GLOBAL FOOD SECURITY IN A RISKIER WORLD

Diversification for resilient food and nutrition systems

The Crawford Fund 2023 ANNUAL CONFERENCE

4–5 September 2023

QT Canberra Hotel
ACT Australia
and online

Crawford Fund FOR A FOOD SECURE WORLD

Editor Ann Milligan

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The Crawford Fund

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

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

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

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

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

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

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Foreword

The Crawford Fund, the speakers and Chairs at this conference acknowledged it was held on the traditional lands of the Ngunnawal nation, and paid their respects to Elders past, present and emerging.

The Crawford Fund's annual conference is a unique opportunity for young people to encounter highly esteemed thinkers, leaders and practitioners in agricultural research and policy for development, from Australia and across the world.

This year the conference discussed 'Global food security in a riskier world: diversification for resilient food and nutrition systems', against the background of climate change, COVID and conflict. Delegates, as is usual now, attended in person or online all over the world, including this year's 40 conference scholars, as well as members of the RAID Network* (Researchers in Agriculture for International Development), one of the Fund's next-gen initiatives.

Agricultural production, and the policy, economics and research involved, are noble pursuits, aiming to feed the world and lift people out of deprivation and into opportunity and a brighter future. It is incredible to think of the progress that has been made so far, and that until the war in Ukraine the world's farmers were producing enough food to feed a global population of 10 billion. Clearly, we need to be very astute, very aware of the challenges that undoubtedly confront us in an unstable world – and to think ahead. As Dr Éliane Ubalijoro reminds us in the 2023 Sir John Crawford Memorial Address, it takes years to grow a tree for shade or fruit or wood, and it takes the forethought involved in comprehensive seedbanks to enable cropping, forestry and agroforestry to be rebuilt after intense conflict or climatic disasters.

The papers in these proceedings highlight how diversification opens new opportunities, such as via: reintroducing indigenous crops to cropping systems; relevant information for crop production and management; farming insect larvae; new fertiliser formulations; supply chains working to reduce greenhouse gas emissions; and governments improving food systems, and reforming agri-food policies and investment.

Our conferences benefit hugely from the support of the sponsoring organisations and individuals that are listed in the Acknowledgements below. Many of these people and organisations are also involved in the Crawford Fund's training and next-gen activities that support the conference scholars. We truly appreciate their ongoing collaboration.

The Hon John Anderson AC
Chair, The Crawford Fund

* see the RAID Keynote Listeners' summary at
https://www.crawfordfund.org/news/crawford-2023-conf-keynote-listeners-report/

Acknowledgements

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

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Attending Crawford Fund Board, coordinators and staff, with the 2023 conference scholars, at QT Canberra Hotel, 4 September.

SIR JOHN CRAWFORD MEMORIAL ADDRESS 2023

Food and nutrition security: the climate, food systems, agroforestry and forestry nexus

Dr Éliane Ubalijoro

CEO, Center for International Forestry Research (CIFOR) and World Agroforestry (ICRAF)

Good evening, everyone. It is my great pleasure to join all of you this evening and present the Sir John Crawford Memorial Address on food and nutrition security: the climate, food systems, agroforestry and forestry nexus. I want to thank the Crawford Fund for inviting me to speak on these critically important topics, so very close to my heart.

As we navigate what it takes to stay within three degrees Celsius to avoid climate tipping point, we also face immense food security and nutritional challenges. According to the *State of Food Security and Nutrition in the World 2023* report (FAO 2023), an additional 122 million people have been pushed into hunger since 2019. Of the 2.4 billion people facing the lack of constant access to food, around 900 million individuals faced severe food insecurity in 2022. Moreover, access to healthy diets has deteriorated since the global pandemic, with 3.1 billion people unable to afford a nutritious diet in 2021, an increase of 134 million people compared to 2019.

We all know the challenges humanity is facing. However, we also have access to decades of action research and development data that show solutions to problems, and opportunities to reimagine the way we interact with nature. And we can do it through global cooperation, knowledge-sharing and a commitment to building a better world – one that respects nature and one where people can live healthy lives and with enough nutritious food.

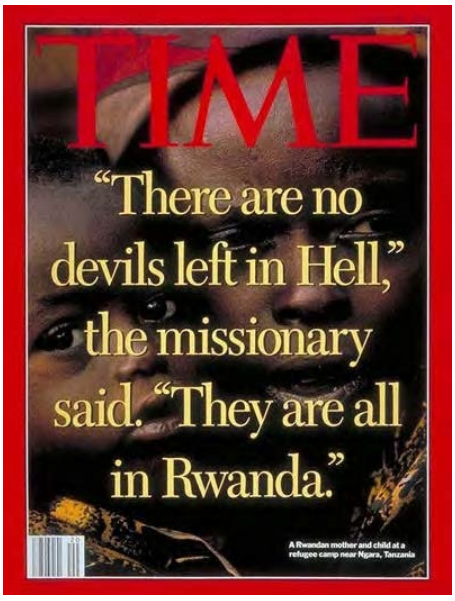
Trees and forest landscapes play a critical role in this; without them, a food-secure nutritious future is impossible. Warren Buffett once said: 'Someone is sitting in the shade today because someone planted a tree a long time ago'. Some of the work we do today may take a long time to bear fruit, but a lot of it can have an almost immediate impact on well-being and food and nutritional security.

I am told I'm the first person representing forestry and agroforestry to be delivering this address, and so I look forward to sharing what forestry and agroforestry have to do with climate and food systems, and it's an immense honour for me to be here to do that. Over the past four months, since I joined CIFOR-ICRAF, I have experienced a number of firsts, including becoming the first African woman CEO of a CGIAR Center. These firsts are both a great privilege and a great responsibility, and one that I'm delighted and eager to take on, and as such it feels very fitting that you welcome me here this evening to speak on food and nutrition security. But my trajectory was not meant to bring me here today.

Now, as I mention the challenges that CIFOR-ICRAF is working to solve, I will take the opportunity to introduce myself through these challenges. As also for many of you, these challenges have touched my personal life. They have influenced what I have studied in university, the direction of my life and the decisions I make. They are challenges that I hope my own child and other children will not be left to grapple with once they take over leadership from us.

I was born in Rwanda in the seventies, and I am privileged to have poignant memories of a childhood connected to the Earth and of the lessons I learned from my mother about how to take care of the Earth. When I embarked on my journey from Kigali to Montreal in August 1989 at the age of 17, I expected to be back three years later from McGill University with my bachelor's degree in general agriculture in hand, to work with smallholder farmers. But life had different plans. I started university with a desire to be on the cutting edge of what's possible and to use these scientific tools to improve lives, particularly the lives of the most vulnerable to food security and malnutrition in Africa. But I didn't expect that the arc of my life would take me on an unexpected journey, and that it would take me 34 years to get back to the continent to settle.

When Rwanda initially went through a civil war, I went home as a 19-year-old intern to work on improving local forages. But what should have been a summer of immersion in research and action was also a summer of getting authorisation passes from field site to field site, going through checkpoints manned by our military. When this escalated in the 1994 genocide against the Tutsis in April 1994, I was 22 years old. At that point, I was writing my Master's thesis on mapping genes resistant to plant viruses.



While my homeland was aflame, *Time* magazine had this on its cover: 'There are no devils left in Hell ...They are all in Rwanda'. This is a memory I will hold in my heart forever. Somewhere between 800,000 and a million people were slaughtered in 100 days. Many were slaughtered with machetes that should have been meant for agricultural use.

But many people don't know that as a result of this terrible time in Rwanda, and since then in its aftermath, many forested lands were lost. Rwanda's Gishwati Natural Forest, which was about 100,000 hectares, lost 99% of its cover, the result of subsistence harvesting and cultivation by refugees in the aftermath. This brings me to the challenges that CIFOR-ICRAF is solving.

Challenge: Safeguarding biodiversity

Here are some grim statistics: over 50% of the world's tropical forests have been destroyed. On average, 137 species are driven to extinction in tropical rainforests every day; and more than a quarter of the threatened species are threatened with extinction.

But there is good news: there's an incredible amount of work on the ground right now to counter this threat. Prior to joining CIFOR-ICRAF I was on the executive board of the Global Crop Diversity Trust, and was lucky enough to work with the Honourable Tim Fischer, former Deputy Prime Minister of Australia. The Crop Trust provides funding to key seedbanks and genebanks around the world, including the CIFOR-ICRAF tree genebank in Nairobi, so they can safeguard the seeds and share them with farmers, researchers and plant breeders globally. I was already familiar with the importance of genebanks before joining CIFOR-ICRAF and the Crop Trust. In fact, I saw first-hand how important they are after the genocide that happened in Rwanda.

As a continent, Africa holds 26% of the biodiversity on the planet. We hold immense potential in terms of carbon sequestration and bringing back biodiversity. But unless the biodiversity is safeguarded, it can too easily be lost. During the 100 days of the genocide against the Tutsis, I didn't know if most of the people I loved in Rwanda were alive. I was writing my thesis, so the contrast between what was happening in my motherland and what I was doing as a student in Canada was huge; it was very difficult to reconcile.

In the years since, I have met some of the people who worked with bean genebanks. Beans are really critical to the Rwandan economy and our traditional diets, and when the genocide happened, people weren't able to harvest their crops, and so the crops withered in the fields and farmers couldn't collect seeds from them to plant and harvest the next year. When the economy restarted, we needed to replenish the stocks of beans in

the country – and because there were genebanks around the world that held copies of the genetic diversity of beans from Rwanda, we were able to restart.

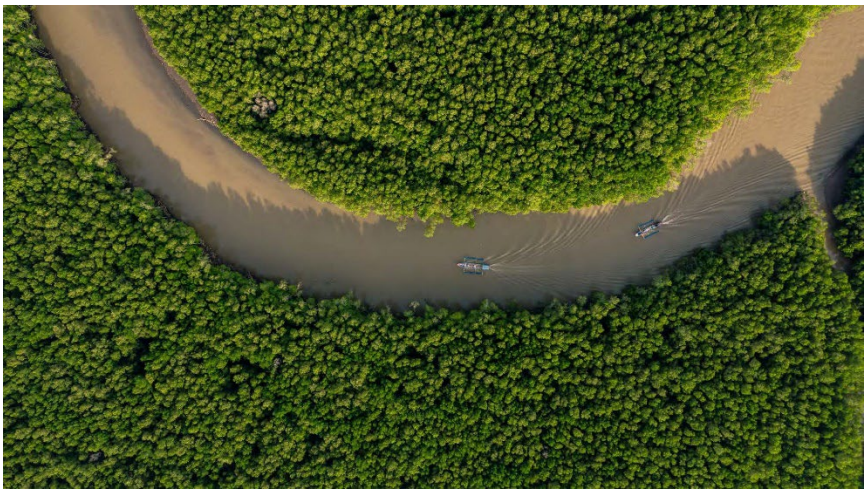
People don't understand the relationship between genebanks and what needs to happen when we have conflict or other terrible situations in the world and need to restart economies or restoration. It's important to understand that genebanks are very crucial for keeping hope alive, especially for our food systems and bringing back nature after major crises.

At CIFOR-ICRAF we are home to one of the largest tropical tree seed collections in the world: 190 tree species represented; 7000 seed samples and accessions conserved; three decades of scientific and on-the-ground expertise; 30 countries represented in where these genebanks are; 1800 smallholder farm-households supported to access food-tree species; and 6000 farmers trained in food-tree cultivation and use. And beyond safeguarding these seeds and making them available for use, we also use our expertise to help ensure that we grow the right tree at the right time for the right place, so that the seedlings can thrive with purpose.

Leading an organisation that not only helps safeguard the brilliant tree diversity around us, but also shares materials with farmers, breeders and researchers and supports work to adapt trees to the changing climate, pest disease and other challenges, is a way of making sure my daughter – and my daughter's children – will never need to be left with an Earth that's barren of biodiversity and life. That brings me to our second challenge.

Challenge: Solving climate change

CIFOR-ICRAF is committed to solving climate change. A question we are confronted with daily is how do we live within our planetary boundaries? How do we build interconnectedness? Right now, many of us are confronted with vicious cycles where poor practices or situations result in greater environmental damage, which exacerbates existing problems. In fact, the volatile challenges we face negatively impact one another. But with key changes we can move these vicious cycles into virtuous ones, creating small or big changes that positively influence one another to create new, positive and 'green' ways of thinking and doing things.



