, Peter	Charles Sturt University
Yani, Nofri	Cahaya Maritime Foundation (Indonesia)
York, Tony	ACIAR
Young, Anthony	The University of Queensland – School of Agriculture and Food Sciences
Zarco-Tejada, Pablo J.	The University of Melbourne
*Zhou, Ziwei	Griffith University

Acronyms expanded

ACIAR	Australian Centre for International Agricultural Research
ANU	Australian National University
CSIRO	Commonwealth Scientific and Industrial Research Organisation
QAAFI	Queensland Alliance for Agriculture and Food Innovation
RAID	Researchers in Agriculture for International Development

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For further information,
to support us or to be kept informed
of the Crawford Fund's work, please contact:

THE CRAWFORD FUND
Building 7, Unit 7, 1 Dairy Road
Fyshwick ACT 2609 Australia

Phone: 02 6280 8611
Email: crawford@crawfordfund.org

www.crawfordfund.org

ABN: 86 141 714 490

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