I recall that in my childhood I spent a lot of time in the countryside with smallholder farmers, enjoying the beauty of our forests, and I remember how green everything was, how lush it was, and how little dust was in the air. Decades later, the same areas have seen genocide, deforestation, soil degradation. But there is hope in Rwanda, because to bring back biodiversity and to focus on green growth are priorities for the country. I feel very lucky to have contributed to this new history for Rwanda as a member of the Presidential Advisory Council, which also includes two amazing Australians – Michael Roux and Doug Shears – both of whom are deeply committed to being outstanding global citizens.

As you probably know, global temperatures are expected to rise three degrees by the end of the century, and I'm sure it's no surprise to anyone that trees play a critical role in avoiding catastrophic climate change. Trees are a source of food and shade; they conserve water, give us oxygen and clean air, support soil health and support wildlife. Sustainable land management – including agroforestry, ecosystem conservation and restoration – and a transition to sustainable economic models are key for this.

All CIFOR-ICRAF research contributes to climate-change mitigation and adaptation by helping to keep trees in the ground, increasing tree cover and finding the best trees for local conditions. We have also done ground-breaking and award-winning research on wetlands. In 2017, our research

using the Global Wetlands Map (https://www2.cifor.org/global-wetlands/) revealed that there is three times more peat worldwide than previously thought. And prior to this, there was the pivotal 2011 discovery that mangroves store 3 to 5 times more carbon than other tropical forests, most of it in the soil (Donato *et al*. 2011). No-one really realises just how critical they are in our fight against climate change. Through this research, we are able to galvanise greater protection for wetlands, working together with partners, especially in Indonesia. It is important research like this that both reveals and quantifies the value of our Earth's resources, that helps inspire protection – and our scientists are at the forefront of it.

I should also mention our research on carbon markets. When I started looking at carbon markets in the early 2000s, Africa only had 5% of that market. I thought that to grow Africa's sustainability, and to build prosperity there had to be 'green growth' – that is, paths of economic growth that are environmentally sustainable – and so I knew we would have to focus on climate funding. Today we're in a much different space around nature and finance. We had a very successful COP15 in Montreal in 2022, where I had the opportunity to participate with the largest private-sector presence ever for a biodiversity COP, and so this is work I see expanding. I envision a world where the private sector takes a greater role in climate-change mitigation, and reduces their own impact. Work at CIFOR-ICRAF supports them to do this.

Challenge: Food security

Perhaps most important for those at this Crawford Fund conference is our work explicitly around food security, although I would argue that everything we do, as I've outlined so far, has an impact on this. As I mentioned before, I became acutely aware of the importance of ensuring we safeguard our food security through international collaboration and genebanks during the Rwandan civil war. Safeguarding and sharing seeds is one piece of the puzzle. Whether restoring degraded forests, or re-establishing local crop seed systems, no conversation about food security can be had without discussions about trees. For food and nutrition security in the context of agroforestry and forestry, no other organisation has as holistic an approach as CIFOR-ICRAF.

For my part, I began my academic career at 17 at McGill, and during my undergraduate studies when I went home, and during my internship, it was really difficult to think that one day I'd be able to come back to Africa and work with smallholder farmers. So, I decided to take on a PhD, and I studied molecular genetics because I was interested in the cutting edge of innovation. Working at

that interface of genetics, of discoveries that were going to change how we relate to DNA, for me was an alternative path to what I really longed for – which was to be working at the forefront of food security globally. When I finished my PhD I joined a biotechnology company in molecular diagnostics and worked on how to use DNA to look at food industry safety: on whether there are microbial contaminants for food, environmental contaminants; in some cases, we even worked on bioterrorism. These early beginnings allowed me to do work that I now see was crucial to me becoming the woman and the scientist I am today.

One of the areas that I think is absolutely critical is how we are looking after our soil, the Earth's skin. The health of our soil determines the health of our food systems, which will determine the health of our global populations.

In Africa, 65% of the soils are degraded, as are a third of soils around the world. Healthy soils are a foundation for functioning ecosystems, including sustainable agricultural systems. Our Nairobi campus of ICRAF is home to a state-of-the-art soil spectroscopy lab (the ICRAF GeoScience Laboratory) and the global database of ecosystem health indicators – one of the world's best tools for large-scale and accurate soil analytics. By assessing land and soil health, we can provide analysis at farm, landscape and global levels and beyond.

We also look at trees and look at how they are dependent on the quality of soil, in order to solve hunger. We are currently working with partners in India on trees outside forests, in a five-year initiative funded by the United States Agency for International Development (USAID) and India's Union Ministry of Environment, Forest and Climate Change. The initiative looks at expanding the areas that are cultivated under trees outside forests. The greatest opportunities in the world for growing trees are actually on-farm.

One of the things we see as critical in this project in India, which is a US$25 million project, is the possibility of strengthening the enabling environment: to improve laws, regulations, policy, certification and standards, to scale-up trees outside forests. We see this as a way to increase access to finance, insurance and good-quality planting material, to provide incentives and value-chain support to boost the demand for products from trees outside farms. We also see this as a way to bridge the gaps in technical and market information through extension service, knowledge, data, monitoring and decision systems.

When I see the work that we're doing in India in this case, I am reminded of my own home of Rwanda and how planting the right tree in the right place for the right purpose can have such an immense impact in a relatively short amount of time, especially when planted on farms. And I am reminded, as well, of how dry dusty air can be transformed by a greener environment when there's fruit, when there's fertile soil, and when smallholder farmers can have rich harvests of the traditional foods often neglected but so important for local nutrition and food security.

CIFOR-ICRAF achievements

In fact, the topics we care so deeply about this evening are ones that CIFOR-ICRAF has been committed to solving for the past 40-plus years: safeguarding biodiversity, stabilising the climate, transforming food systems and value chains, and ensuring equity in everything we do. These challenges interact with one another, and what we know now is that, fortunately, there are solutions which many of you here today are either championing or funding or researching. At CIFOR-ICRAF that's exactly what happens every day. We have been at the forefront of combining rigorous science with an action-focused mission, building capacity, influencing global policy and transforming ecosystems.

Today, CIFOR-ICRAF stands as one of the best examples of what is possible. I'm invigorated to lead CIFOR-ICRAF to harness what we have learned over decades of work and to rise to the moment in this particular moment in human history, and use our collective passion, creativity and intellect to build a better Earth.

At CIFOR-ICRAF what we do is ground-breaking research around trees, forests and agroforestry, and landscapes. We have used our research to improve the lives of people and influence policy globally, and fortunately we are implementing these solutions in partnership, and many of you today here are partners whom we work with happily, and look forward to doing even more with in the future.

CIFOR has been around for 30 years headquartered in Indonesia, and ICRAF for 45 years headquartered in Nairobi, with offices in many countries in Asia, Africa and Latin America. We are now a unified organisation, where seeds of trees stored in a world-class genebank allow research on forests and communities and biodiversity. We bring together the expertise of scientists from around the world, communication experts and fund raisers, to develop innovative solutions to scale-up investment in sustainable development and address the global challenges of our time. My journey has interfaced biodiversity, health, gender, agriculture and research, and I am so proud of the work we're doing today.

Examples

One example of the work we're doing is the Yangambi 'engagement landscape' in the Democratic Republic of Congo (DRC). DRC is fortunate to have a wealth of natural resources. It's home to rich tropical forests that are as important to the planet as are the forests of Indonesia and the Amazon. Nevertheless, the economic value of these resources hasn't reached most citizens of DRC.

Our work in Yangambi is an example of what we can do when we work with local communities to support resource management. More than 200,000 people live in this landscape. They rely on natural resources for their livelihoods, including logging, slash and burn agriculture, hunting and fishing. And the region's value chains primarily serve the city of Kisangani, a thriving market of about 2 million urban dwellers.

Unfortunately, as you know, when income-generating activities are limited, and the local population often has no other alternative than overexploitation, this can turn into a vicious cycle of destruction. Change in such a complex environment requires long-term work. Fortunately, CIFOR-ICRAF has been working in Yangambi for 15 years with a wide range of interventions in single landscapes, because the opposite of poverty isn't wealth; the opposite of poverty is actually *opportunity*.

Our objective is to help create opportunity in DRC. To do this, we support entrepreneurship, innovation, research and management of natural resources, leading to the transformation of the Yangambi landscape into a place where forests contribute to the stable well-being of local communities. We focus on five main activities: capacity improvements; support for local entrepreneurship; biodiversity protection; research for development; and awareness raising; and we are achieving remarkable results, turning a vicious cycle into a virtuous circle.

By involving local communities in conservation scientific activities, they can improve their living conditions for a green future. Since 2019, our work has led to 2 million trees being planted and 2300 hectares of land being restored. It has also created more than 3400 seasonal and direct jobs. This is just one example of the work that CIFOR-ICRAF's amazing staff are involved in.

Another very important example is the work we are doing supporting communication around the world. The Global Landscape Forum (GLF) is a powerful tool that reaches millions of people around

the world and has chapters of young people who are champions of restoration and that are able to connect via a network and collectively support each other in their initiatives.

Another example of our work is in Cote d'Ivoire, which is one of the world's leading producers of cacao. In that country, 800,000 smallholders produce about 40% of the world's supply of cocoa, but those farmers get only about 4% of the value that consumers pay for chocolate every year. Our work there, and everywhere, aims to ensure greater benefits to these farmers and other smallholders that feed 75% of the population on the planet.

The work we do, whether it's soil analysis, whether it's partnering with indigenous peoples around the world, whether it's looking at how we can serve forests around the world, whether it's via capacity I have with others to influence policy such as on the Presidential Advisory Council of Rwanda, is all pursuing the legacy of Wangari Maathai, Nobel Peace Prize Laureate for 2004, who led a non-government movement promoting environmental conservation and tree planting, among other things. She is my hero, and I had the opportunity of meeting her after she got her Nobel laureate. Wangari Maathai said: 'It's the little things citizens do that make the difference'. My 'little thing' is planting trees. I have the honour now of working with her daughter, Wanjira.

I think it is amazing to know that we can work, generation to generation, and build on the wisdom, the resilience and the vision of the ancestors that came before us, to build a future that we hope will be better, so that future generations know we've done all we could so that they have a better chance on this planet, in harmony with nature, than we currently have.

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Éliane Ubalijoro, PhD, is Chief Executive Officer of the Center for International Forestry Research and World Agroforestry (CIFOR-ICRAF) and Director General of ICRAF. An accomplished leader with a background in agriculture and molecular genetics, she serves on several boards and has been recognised for outstanding contributions in the areas of innovation, gender equity, and sustainable prosperity creation. Dr Ubalijoro has been a professor of practice for public–private sector partnerships at McGill University since 2008, with research interests focusing on innovation, gender and sustainable development for prosperity creation. From 2021 to March 2023, she was the Executive Director of Sustainability in the Digital Age and the Canada Hub Director for Future Earth. She is a member of Rwanda's National Science and Technology Council and Presidential Advisory Council, the Impact Advisory Board of the Global Alliance for a Sustainable Planet, the Science for Africa Foundation, and the Capitals Coalition Supervisory Board, among others. She is a fellow of the International Science Council. Recognised for her work in leadership and gender equity, Dr Ubalijoro is a recipient of the International Leadership Association's 2022 awards in women and leadership for outstanding practice with broad impact, and is part of a cohort of appointed International Science Council fellows in recognition for outstanding contributions to promoting science as a global public good. She has facilitated the UNAIDS Leadership Programme for Women at the United Nations System Staff College. Dr Ubalijoro was a member of FemStep, a research network highlighting rural girls' and women's perspectives for engendering poverty reduction strategies in Rwanda, South Africa, Tanzania, DR Congo and Ethiopia using arts-based methodologies. Her career path was featured in Forbes in celebration of International Women's Day 2019.

OPENING ADDRESS, 5 SEPTEMBER 2023

Global food security in a riskier world. Diversification for resilient food and nutrition systems

The Hon John Anderson AC

Chair, The Crawford Fund

I welcome you all. It's terrific to have you here for what promises to be a very interesting day indeed. I particularly welcome some groups here today. First, the 50 or so conference scholars. The Crawford Fund has brought them here to experience our conference and special mentoring, networking and learning activities. The scholar program has now been running for quite a few years and has built up real 'steam'. It's tremendously energising to meet with you, to talk with you, to hear how much you are enjoying interacting with your mentors and how you are benefiting from the whole program.

We live in an age of great change and a lot of anxiety, or even a feeling that it's all becoming 'too much'. Much of that centres on the challenges of climate change. To the members of the audience who are younger or just starting your career, I want to encourage you to see the challenges before you as challenges to be *overcome*, to be tackled with *enthusiasm* and with *boldness* and with *positivity* – and in a context of *teamwork*. As graduates, in science or other disciplines, you have been (I hope and trust) taught to think logically, to follow the evidence and deduce sensible ways forward. This is very important in an age where there is – in my opinion – too much 'feeling' and too little 'clear thinking'. Too much emotion often will lead to despair and a reluctance to think clearly about best ways forward.

You, conference scholars, have been trained to think. Your mentors are people who have thought clearly and learned how to use scientific methods well, and I think that's to be greatly encouraged. The world needs you and your care for your fellow human beings.

A special welcome also to this year's RAID Network members who have been helping us with the scholar program. Also, welcome to the group here from Western Sydney University who have made the effort to get here. And welcome to the high school student from Queensland who is here with his dad. He has just won a Department of Agriculture award related to a competition that our Queensland committee has been supporting for over ten years. Finally, welcome to this year's two keynote listeners from RAID: Camilla Humphries and Anna Mackintosh.

This year our conference is a great opportunity to celebrate the 10th birthday of the RAID Network: Researchers in Agriculture for International Development. It is a program of the Crawford Fund and an important part of our Next Gen activities.

The 2023 conference

Our conference this year looks at global food security in a riskier world. Three prominent risks – the three C's (COVID, conflict and climate change) – have been at the forefront of our thinking in recent years and were certainly at the centre of our discussions last year. The Ukraine conflict, the Russian bans on Ukrainian food exports, the impact on energy prices globally and on supply chains.

Farmers, especially, are currently very conscious that this supply problem more generally, coupled with inflation, almost needs to be added to the three C's as a category of its own. The way our costs have exploded over the last couple of years is a real problem for farmers everywhere and is an integral part of the problem of food affordability as we have heard in this year's Sir John Crawford Memorial Address. It is having impacts on the poor, but also making difficulties for farmers everywhere.

Climatic issues continue to concern us, in terms of variability and our lack of capacity to accurately model what will happen, and when and where; and where areas of lesser production and of greater production will be coupled. There may be a sudden emergence of what some people are already calling 'depopulation bombs': that is, that some of the most densely populated parts of the world may have huge declines in population over coming decades, while others continue to expand very rapidly. It is a very challenging age – one that should excite young researchers, to help us deal with the challenges.

The three C's demonstrate how sensitive the task of feeding 8 billion people is going to be. It's not going to be a straightforward environment. It's clear from the current global situation that while some of the above risks are widespread, others are localised. This suggests that all countries need to prioritise different mitigation actions and adaptation actions, and to ensure they have adequate policy frameworks, institutional capacity and participatory mechanisms to allow agriculture to adapt to threats to production at the regional, local and on-farm levels.

However, responses need to be considered in the context of other off-farm factors such as labour supply, market and trade drivers, and the broader issues of environmental sustainability. Consequently, the goal of this year's Crawford Fund annual conference is to consider how farmers the world over, who are generally facing similar significant risks, can understand those risks and adapt and diversify. Diversified agricultural production systems have the potential to lead to greater biophysical and economic resilience, and thus sustainability for all. Furthermore, diversification of production options on smallholder farms may also increase the potential for improving nutritional options for consumers.

Therefore, key conference themes today examine on- and off-farm risks and solutions, and policy settings that will facilitate the development of resilient farming systems.

With some difficulty, the conference team has chosen a small sample of impacts and successes and on-farm and off-farm risks, focusing, as usual, on farming systems in developing countries. What is happening in terms of production and markets will not only have a major impact on food and nutrition elsewhere, but also may provide important lessons on appropriate ways in which to improve resilience.

Speakers, and thanks

We are looking forward to hearing from our terrific line-up of speakers today: Dr Cary Fowler, the US Special Envoy on Food Security; Professor Kym Anderson AC who was last night presented with this year's Sir John Crawford medal; Dr Wendy Umberger, who three weeks ago began her important role as the chair of ACIAR; and we are honoured to have speakers from the International Centre of Insect Physiology and Ecology, The Food and Agriculture Organization of the United Nations, the Australian National University, The University of Western Australia, Cargill Asia Pacific and Incitec Pivot.

I thank our Chairs for today's sessions, whose organisations are loyal supporters of our conferences: the Department of Agriculture, Fisheries and Forestry; the Department of Foreign Affairs and Trade; the Grains Research & Development Corporation; and CSIRO.

And the Crawford Fund would also like to thank the many supporters of our event, who are acknowledged by name on the conference website and in the forthcoming Proceedings of the conference. Many of them not only support our conference but are also involved in the Crawford Fund's training and Next Gen activities. We very much appreciate their ongoing collaboration.

This year's speakers will show that if we want to really start to ensure global security and food security going forward, we need to bring together specialists from many disciplines who will look at agriculture from different and overlapping perspectives. That way, we can work together to deliver effective on-ground sustainable solutions for food and nutrition security through the supply chain to the consumer.

Sir John Crawford and the 2023 Crawford Fund Medal

Sir John Crawford was a scientist and a statesman, with a deep compassion for the less fortunate. Churchill once quipped that if you want to understand the future, you've got to understand the past. The business of feeding people, particularly in our part of the world in the 1940s and 1950s, must have looked absolutely daunting and impossible, and a challenge that a lot of people would have walked away from. But Sir John Crawford, and others like him, did not. His story is a remarkable one of courage and heroism and optimism in the face of great difficulties. We need to keep in mind the stories of our heroes. They do matter, particularly when you're feeling a bit grim and a bit overwhelmed by the challenges that face us.

The Crawford Fund Medal recognises people who have made a considerable and continued contribution to international agricultural research. This year's medal was presented, last evening 4 September, before the Sir John Crawford Memorial Address, to one of today's speakers: leading international trade and development economist Emeritus Professor Kym Anderson, Companion of the Order of Australia.

Kym's work has been prodigious, varied and long recognised for its quality and its significance in Australia and abroad. In addition to his long association with The University of Adelaide and his lengthy and continuing connection with the Australian National University here in Canberra, Kym Anderson has held senior research leadership positions at the World Trade Organization and the World Bank, and a large number of significant research advisory positions, including in Australia. He has Chaired the International Food Policy Research Institute (IFPRI) – which had Sir John Crawford as its foundation Chair: the vision of that institute is 'a world free of hunger and malnutrition', and its mission is to provide research-based policy solutions that sustainably reduce poverty and hunger and malnutrition. Kym now Chairs the International Centre of Insect Physiology and Ecology, and we will hear of its work today. Kym was also a Commissioner on the Commission for International Agricultural Research from 2011 to 2014 and he was President of ACIAR's International Policy Advisory Council from 2014 to 2020.

The wording on the medal certificate says: 'In recognition of Professor Kym Anderson's immense contribution to the development of economics in the overlapping fields of international trade and political economy, with a strong focus on agriculture and products of importance to developing economies; and his strong governance and advisory roles with the CGIAR and with ACIAR'.

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

MINISTERIAL OPENING MESSAGE

Senator the Hon Penny Wong

Minister for Foreign Affairs, Leader of the Australian Government in the Senate

Good morning. I begin by acknowledging the traditional custodians of the land on which this conference takes place – the Ngunnawal and Ngambri peoples – and I pay my respects to Elders past and present.

Thank you to John Anderson for your introduction and to the team at the Crawford Fund for putting together a thought-provoking conference program. I also acknowledge Dr Cary Fowler, the US Special Envoy for Global food security. It is an honour to have such a prominent voice for global food security action here today. And Professor Wendy Umberger, recently appointed CEO of the Australian Centre for International Agricultural Research – we are very proud of the work ACIAR does with our partners around the world to strengthen food security. I acknowledge Dr Éliane Ubalijoro, CEO of the Center for International Forestry Research and World Agroforestry. And I congratulate Emeritus Professor Kym Anderson AC who received the Crawford Fund Medal last night. I am also so delighted that Crawford Fund Next Gen program participants are attending – our future leaders in agriculture for development.

This year's conference theme 'Global Food Security in a Riskier World' could not be more relevant. As Australia's Foreign Minister, I know the devastation being brought by worsening food insecurity around the world. Up to 783 million people faced hunger in 2022, an increase of 122 million since 2019. No one should go hungry; yet more and more are. And we know why: conflicts, economic shocks, climate change have all affected food security during this time. This includes Russia's illegal and immoral invasion of Ukraine and its decision to terminate the Black Sea Grain Initiative, which risks destabilising the world's access to grain. The Black Sea Grain Initiative is critical to ensuring predictable supplies of food to many countries, including our neighbours in the Indo-Pacific. In addition, the price of rice, a staple for nearly half the world's population, is also rising; and climate change is affecting every aspect of food availability. These challenges are the most complex our region has faced in living memory.

So that's the 'why', but I am interested in the 'how'. How do we secure a future where no-one goes hungry?

Last month, together with my Ministerial colleagues, I launched a new International Development Policy. The first long-term development policy in Australia in almost ten years, it underpins the Albanese Government's record international development investments of an additional $1.7 billion over five years. We are delivering for our partners' priorities, including financial and technical assistance, to make food production systems resilient to economic and climate impacts.

We remain dedicated to implementing the 2030 Agenda and Sustainable Development Goals, the internationally agreed blueprint for inclusive sustainable development. Through the World Trade Organization and our leadership of the Cairns Group, we also advocate for the reduction of trade-distorting measures – measures which are often imposed under the false guise of 'food security'

but can actually weaken the resilience of agricultural sectors. And we will continue to work with partners like the World Food Programme to provide emergency food assistance where it is needed most. Australia will continue to support partner governments and communities in our region to build long-term resilience and to lead their own adaptation and disaster-risk-reduction efforts.

But there's always more we could be doing.

During this conference you will test the ideas that will form the foundations of global food security policy: where food supply is adaptive, diversified, nutritious and accessible. We are living in a riskier world, but together we will find solutions. We must find solutions.

So, I hope you enjoy the conference, and I look forward to working with you.

Penny Wong was born in the Malaysian state of Sabah. Her family moved to Australia in 1976, when she was eight years old, and settled in Adelaide. She studied law and arts at The University of Adelaide. After university she worked for the trade union covering furniture industry employees, taking part in campaigns to improve pay and conditions for the union's members, including poorly paid female migrants working in upholstery workshops.
She worked as an adviser to the NSW Labor Government where she helped develop forests policy, and then as a barrister, before being elected to the Senate for the Australian Labor Party in 2001. Senator Wong has been re-elected four times – in 2007, 2013, 2016 and 2022.
With the election of the Rudd Government in 2007, she was appointed Minister for Climate Change and Water. In this position she significantly expanded the Renewable Energy Target, which has driven significant investment in wind and solar power. She also represented Australia in international climate change negotiations and developed the Rudd Government's emissions trading scheme, a market-based mechanism to reduce Australia's greenhouse gas emissions in the most economically efficient way. After the federal election of 2010, Senator Wong was appointed as Minister for Finance and Deregulation. As Finance Minister she worked with Treasurer Wayne Swan to deliver three Budgets in the aftermath of the Global Financial Crisis. She also implemented a policy to ensure women are considered for appointments to senior positions in government agencies and corporations. In 2013 Senator Wong was elected Leader of the Government in the Senate and, after the change of government in 2013, became Leader of the Opposition in the Senate – the first woman to hold either of these roles. She served as Shadow Foreign Minister for six years before the election of the Albanese Government in 2022, when she was appointed Minister for Foreign Affairs.
As Minister for Foreign Affairs, Senator Wong seeks to rebuild Australia's reputation as partner of choice – drawing on all elements of our national power – to build a stable and prosperous region, where sovereignty is respected and the rules of the road are upheld.

KEYNOTE ADDRESS, TUESDAY 5 SEPTEMBER 2023

Creating global food security: a vision of adapted crops and soils

Dr Cary Fowler

US Special Envoy for Global Food Security

Good morning. When Cathy Reade invited me to come Australia to give this keynote address today, I recalled giving the Sir John Crawford Memorial Address in 2015, and I began to ask myself: What's different now from 2015? What has changed? What have I learned in those years and what did I get wrong? What did I overlook? Not surprisingly, I did get a few things wrong, and I did overlook some stuff, and that is what I will talk about today.

One thing that has changed is the number of food-insecure people, which is now 800 million or so. In 2015, I based my lecture on a wonderful book by Lloyd Evans (of CSIRO). The book was called *Feeding the ten billion*. I think it is still one of the best books I have read on the subject. Towards the end of that book Dr Evans outlined that there are only six ways of increasing food supplies, and we all know that food supply is going to have to increase, if only because of population growth.

Land, water, climate

In the 2015 lecture I considered the constraints or obstacles, the challenges towards increasing food supply, and in particular I looked at climate and at land and at water.

- The amount of land devoted to grain production in this world, on a per capita basis, is half what it was in 1961. So that is probably not going to be a way out of our current crisis.
- Most of the aquifers in the world today are in a state of depletion: they are being depleted faster than they are being replenished.

Even though I was really preoccupied by climate in 2015, I don't think that I or, maybe, any of us quite anticipated the speed or the severity of the changes that were ahead: the number and the extent of extreme weather events. This past June was the hottest June ever recorded for global temperatures. July was the hottest July ever recorded. July was the 533rd consecutive month in which the global average temperature for the month – July in this case – exceeded the 20th century average for July. Five hundred and thirty-three consecutive months of 'above average' temperatures! I don't know anything in life that happens 533 consecutive times by coincidence. Something is changing, and it is happening in real time.

We are seeing historic drought in the Horn of Africa. We have had heatwaves and droughts and fires in the United States and Europe. Pakistan has just been through a monsoon that was five times the 30-year average: 2 million acres were flooded and 800,000 animals were killed. And now we're heading into El Niño, and you know what that that means.

Many people are saying, 'Well, you know, this is the new normal'. But maybe not. Maybe the new normal has not quite arrived yet. Maybe the new normal is actually in the future. If you look at climate predictions, you would have to say the new normal is not yet here. In fact, today's weather may turn out to be the coolest and best that our agricultural systems experience in our lifetime.

Although the speed and the severity of climate change has exceeded even my expectations, it is not clear to me that our analysis has caught up with that. I am not sure that our analysis of what to do, or how much to do, has really changed quite as much or quite as fast as the climate itself. And I am not sure that we in the global community have fully come to appreciate how profoundly and how extensively climate change is going to affect our agricultural production.

If you look at crops, you know that excessive heat affects every part of the plant, at every part of the growing season, from roots to flowers. Therefore, in the future, our plant breeders are going to have their work cut out for them in adapting every part of the plant to climate, at every part of the growing season, and they will need to do that for every one of our crops.

Conflict

Looking back at my 2015 lecture, the one big thing I really missed was conflict. I don't think I mentioned it in the 2015 lecture. We know, of course, that there is a strong correlation between climate, food insecurity and national security and conflict. That correlation goes back many years.

In 2007 and 2008, we saw climate events, we saw food-price hikes, we saw unrest in 15 countries in sub-Saharan Africa. If you look back at the 'Arab Spring' in 2010–2011, you'll see it was a time when China was having a drought; food prices were going up. All the countries that are the largest importers of wheat on a per capita basis were in the Middle East, and there was the Arab Spring.

I am not saying that the correlation is total, but I am saying that climate is a threat multiplier for conflict, and conflict is a threat multiplier for insecurity. Of the people on Earth that are food-insecure, 60% live in countries that are experiencing conflict, and 80% of the children on Earth that are stunted or malnourished are living in countries with conflict.

Regarding the invasion of Ukraine by Russia, Ukraine was one of the top five exporters of food in the world. It has historically been a breadbasket for Europe. Ukraine is a top-five exporter of wheat, barley, sunflower and maize, and the whole infrastructure of the country is geared towards exporting that grain through the Black Sea. As you all know, Russia has pulled out of the Black Sea Grain Initiative, but you may not realise that during the time that the Black Sea Grain Initiative was in effect Ukraine exported 32 million metric tonnes through the Black Sea. That is not as much as Ukraine would normally export, but it is a lot of grain. The wheat portion of those 32 million metric tonnes was enough to make 18 billion loaves of bread. It's not trivial. Now, in the last two days, Russia has bombed the Ukrainian ports on the River Danube delta, which is the alternative way Ukraine can export its grain through the Black Sea.

This is a war on food security. Poor people in the global south are the collateral damage for Mr Putin's war in Ukraine. Words fail me to describe the immorality of what is happening.

Trade

Another thing I failed to mention in 2015 was the importance of trade. In a world with many different risks and many different uncertainties, trade becomes much more important. One hundred and thirty-one out of 196 countries on Earth are net food importers, which underlines the importance of trade. I think that as shocks continue to the system, and as they increase, we are going to see trade become much more important. Already we see some countries reacting to climate issues and other production issues by trade restrictions and export bans. India has put bans on exports of wheat and rice, and duties on onions.

To recap, what did I get wrong in 2015; what did I not emphasise enough; what did I overlook? I missed aspects of the effects of climate, and I didn't anticipate conflict, and problems in trade.

All these issues show that we must think more seriously about building resilience into our food systems, ensuring that countries and farmers have viable options. I think resilience is something we certainly need at the national level and, in many places, at the farm level.

New initiatives: understanding soils; using adapted crops

When I joined the State Department, I asked myself: What faulty assumptions are we making? Where and how can we add value, and what can we do that is meaningful in that scale; that has a big impact and that is not easily undone by politics? That led me back to thinking about the basics, about the fundamentals.

It seemed to me that if we are following the Hippocratic Oath – 'first do no harm' – that we must realise that there is no such thing as food security unless you have good soil and you have adapted crops. We cannot have food security based on poor depleted soils and unadapted crops; yet poor soils and unadapted crops are found in many places in Africa. By the end of the century, Africa will be the continent with the biggest population on Earth. Therefore, the State Department has begun to promote 'a vision for adapted crops and soils' (VACS).

For soils, and particularly paying attention to Africa, we think that what is needed is better information, better soil mapping, and better analytics. Those should allow the countries to make more-informed planning decisions about agriculture, and enable farmers to make better management decisions: such as how to fertilise appropriately so that they get the most benefit from the small amounts of fertilisers they are applying. Erosion is taking away soil in Africa right now at a rate that is 100 times the rate of soil replenishment. Obviously, therefore, if we're looking for food security in Africa we should not think of humanitarian aid as being equal to food security, nor can we think about food security without having good healthy soils.

For crops, we have started an initiative that is co-sponsored by the Food and Agriculture Organization of the United Nations (FAO) and by the African Union. It is a three-step program. As background, the African Union a few years ago adopted a common position on food systems, in which they emphasised the importance of traditional and under-utilised and indigenous crops in Africa. They noted that there has been massive under-investment in these crops. In Africa today, the staples are wheat, maize and rice – and these crops all originated outside Africa. Probably no other continent in the developing world is in that situation.

In the three-step program, the State Department is investigating some of the under-utilised crops, both to help them fulfil their potential to increase the resilience of the systems, and also to provide good nutrition for people in Africa.

- The first step, with co-sponsor the African Union, is to identify those crops that have the most potential for adding good nutrition to diets in Africa.
- The second step is to narrow that list – we started with about 300 indigenous African crops – down to the 60 we think have the most potential for boosting nutrition. And the second stage of that is to examine those 60 crops for their likelihood of performing well in a changing climate. If we have that information – that is, if we know which of the crops have the most potential to boost nutrition and which of those are likely to do best despite climate

change, then for the first time in history we have a rational basis for making investments in crop improvement.

Therefore, we have brought together the nutrition community, the climate-change community, and the agricultural development and plant-breeding community, for the first time in the same room, to discuss these issues and to rethink what a cropping system would look like, based on nutrition, and then to facilitate it via this work on crops and soils.

We believe that diversity of crops equals greater resilience, and that dietary diversity equals better nutrition and less stunting of children in Africa, which is a terrible problem.

- The third step in our program is to establish a multi-donor trust fund. We are in discussions with the International Fund for Agricultural Development in Rome about establishing that fund so we can provide ongoing support for these types of efforts. Plant breeding takes a long-term commitment, as you well know.

New initiatives: focus on agricultural R&D

The second big thing that we have tried to push at the US State Department is simply to bring more attention to the need for agricultural research and development.

Agricultural research and development is the comparative advantage that countries like Australia and the United States have in this world. And yet, speaking for the United States, I will say that our public investment in agricultural research on an inflation-adjusted basis is back where it was 50 years ago. In the midst of growing and severe challenges to food security, we need to be prioritising agricultural research and development if we are going to maintain our status in the world and if we are going to promote the kind of values that the United States and Australia share.

To have a chance of creating a food secure world, we must reprioritise agricultural research. 'Business as usual' is not going to be enough. In fact, I think we need to be ambitious and aspirational, and perhaps go for a few 'moon shots', a few big developments in agricultural research and development.

I am not the right person to tell you what those would be, but maybe it could be nitrogen-fixing grains, or maybe perennial grains, or maybe a transition of some C3 grains to C4 for photosynthesis. Maybe it could be work on aflatoxins and mycotoxins to reduce post-harvest loss. There are many different things that we could be putting scientific effort into. These are the kinds of things that we want to do, and I think that we have to adopt a mindset of being willing to make long-term investments and long-term commitments to do those.

Closing thoughts

Finally, two thoughts. One is that I hope everyone in this room appreciates how important and how special the Crawford Fund is, and that it is an amazing institution. There is no institution like it in any other country that I know of. I really wish every country in the world had a Crawford Fund, and I really wish that every country in the world had a Cathy Reade. Unfortunately, there is only one of each.

The second thing I want to mention as a final note is that, as John Anderson has also mentioned, we have lost some real 'giants' in our field in recent years. In 2019, we lost Tim Fischer, who had been the Chair of the board of the Global Crop Diversity Trust and who was such a friend and such an ally for us.

You in Australia lost John Kerin recently, and in August we in the US lost a couple of other very special people. One was Professor Sir Gordon Conway, who was a former president of the Rockefeller Foundation and who wrote a book called *The doubly green revolution*. And then we lost a person who was one of my dearest friends and a dear friend to several people in the audience, and that was Wally [Walter Falcon].

Wally was an agricultural economist, a professor at Stanford University, co-founder of the Center on Food Security and the Environment, and of the Presidential Commission on World Hunger. He was one of the few people (with only one or two others) who have been Chair of the Board of both the International Maize and Wheat Improvement Center (CIMMYT) and the International Rice Research Institute (IRRI).

Wally was a bigger-than-life person on the outside. He looked a bit like Winston Churchill in the face, and he had a gruff exterior, and a deep voice. I was thinking about him as I thought about what to say to you today; and I thought: Well, if Wally were here and if he were out in the audience after I finished my talk, he would come up to me probably, and in that deep voice of his he would say, 'Well, pretty good lecture, Cary'. And then he would say, 'You know, you made some important points there'. And then, with a little twinkle in his eye, he would add, 'Some of them might even be true'.

I will leave it to you to decide whether anything I have said today is true, but if you invite me back again I'll tell you what I think about it. Have a great conference.

References

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Dr Cary Fowler is perhaps best known as the 'father' of the Svalbard Global Seed Vault, which UN Secretary General Ban Ki-Moon described as an "inspirational symbol of peace and food security for the entire humanity". This facility provides ultimate security for more than 1 million unique crop varieties, the biological foundation of agriculture and the raw material for all future plant breeding and crop improvement efforts. Dr Fowler is the former Executive Director of the Global Crop Diversity Trust, an international organisation co-sponsored by the Food and Agriculture Organization of the UN (FAO) and the Consultative Group on International Agricultural Research (CGIAR). Prior to leading the Crop Trust, he was a Professor at the Norwegian University of Life Sciences, and a senior staff member of Bioversity International. Earlier, he oversaw the UN's first global assessment of the State of the World's Plant Genetic Resources. He was responsible for drafting and negotiating the first FAO Global Plan of Action on the Conservation and Sustainable Utilization of Plant Genetic Resources, formally adopted by 150 countries in 1996. Following this, Dr Fowler twice served as Special Assistant to the Secretary General of the World Food Summit and represented the CGIAR in the multi-year negotiations on the International Treaty on Plant Genetic Resources.
In 2015, Dr Fowler was appointed to the Board for International Food and Agricultural Development by President Obama. He is a former board member of the International Maize and Wheat Improvement Center, and former Chair of the Livestock Conservancy.
Dr Fowler has been recognised with several honorary doctorates and many awards including the Thomas Jefferson Award for Citizen Leadership, the Heinz Award, the Meyer Medal from the Crop Science Society of America, the Wm. Brown Award from the Missouri Botanical Garden, and the Proctor Medal from the Garden Clubs of America.

Q&A with Dr Cary Fowler

on 'Creating global food security: a vision of adapted soils and crops'

Chair: Dr Beth Woods,
Member of Australia's Commission for International Agricultural Research

Q: Beth Woods

The Chair's prerogative is to ask the first question, and I am particularly interested in somebody who I have always thought of as being a champion of plant resources and plant genetics straying into my husband's field: I declare right up front, I'm married to a soil scientist. I'm really interested to get your sense of trying to work with this at scale, and thinking about the issue of improvements that can be made that aren't easily reversed. What do you see as the particular obstacles on the one hand, and the particular opportunities to improve soil condition and make long-term impacts on productivity and long-term outcomes for food production?

A: Cary Fowler

I am definitely not a soil scientist. In my current job, I feel like I've had to draw on every moment in my life and every experience I've had. The earliest experience I had with soil was driving around western Tennessee with my grandmother, who was a farmer, and having her point out which fields were good and which weren't, when nothing was growing in them.

And she would tell me that 'That field is going to produce so many bushels of corn, or so many bales of cotton'. Intuitively, I realised she was teaching me either to be a farmer or at least not to get cheated on buying land, because I should know what land was good and what wasn't. Only recently I realised that she was teaching me to look at organic matter in the soil, and which soils were rich and which weren't. I have to wonder where I was all these years in not realising how intricately linked soil health and fertility is to our future, to sustainability.

One of the things that we are trying to do with this program that we are co-sponsoring with the African Union in Africa is to join up soil health and fertility with crop adaptation.

A lot of the crops we want to promote are legumes, which will help enrich the soil and of course provide good nutrition. But we realise that food systems are very complicated and have many different elements to them, and not every element is created equal, but that doesn't stop you having a sequence of things you need to do to improve food systems.

Africa is using only 3–4% of the fertiliser in the world. When I started at the State Department, the Secretary of State asked me, 'Why is it that so many countries, particularly African countries, are coming to us saying they need fertiliser?'. And I said, 'Well, you know, if you don't have enough production in your garden, you decide to add some more fertiliser'. But the soils in Africa – and I'm generalising terribly here – need more than fertiliser, because with really poor degraded soils, fertiliser-use-efficiency is not great. For many farmers in Africa, it would be an irrational choice to apply fertilisers. Why? Because they wouldn't get enough increase in production and value to justify the cost of the fertiliser.

This is a terrible situation, and so we need to make these long-term investments. I really give credit for my epiphany in this to one of the previous Food Prize Laureates, Rattan Lal, who is a soil scientist extraordinaire. I asked him, 'We're dealing with the soil health and fertility problem in Africa, but once upon a time weren't Africa and South America the same? Didn't they have very poor soils in Brazil, for example?' And he said, 'Yes, but with one difference. The soils in Brazil were actually a little worse. So what did they do? They engaged in a multi-decade initiative to improve those soils, and now those soils are supporting export agriculture in Brazil.'

A couple of lessons there. One lesson is: we can address this problem. The second lesson is: we have to make a long-term commitment to do it.

Q: John Muir, iHemp Consulting Agronomist, Agrifutures

I am really impressed by what you're saying, and I just want to help. I work with poor people in Cambodia as a volunteer. Kenaf, which is *Hibiscus cannabinus*, a type of industrial hemp, comes from Africa. Has kenaf been identified? These biomass crops, these superfood crops will grow anywhere; they fit well in rotations in Queensland. Did it get identified? And how can we get a CGIAR center to look at it and others of these types of crops that were in the old world and can now be brought in here?

A: Cary Fowler

Well, you know, I've had a number of comments or questions asking about the nature of crops that we've identified as indigenous crops with potential for Africa. And the questions themselves are quite revealing. People ask, 'Well, if they're so good, why aren't people using them more?'. And I sometimes don't know what to say about that. These are crops that have been in use in Africa for 10,000 years. If they weren't any good, maybe they would have gone out of business before now. They're not being used more today simply because we have underinvested in them. We have put billions of dollars of investment into wheat and rice and corn research. I don't begrudge that. Look, Tim Reeves is in the audience here; he was the Director General of CIMMYT; I Chaired the Program Committee at CIMMYT when we were doing research on maize and wheat. I am a big proponent of that. But we also need to be putting investments into some of these other crops to realise their potential.

For us in the US Government, we want to start by focusing on Africa. That is where the greatest need is right now. But I think down the road these are efforts that could be brought to Asia and South America.

Q: David Guest, School of Life & Environmental Sciences, The University of Sydney

Cary, you have made some really important points. Thinking about the links between healthy soils and adapted crops, I am wondering if we could go even further. In the early part of the 20th century there were a couple of people, Albert Howard and Abe Balfour, who talked about the health of soil, water plants, animals, humans in the environment as being one, and indistinguishable. I am wondering if there is an opportunity for more transdisciplinary research that breaks down the disciplinary silos that we tend to use when looking at questions like food security. Are there opportunities to link up agronomists, soil scientists, pathologists like myself, and animal health people, economists, anthropologists, health, nutrition, in really transdisciplinary 'One Health' research? Is that a way forward?

A: Cary Fowler

Yes, absolutely; I think it's tempting. It's very encouraging and energising for me to be at a conference like this with a lot of young scientists and researchers. I think the area that you start in, you have to realise, is just a start. It's your anchor for your career. It's not the end of your career. And to do something truly at scale and meaningful and long-term sustainable – all those good words – you will have to get a little bit outside your discipline. I'm currently reading a biography of Norman Borlaug. As you know, Norman Borlaug won the Nobel Peace Prize for his work on wheat. Some people say he saved more lives than any other human being in history. But, interestingly, what a lot of us know about Norman Borlaug now is that he was a wheat researcher and that he bred dwarf varieties and high yielding varieties of wheat.

Read his biography! Why? Because you'll see that he wasn't just a scientist breeding new varieties of wheat. He had to overcome countless problems – financial, bureaucratic, administrative, political – all those things. If he hadn't done those, we wouldn't know who Norman Borlaug is today. If you were visiting from another planet and reading that biography, you might not identify him as Norman Borlaug the great scientist. You might say instead that he was a great organiser or facilitator or promoter, or whatever.

So I think that your point is that we do have these professional silos, and we need to be thinking constantly outside them, because I don't know of a single world problem worthy of that name that can be solved within the confines of a single discipline.

Q: Maylee Thavat, Department of Foreign Affairs and Trade

You emphasise the importance of trade to food security. I note the recent 2023 *OECD-FAO Outlook*, which says that agricultural trade is becoming more a balance between food importers and exporters, with obviously a growing distrust in the trade system. I was wondering whether you could make a few comments on what you see as the US's leadership role in reform efforts in the World Trade Organization, noting that agricultural trade negotiations on this issue have stalled on that, for more than 20 years.

A: Cary Fowler

This is a little bit out of my field, but I'll just say that for the year or so that I've been at the State Department, I have personally had, and the US Government has had, a number of discussions with other countries, particularly after last summer in the northern hemisphere when food price spikes were really going up and we saw food export bans being placed by a number of countries.

We are pretty consistent and quick off the mark to talk to countries about not having those kinds of trade restrictions. (A) They don't work: they actually don't usually work for the political purposes that the countries install them. And (B) they just cause a lot more volatility in the marketplace, and that filters down to farmers who then make rational decisions based on irrational policies. And that doesn't work out very well in the long run either. We may be about to see another round of those kinds of restrictions. I hope not.

Q: Helen Scott-Orr, the Crawford Fund in NSW

In the emphasis on crops and soils, does your strategy include integrating livestock into the systems, particularly for soil health and for rotations, and in view of traditional Indigenous practices in different areas? Also, are you integrating agroforestry, in view of the climate emergency, because the whole integration of the landscape, I think, is so important.

A: Cary Fowler

The quick answer is yes and no. On agroforestry, we've considered agroforestry species in relation to our work on indigenous crops in Africa, and support for improvement of those crops. We think that some tree crops on our list have a lot of potential and really ought to be pursued. On the livestock question, I would have to defer to our US Agency for International Development and the 'Feed the Future' program, which I actually have a role in. But for the particular initiative that I'm talking about, the State Department has not tried to bite off more than we can chew, so to speak. With the programs I described and with limited resources and limited staffing, we are just focusing on what we think we can do. Like all governments, ours has a 'best by' date – a shelf life – and we are trying to keep to what we can do in the time that we know that we have available to do it in. In this case, that is a year and a half.

Q: Yasmina Sultanbawa, The University of Queensland and the Crawford Fund in Queensland

Thank you for a very insightful presentation. It's very close to my heart because I work with a lot of Indigenous people in Australia and their 65,000 years of knowledge and their nutrient dense food. How do we bring together the local food systems and global food systems and introduce them to trade? Because when you say 'under-utilised' crops, it's all about scaling-up. How do we make them available for the wider community? And then global food crops – how do we bring them together, and also in a trading context?

A: Cary Fowler

There are some versions of this question that I often get back in the United States, actually. If you look around the world and you look historically, you will see food systems that can only be explained by the kinds of incentives that have been put forth for the food system, including in particular to farmers. Our major crops have been heavily subsidised in one way or another.

That hasn't been the case with the crops that we don't know much about – with the traditional and under-utilised and indigenous crops. So we first have to realise that their status in diets, in developing countries in particular, and even here, is based on history and based on these kinds of incentives. We have to get those incentives right if we expect to broaden the food basket, so to speak, and improve nutrition.

For people who ask why isn't there already more use of these indigenous crops, I would say that actually diets have changed a fair amount in the United States in my lifetime. We eat crops now that I didn't know about when I was a child. It may not happen from one day to the next, but over a period of years food systems do evolve, and tastes evolve and diets change, and I think that can happen anywhere and everywhere. We need to realise what climate is doing to food systems; climate is rearranging all of our food systems.

So for us, the question going forward is, are we going to be in the driver's seat of that, and are we going to refashion those food systems based on nutrition? That's not how any food system in the world today started out, but now we have a possibility of reordering our food systems based primarily on nutrition. And that's what we can do, and I think people will embrace that.

Q: Tony Fischer, the Australian National University and the Crawford Fund in ACT

Thank you very much for your presentation. I think focusing on sub-Saharan Africa is dead right. That is a huge problem facing the world. But I would argue that the modern varieties of all the crops that we are familiar with – maize, rice, wheat, cassava, sweet potato, kelpie – grown right now are perfectly well enough adapted to the environment, including the climate changes that are coming. But they are not adapted – and no new crops will be adapted – to the depauperate soils of Africa. The soils have been run down after a century of farming without turning to nutrients, or by the institutional constraints, or the political constraints, in sub-Saharan Africa. We have the technology to triple the yield of current crops in Africa, but there are all those other constraints. Norman Borlaug spent the last 30 years of his life working in Africa; that is never mentioned in the book, which finished unfortunately in 1970 when he got the Nobel Peace Prize for his breeding, and he worked in agronomy and the political area that you mentioned. I think we need to remember that that big picture is what is holding kids back in sub-Saharan Africa.

Q: Patrick Macdonald, Gardiner Foundation, Victoria

With limited arable land and the globalised agricultural trade, and by adding more crop variety into the current system, does that really work in the current situation for African nations, given the vanilla crisis in Madagascar triggered the Madagascar hunger, and also the majority of the cut flowers exported to Europe are actually coming from Africa? Do you think those cash crops still need to be produced in the African nations, or do they need to look at the staple foods rather than just cash crops, to improve the global food security?

A: Cary Fowler

It is very hard to reply about a specific situation. I think there's a role for cash crops. At the same time I look at Madagascar, and Madagascar is a country that that we were worried about last year, and are still worried about this year. That is because of the drought in southern Madagascar, the decrease in food production there, the childhood stunting rate, and the fact that they were importing a lot of their rice from India and India put a ban on broken rice exports which really affected Madagascar. That, of course, is a situation that might be playing out again today. Without being too prescriptive, I'll just say that I think there's a place for cash crops, but I think there's also a place for looking at the whole food system itself, and certainly through a lens of what is good for farmers and what is good for nutrition.

Q: student at The University of Queensland and a Crawford Fund scholar

In creating global food security, if we look at the countries like South Asia and African countries, where there is gender discrimination in the agricultural systems, some people think that education can give support. But there is discrimination in getting this support. So how can we deal with these challenges? Only imposing or creating policies like government supports is not helping to change the cultural systems or change the cultural norms. So how can we deal with these challenges?

A: Cary Fowler

I don't have an easy answer for the big question there. But I will mention two quick things that I think are really important about the work that I just described with indigenous crops in Africa. The first, which really excites me and keeps me going, is that most of these crops are tended by women. Women are the predominant farmers for most of these crops, so improving crops grown by women is an empowering effort. And if we improve crops grown by women, we are improving childhood nutrition, which is another thing that is really important to me. Some of the countries in

Africa have very high rates of childhood stunting. I was just in Malawi recently, and the childhood stunting rate there is approaching 50%, in children under five years. Not only is that a humanitarian disaster now, but think about the challenge of trying to develop an economy in a society where half of your upcoming generation is stunted. That's really bad.

The second thing is that there's a group called the African Orphan Crops Consortium. It's low-key, 'flying under the radar'. They have been training plant breeders in Africa on particular crops. Almost half of the plant breeders that they have trained up to PhD level – and they've trained more than 150 – are women. I think something really interesting is happening there. If we get a large number of women plant breeders working on traditional crops for women in Africa, that looks, to me, like a 'game changer'.

Chair: Beth Woods

Thank you, Cary. We have heard a very interesting talk, and then some very interesting additional points brought up in our question-and-answer period. I particularly note the example given by Cary of the multi-decade work on soil improvement in Brazil, and the importance of thinking about trade in this whole discussion; and your last point, the focus on diversity, particularly the role of women. I think all those are critical factors that we will need to bring to bear to deal with the challenges that we face with climate change in a very complicated world. Thank you very much. Please join me in thanking Cary.

SESSION 2

On-farm risks for resilient food and nutrition systems

Professor Wendy Umberger

CEO, Australian Centre for International Agricultural Research (ACIAR)

Abstract

Our demands on the world's food producers continue to grow as we look to the global food system to efficiently provide growing populations with safe, nutritious and higher quality food, while also using fewer inputs and preserving vulnerable ecosystems. At the same time, rapid economic transition in many countries, increased integration of global markets and new technologies provide many opportunities for the farming sector. Smallholder farmers, who feed a significant portion of the global population, remain amongst the world's poorest people, and they are one of the groups most vulnerable to impacts of climate change such as more extreme weather events, less predictable weather patterns, threatened water security, emerging pest and disease threats and soil and land degradation. They face complex livelihood decisions which will see many leave the sector for opportunities in urban areas, leaving increasing labour shortages in rural areas. This presentation explores options for innovation by smallholders to address these on-farm risks and the technologies, policies, and economic and social enablers needed to facilitate more resilient food and nutrition systems.

First I want to say some words about the Crawford Fund. In Adelaide, South Australia, the Crawford Fund has offered me an outstanding opportunity, as someone new to the country, to get to know some of the 'legends' of agriculture and development. They have been very good mentors and friends. And it is exciting for me every time I come to the Crawford Fund conferences to see so many young people including former students and early career researchers and colleagues here. There's no other organisation like this anywhere in the world. At ACIAR we are grateful for the work that you do. Thank you. For those of you that don't know, the Crawford Fund has only a small budget, and they leverage that money very well through the work of many volunteers and in-kind support across the generations. Congratulations. And thanks also to RAID, who are our future generation of people contributing in-kind to this area.

Addressing on-farm risks to add resilience to food and nutrition systems

Risk is a challenging topic. On-farm risks are at the root of many of our global food security and nutrition problems, and global conflicts. The world relies on farmers, at all scales, to address and mitigate the risks posed by issues such as climate (droughts, storms), pests and diseases, often simultaneously. Such risks are at the heart of many problems in food system resilience and our economic stability more broadly, and that is something people not working in this space do not always understand.

People engaged in resource-based production via farming, as well as by fishing or forestry, face price/market, financial, institutional and human risks, as well as from climate, that I'd say no other sector in the world faces. Small-scale producers such as smallholders are particularly vulnerable

Figure 1.

(Figure 1). Often, they are insecure, or they are very dependent upon agriculture for cash, for education, and to buy food if they're not consuming their own food. They may have less capital – not just typical capital assets such as tractors but also finance and human capital. Often, smallholder farmers have very low levels of education. There is poor infrastructure such as roads in many countries. There can be issues with post-harvest facilities, with land tenure (an issue that is often forgotten about), with open access (such as, who has rights in fisheries and forestry? who has property rights?), with informal market institutions and lack of standards, with poor information systems, lack of extension, and poor social safety nets, as well as little market power. Larger-scale farmers in Australia complain about lack of market power, but it's even worse when you're a smallholder.

The outcomes of those risks, and how they are dealt with, have compounding effects throughout our food system because they flow on to the consumers. For example, ACIAR has been working in north-west Vietnam to modify the farming system by encouraging farmers, many of them women, to plant vegetables into traditionally rice-farming systems to add to people's nutrition, aiming to help reduce stunting in their children. Consider how changing a farming system can affect the overall impacts on households. What are the livelihood impacts not only for the farmers but also for the consumers?

Figure 2.

Global change is a risk multiplier, as Figure 2 shows and as previous speakers at this conference have already touched on. We know that climate issues on-farm can lead to conflicts such as happened in 2007, 2008, when we saw price spikes, export restrictions and overall instability in some countries. All those simultaneous risks I've mentioned are now more important because of

the climate emergency. It's not just climate issues of variability, volatility and changing weather patterns. As climate changes in a region so we see new pests, new diseases coming in because of the different conditions that now allow these invading organisms to thrive. Climate also affects water quality and quantity.

Global change multiplies the risks of economic volatility, and conflict through globalisation and trade issues. We have seen that when countries impose export bans on particular commodities they can cause very big problems for farmers as well as consumers. Part of global change is the world's growing urbanisation, with the effects shown in Figure 2, as well as effects on peri-urban agriculture, opportunities to earn off-farm income, to affect gender equity, and to generate changes in food demand.

Individual circumstances matter

Figure 3 shows a group of women from the same country and from the same community, who happen to be involved in an ACIAR project. You might think that they are all facing similar household and family situations, but from our social scientists' interviews with them we realise that they face very different issues: their spouses may have died; they're having to work off-farm; they are carers for young children or elderly parents; and so on. It is very important to understand that risk involves more than just culture; that at the household level, in trying to help farmers deal with risk we need to understand the family circumstances and how they affect individual farmers' decisions. We often think that keeping people in farming is the right thing to do, but Figure 3 shows four options for smallholders in dealing with risk: stepping up, hanging in, stepping out, stepping in.

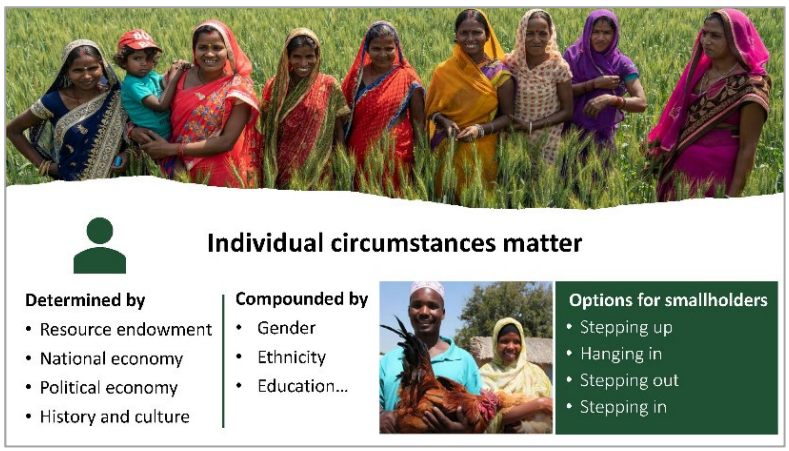

Figure 3.

How can research and capacity-building contribute?

ACIAR aims to help farmers mitigate risk and build resilience, via management tools, and by offering options to adapt the family farm business. For example,

- helping reduce production variability in both yield and quality (Figure 4): through smallholder irrigation schemes and the Chameleon Soil Water Sensor [*see Jamie Pittock's talk in this Proceedings*]; through dealing with pests and diseases, such as via new wheat varieties resistant to wheat blast; through offering different farming systems such as conservation agriculture; through sustainable intensification; and there have been many other examples over 40 years' work.

Figure 4.

Figure 5.

Figure 6.

- Offering options for diversification and addressing situations that constrain attempts to build resilience (Figures 5,6). For instance: different markets selling different products, including value-adding for the (native) galip nut in Papua New Guinea, where ACIAR worked with smallholders, universities and a private-sector processor to help increase the value of the nut, ready for market; new resources, such as turning waste into protein with Black Soldier Fly larvae; new technologies, such as innovation in weed control, and two-wheeled tractors to bring mechanisation to African agriculture; new institutions and expertise, such as Plant

Doctors in the Pacific islands; new markets; new business models and information, such as price incentives in Indonesian dairying, and mobile financing in Laos and Cambodia; and other opportunities to diversify, for example helping farmers get certified so they can get into modern markets. And so on.

Addressing risk is about addressing different constraints. In order to do that, we need to understand the needs of the smallholders – to talk to them, in their households. It is about understanding these different constraints and different opportunities in terms of what fits with their values.

Global shocks

Last year I had the opportunity to go with the ACIAR Commission and our Policy Advisory Council to look at ACIAR work in the Mekong Delta (Figure 7), which is really the food bowl of Asia. The region sends food to Australia, to Europe and elsewhere all over the world. It provides over 50% of the food for Vietnam alone, and it is home to 18 or 19 million people, many of them smallholders.

Figure 7.

Yet 40% of this delta area may be one 1 m underwater in a matter of decades because of rising sea-level. In some areas already there are huge issues with salinity from the intrusion of water. How can smallholders in the Mekong manage the risks from that global issue? What can we do to help deal with this? Is it risk or is it uncertainty?

ACIAR has begun looking ahead at future risk, based on scientific projections: at new varieties that are salt tolerant; at using the mangroves differently; at growing different products in those areas. ACIAR now has a very good partnership with other institutions in that region, aiming for huge innovative approaches.

Beyond 'business as usual'

As all the speakers so far at this conference have said, there are huge challenges now for the world's natural resource-based systems and for farmers – whether they are smallholders or large-scale – who are at the heart of the issues. It's not just production variability; it's all the other One Health issues (Figure 8). They need thinking about holistically.

Our innovation system requires rethinking, in terms of what we do and how we do it. On-farm risk can no longer just be managed on-farm, and I think that's a very important thing to remember.

Figure 8.

As the new CEO of ACIAR, I am very keen to talk to people and think together about how we address these matters. ACIAR has a small budget (about $111 million) which I hope to enlarge. However, I think the only way we can do that in the short term is through innovative partnering, and more multi-disciplinary work, though not at the expense of disciplinary excellence. Can transdisciplinary work have a role; that is, having end users involved through sophisticated participatory methods? Can we broker new collaborations along whole value chains (e.g. public health, nutrition, energy, information and communication technology (ICT), finance)? Can we improve how we advise policy? Although I think ACIAR already does well in those fields, we could be doing significantly better.

We need to think about what we invest in, where we should invest, how we should invest, who should we partner with, and how can we partner differently? I think ACIAR in particular could be doing more with the private sector, and with not-for-profits, taking a climate and a nutrition approach.

Professor Wendy Umberger is the new CEO of ACIAR. Previously, she was the President of Australia's Policy Advisory Council (for International Agricultural Research and Development) and an Honorary Professorial Fellow in the School of Agriculture and Food at the University of Melbourne. She is an expert in agricultural economics and development and food policy. She has worked on food system issues across the Indo-Pacific region and led interdisciplinary value chain research projects in Asia, Australia, North America, the Pacific Islands and South Africa. Her research has explored opportunities for agricultural smallholder households in producing high value (horticulture, dairy, beef) food products and adopting new technology to gain access to modern food value chains.
From 2013 to 2022 she was the Foundation Executive Director at the Centre for Global Food and Resources at the University of Adelaide and a Professor in the School of Economics and Public Policy. She served on the Board of Trustees of the International Crops Research Institute for Semi-Arid Tropics (ICRISAT) from 2015 to 2021. She is also an Independent Director of Grain Producers South Australia (GPSA), a Director of the International Association of Agricultural Economists, a board member of Food Bank SA, an Honorary Fellow of Food Standards Australia New Zealand, and a Distinguished Fellow of the Australasian Agricultural and Resource Economics Society. Wendy has a B.S. in Animal Science (1996) and M.S. in Economics (1998) from South Dakota State University and PhD in Agricultural Economics (2001) from the University of Nebraska-Lincoln.

Q&A with Professor Wendy Umberger

on 'On-farm risks for resilient food and nutrition systems'

Chair: Nicola Hinder,
Deputy Secretary, Agricultural Trade Group, DAFF

Chair: Nicola Hinder

Thank you very much, Professor Umberger. There were lots of things you said in your talk that really resonated with me. Among them, the recognition that agriculture goes beyond those we traditionally call our farmers and that it involves fishers and foresters as well. It is incredibly important.

Q: Peter Wynn, the Crawford Fund in NSW

Cary Fowler referred to the declining water availability in aquifers in many intensive agricultural areas of the world. Where do you think water stands in economic importance, as we face climate change, for smallholder farmers throughout the world?

A: Wendy Umberger

That's a challenging question. Water is obviously at the core of those challenges, not just in terms of having enough but also, as with salinity in the Mekong Delta, making sure it's good quality. It's not just irrigation and not just efficient irrigation, because dry-land areas survive without it. It can be a matter of looking at varieties to grow, to use in areas where you don't have the option to irrigate, or where in the future you may not have water to irrigate with.

In dealing with drought tolerance and varieties that can sustain good growth on limited amounts of water, I think Australia does an amazing job. I know the Grains Research & Development Corporation explores suitable crop varieties. There is also the possibility of building dams, such as in Laos where ACIAR has worked with Charles Sturt University staff and the Lao Government to build fish ladders to bypass dams on the Mekong. Dams affect the local ecosystem and biodiversity, and are problematic for communities that depend not only on that water but also on its fish and other aquatic fauna. We need to think about policies around sharing resources with biodiversity, and other ways to protect it. Water is of critical importance.

Q. Uwe Dulleck, Centre for Behavioural Economics, Society & Technology, QUT

I am interested in understanding behavioural, economic and technical barriers to resilience and innovation. If you talk about risk, the behavioural economist in me thinks 'we know that people have trouble making decisions on their risk and uncertainty'. Have you thought about that? And how does that inform your policy research in this space?

A: Wendy Umberger

You are talking to someone who is passionate about this. I am a behavioural economist at heart. I think there are probably several people in the room in addition to you who have done quite a bit of work on looking at risk preferences. For example, how do individual circumstances, individual risk profiles affect what someone does. You can teach somebody about risk management strategies, but whether or not they are going to change their behaviour is another question

altogether. Therefore, I think you can't rely only on education, because it doesn't matter how much we educate or inform people, we still need to put some buffers in there to deal with actual behaviour. And that's where policies are very important. Sometimes you need policies to address the fact that people aren't going to behave in accordance … that some people have different risk preferences, and different ways of managing risk.

Q: Sibjan Chaulagain, a Crawford Fund scholar at the Australian National University

I come from Nepal, from a smallholder farm in a rural village of Nepal. All the discussion on smallholders at this conference resonates with me. You talk about different risks, and you also talk about migration. In a country like Nepal where most males migrate to Gulf countries to work as migrant workers, the families who were living in the villages tend to move to urban or semi-urban areas. So the river lands in the urban and semi-urban areas are being used for construction of buildings, whereas the lands that have been abandoned in the villages are useless. In ACIAR, have you done any research on how to deal with those kinds of risk?

A: Wendy Umberger

That's a very important and relevant topic that I personally have not worked on – that is, the issue of what's happening to the lands that are abandoned or that may be left with family members who don't have much experience in agriculture.

I know there's been work done, supported by ACIAR, in the policy area looking at how that land should be used. Some of that work has explored trying to get people to reinvest in agriculture, and policies for that, aiming to bring new entrants into agriculture. Another issue you see when people go to work, even in nearby cities, is that of overuse and misuse of chemicals, and misuse of water, and that creates other issues. So there is work but I am not sure that there are many answers yet. Different policies. Kym Anderson, probably, has done some work on that, and I think there's been a multidisciplinary project on the topic. It is definitely an area needing more work though.

Q: Sabi Kaphle, Central Queensland University

I work in public health and mostly midwifery is my background. Talking about food security issues, women and children in the lower- and middle-income countries, especially those who are in rural and remote areas, are impacted the most with high volumes of disease and associated mortalities.

So when you're talking about innovations, and focusing on solutions, what can be done in those remote communities? What other structural determinants play significant roles to improve their health outcomes as well as to improve their food security?

A: Wendy Umberger

Yeah, that's a very important question, and I have to be very much an economist and say, 'Well, it depends upon the situation'. It means understanding the women at the heart of the issue there. We need to be careful, when we are looking at development activities and development investments, to consider potential perverse outcomes. For example, if you're pulling women away from caring responsibilities, that leads to other issues in the household, and we need to think about that.

The other issue – and there is now, I think, a fair amount of work on this, but I'll use the Vietnam example I mentioned – in that project growing vegetables in a rice farming system, it was assumed that if we get women involved, and we diversify the household agriculture system away from rice

and incorporate more vegetables, more cash crops, the people will eat the different fruits and vegetables that are grown. However, those people are smart and, just like us, they look at what they can do in their households to get the most income because (as you hear if you talk to them in interviews about what's important) it's most important to get education and a diversity of food. To them, protein was very important, and getting new types of protein beyond the normal bit of fish. So going to the market, they would be selling the vegetables they'd grown, not consuming them. Vegetables were seen as not as valuable for consumption because they could be sold to make a lot of money in the markets. When the women had sold the vegetables they had grown, they were empowered by having the cash, which they might take home and share with their spouse. Their concern was that the spouse would either directly invest it back in the farm or, in some cases, use it for drinking or cigarettes etc. (That's not every household; those were things that we heard.) The women would go and buy meat and other sources of food that they viewed to be healthy.

However, the ACIAR project was in an area where there had been good work by not-for-profits, training the women on nutrition and on health and on causes of stunting. We were lucky to have a group of smallholders who had been involved in work with health experts and who understood development.

So, I think it's important to think about the setting of the household; also the culture. In some places where ACIAR has worked we simply don't have the ability to talk to women; there we need to find different ways of empowering the women in ways that are culturally sensitive.

Q: Angus Campbell, the One Health unit, Nossal Institute for Global Health, at The University of Melbourne.

One of the other big risks that has been touched on today has been pandemic risk and disease-spillover risk. It appears there's still little connection between work to make food production-systems secure and work towards production systems that are less risky for disease-spillover and neglected zoonotic diseases.

Could you comment on whether you think that disconnect is as strong as some of us perceive it to be? Are there opportunities that are currently being missed to make food systems and food production more resilient, better at managing risk, but also avoiding some of these future risks that seem to have a lot of global attention at the moment?

A: Wendy Umberger

I absolutely agree that we need to be investing more in the One Health area and combining those different areas of science. I think many of the disease issues that could result in pandemics do happen in smallholder systems or in developing-country settings where there could be massive disease outbreaks and biosecurity issues. So, I think we definitely need to be investing more in understanding those diseases in the One Health area overall. I think it's a critical area and one of those examples where that is truly transdisciplinary, and probably needs much more investment.

Q: Semy Siakimotu, Department of Agriculture Fisheries and Forestry

This is not really a question but more a comment. Prior to coming back to the department I worked as a biosecurity trade adviser for a program funded by the Australian Government. I agree with the comments you made around the challenges that smallholder farmers face in accessing the value chain and in relation to selling their products.

It seems to me – and this is a point I want to put as a challenge to the heads of organisations here in this forum – that a lot of the focus has been on developing capacity in these countries as it relates to food security, food nutrition. But there's very little support on the market side. I think that's the weak link. We try to empower smallholder farmers in relation to participating in value chains that are sustainable, but they have only so much to spend, and if the market is not paying, they're not going to spend.

I think the challenge for us as policy makers, as heads of organisations, is how do we work towards a market system that recognises the efforts that are being invested by these small farmers and these communities, so they can be rewarded, and so that the system continues to pay for the work they have put in?

Chair:

Please join me in acknowledging the great presentation that has been given today by Professor Umberger.

SESSION 3

Addressing off-farm impediments to global food security

Emeritus Professor Kym Anderson AC

The University of Adelaide & Australian National University

Abstract

The riskiness of agricultural production has been increasing this century, but so too have global market and policy uncertainties faced by farmers, agribusinesses and agrifood traders. In addition to short-term geopolitical contributors to which producers in the agrifood system have to become more resilient, there are long-term concerns with climate change (CC) and biodiversity loss and the responses of various governments and international agencies to those concerns. Farmers are among the worst-affected producers but are also significant contributors to greenhouse gas emissions and biodiversity losses. Adapting to global warming and more-extreme weather events, and to new policies aimed at mitigating CC, is challenging many farmers, while some other farmers will see new opportunities such as being paid to contribute to CC mitigation. Better outcomes, in terms of reductions in global food insecurity, malnutrition, CC, biodiversity loss and extreme poverty, require policy reforms in at least three areas: (i) less government intervention in national markets for agrifood products and purchased farm inputs, to ensure better use of the world's agricultural resources, (ii) more-widespread taxing of greenhouse gas emissions, and (iii) better markets for and policies affecting the services of natural capital so as to generate more (and more-appropriate) public investments in agricultural research and rural infrastructure in developing countries, and more public-private collaboration to up-scale innovations pertinent to the needs of farmers and agribusinesses there.

The title of this talk deliberately complements the title of Professor Umberger's talk on on-farm issues. I will discuss the sorts of issues that farmers *cannot* themselves directly affect but that they want to see improved. I have three key messages.

First, in my view not only has the riskiness of agricultural production been increasing this century, but also global markets and policies have become much less certain. Yet farmers and agri-businesses are having to survive in this more uncertain world.

Second, if we're going to boost global food security and generate more sustainable food systems, as everybody says we must do, and enable our farmers to be more resilient and climate-smart, then we need: (i) better markets for the services of natural capital; (ii) more public investment in agricultural research and in rural infrastructure in developing countries to get food from farms to consumers; and (iii) more public–private collaboration, to up-scale innovations that are already available but not yet being used to satisfy the needs of farmers and agri-food businesses in developing countries.

Third, the returns from these types of investments – that is, investments in research for development (R4D), in rural infrastructure and in upscaling innovations – will be enhanced if there is less government intervention in national agricultural markets, as that will ensure we'd be using the world's existing agricultural resources better than we do now.

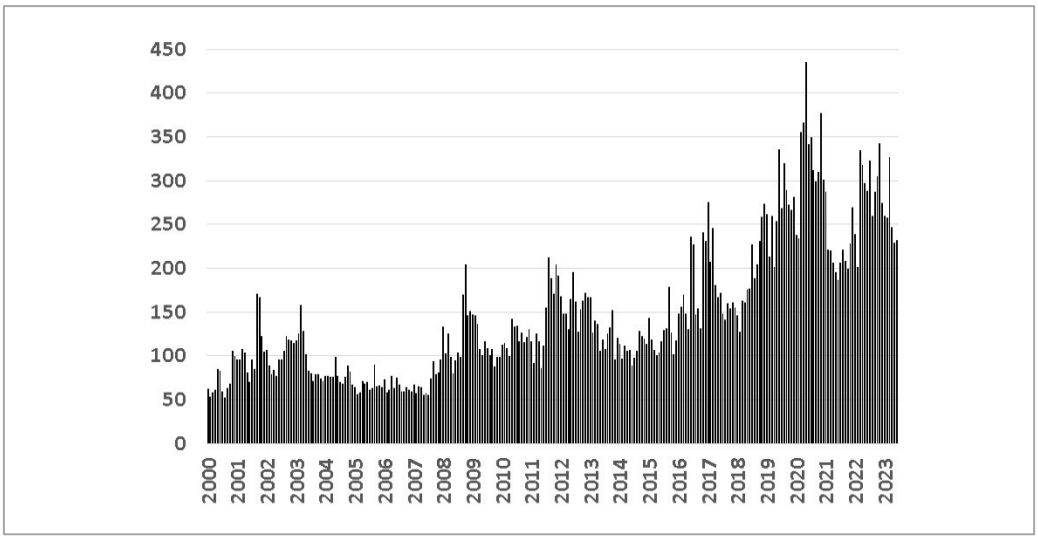

Figure 1. Global index of uncertainty in economic policy. *Source:* www.policyuncertainty.com

1. Riskiness and uncertainty

My first message is about not just the riskiness but also the uncertainty of farming. There have always been risks in farming and in trading. Agriculture is a climate-driven activity and therefore of course there are fluctuations because of seasonal variation, and also because international prices, international interest rates and exchange rates vary over time. True, those risks have increased during this century. That is, in statistical terms, their probability distributions have widened. We have seen this before, in past history, and farmers learn over time how to deal with them. However, now both markets and policies are also less certain. We don't know what their probability distributions look like now. Only with more time can we learn about those things, and thereby reduce the amount of uncertainty and shift them into the 'risk' category.

Market uncertainty is about how globalisation or the digital revolution affects the probability distributions of income and employment contributions. Those consequences are quite difficult to predict. Baldwin (2019) gives a good sense of how we cannot even imagine how services activities are going to change over time with globalisation, and goods markets as well.

There is *technology uncertainty*, because researchers are responding to the changes in climate that we're living with, and also to changes in consumers' preferences (such as wanting substitutes for meat and dairy, and demanding that goods be produced more sustainably). Firms are going to try to meet those new demands in order to continue to satisfy their customers.

The third area of uncertainty that has increased has to do with *policy*. The speed of globalisation and of the ICT revolution is leading countries to respond by imposing unpredictable trade restrictions in a push towards anti-globalisation and populism in their governments. Figure 1 shows the changes over the past 23 years in a global economic policy uncertainty index (vertical axis), extracted from the website https://www.policyuncertainty.com . The blip around 2007–2008 was the global financial crisis. Then uncertainty increased a decade later around Brexit and a little later even more so as Donald Trump went into office.

Looking historically, more populist governments came into power in the 2010s than in any previous decade back to 1900. Figure 2 shows countries with populist governments since 1900. Those governments are a mix of left-wing and right-wing, and both types of regime have adopted wasteful economic policies. This rise of populism is a worry because it leads to economic nationalism, and trade protectionism, and to less multilateralism, and therefore slower economic growth globally (Funke *et al*. 2021). Yet we need *faster* economic growth to reduce poverty; we need *more multilateralism* to generate more of the kinds of global key public goods that can help us reduce climate change, reduce losses in biodiversity, and reduce the risks of communicable health diseases such as COVID-19 (since that pandemic won't be the last one).

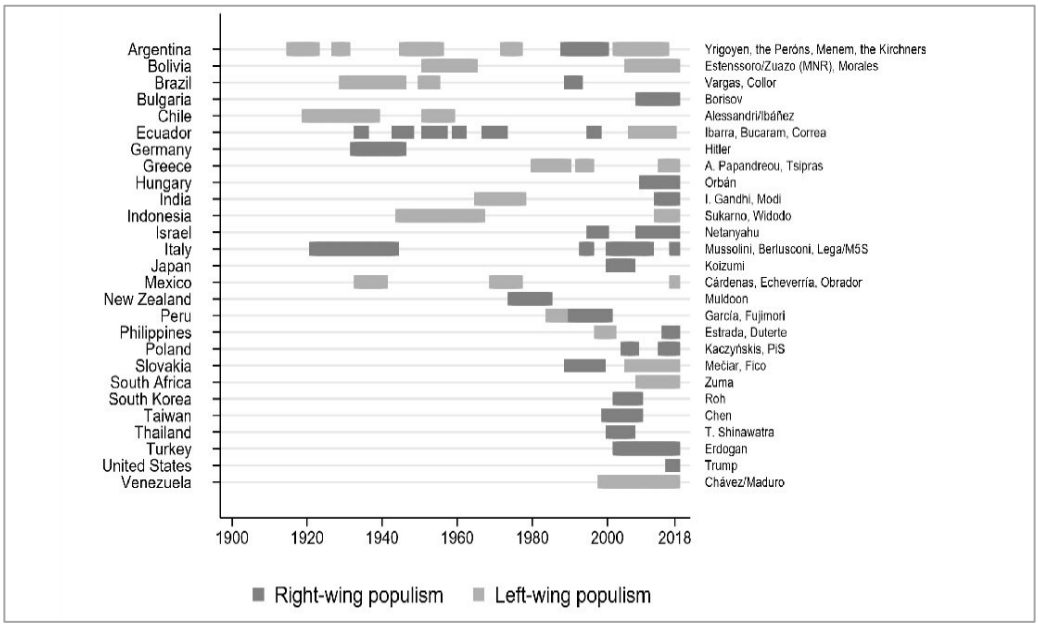

Figure 2. Populist governments since 1900. *Source: Funke* et al. *2021.*

Sources of much of this increase in uncertainty have been talked about both in the Sir John Crawford Memorial Address last night and earlier this morning. For instance,

- China is now more assertive and less reliable as a trading partner;
- Russia, a major exporter of grains, fertilisers and hydrocarbons, has disrupted those markets through its recent aggressive interventions, particularly in Ukraine; and
- The United States, during the Trump era with its populist President, triggered tariff wars not just with China but also with close partners of the US, and undermined the World Trade Organization, the Intergovernmental Panel on Climate Change and the World Health Organization. With a US election coming up next year it's possible that Trump will be President there again.

As a consequence of all this, there is a much-heightened risk of international conflict and, as discussed earlier this morning, conflict affects food security. The situation doesn't seem to have improved even under the Biden administration.

2. Better global food security and a more sustainable food system

The second take-home message from this talk is about trying to see how we could improve markets for natural capital (farmland and irrigable water, for instance), how we could improve government decisions on public investments, R&D and infrastructure, and how we could get more public–private collaboration in upscaling agri-food technologies.

(i) Better markets for the services of natural capital

Efficient use of the available **farmland** requires secure property rights. That doesn't mean taking rights away from Traditional Owners: in Fiji, for example, Traditional Owners have secure holds on their land. If they don't want to use that land, they can lease it out to somebody else who does want to use it. Having efficient markets for that is what is important.

Equally important and much less well developed globally (although we are gradually doing a good job of it in Australia) are markets for **irrigation water**, where again property rights need to be established for both sale and lease, along with good policies for altering the annual allocations according to how seasons change. It is often said that there are water crises around the world, but those crises occur because we don't price water properly. If we price water, instead of giving it away or giving away the electricity to pump that water – as India does – we wouldn't have such a crisis with water. *Water* is not rare or in short supply. What *is* in short supply are good institutions and policies to ensure it is allocated and used efficiently.

For **fertiliser and pesticides**, we can obviously replace subsidies with taxes on those polluting inputs. That would certainly save us over-using those fertilisers, often at great waste to the farmers who don't realise they are using too much.

Also needed are markets for sequestering **carbon** in soil. We are working on that here in Australia and in other countries, but those developments need to be spread more globally to help mitigate climate change.

Markets for **other ecosystem services** – e.g. tree planting to reduce loss of biodiversity – are also very underdeveloped. Twenty years ago, the Europeans and then the Japanese talked about multi-functionality of agriculture. It was seen by Australia and others as simply another way of protecting agriculture, by giving subsidies for doing environmental things. But now, even in Australia, we have moved to understand that natural capital markets do need to be developed, to make sure we don't waste that natural capital, and to look at that also as one of the possible ways of solving problems such as too much carbon in the atmosphere.

(ii) More public investment in agricultural research and in rural infrastructure in developing countries

More public investments in agricultural research and rural infrastructure are sorely needed in many developing countries. One of our colleagues, Phil Pardey (who gave the Overview paper at the 2022 Crawford Fund conference), and others have measured the extent of that under-investment by looking at what the marginal rates of return would be to further investment there. Generally, especially in developing countries, there is a huge gap that could be filled with more expenditure (Rao *et al*. 2020). Obviously, the international agricultural research system is one way in which we could do that by attracting larger amounts of money into that system.

It's desirable to get more research done, and not just for the producers' benefit. Unlike in Australia – where most of that benefit would go to producers – food in developing countries is not much traded internationally. That is, most is sold within the domestic market. If investments lowered the cost of producing that food, or of moving it from farm to urban markets, then consumers also would benefit: a win–win for food security in those countries for both urban and rural people.

(iii) More public–private collaboration, to up-scale innovations that are pertinent to the needs of farmers and agri-food businesses in developing countries

Public–private collaboration could up-scale innovations that are pertinent to small farmers in developing countries. I will mention just two initiatives here.

- USAID has a Development Innovation Ventures program that is supporting innovators and researchers to test out new ideas, to take strategic risks, to build confidence in what works, and to advance the best of those with evidence of their impacts, cost-effectiveness, and viable pathways to scale and to sustainability.
- Building on that, at the University of Chicago, Michael Kremer (who is a Nobel Laureate in development economics) has allowed the Innovation Commission for Climate Change, Food Security and Agriculture to be set up there (see https://bfi.uchicago.edu/project/the-commission-on-innovation-for-climate-change-and-food-security/). More information in this initiative is to be announced at COP28 in December 2023.

This new Commission is trying to do two things: (i) to support adaptation innovations that are difficult to up-scale commercially, by bringing in public sector money for that; and (ii) to encourage private sector mitigation innovations, by offering an advance market commitment. The latter type of system is already in use to encourage development of vaccines. This commission would pay somebody to innovate something only if and when the innovation is shown to be successful, thereby sharing the risk. The innovator has to put in their own money to prove their idea is valid, and only if it works out well will they be granted money to cover their costs and presumably give them some profit.

3. Less government intervention in agri-food markets

My third message is that the returns from the ideas I have just mentioned would be enhanced if we had fewer distortions to agricultural incentives around the world. In many national markets, farmers are supported in some activities but not in other activities, and that is a distortion within that country. And if governments are overly protecting all of agriculture in their country, then that is a distortion against the farmers in the rest of the world.

There is good reason for getting rid of those interventions. Without them, we will get prices right and thereby make better use of existing resources and have a better base from which to use new prospective technologies.

At the moment, agricultural policies are very price-supportive in Europe, though less so than in the past. The same is true in north-east Asia and to a lesser extent in the US, and also in some emerging economies including China. These policies tend to be price-based, which means the richest farmers get the largest proportion of the producer benefit while the poorest consumers are hurt most because those people spend the largest share of their income on food.

Within the World Trade Organization there have been efforts to try to reduce subsidies to agriculture (and also to reduce industrial subsidies). But it turns out that reducing farm subsidies is

not going to help very much. We have just revisited work we did about 20 years ago looking at the extent to which global economic welfare could be enhanced by reducing distortions to agricultural incentives. In that work (see Anderson *et al*. 2006) we found that 93% of the global economic benefit would come from reducing market import restrictions, and only about 5% would come from removing domestic subsidies (and 2% from removing export subsidies). Since then, particularly in Europe, policies have been switched away from import protection and towards direct subsidies to farm households.

We thought that switching would have had big effects, but a recent revisit suggests that the situation hasn't changed very much. It appears that still about 90% of the global economic welfare cost of these policies is due to restrictions to agricultural imports and only 10% or less of the cost is due to domestic agricultural subsidies (see Anderson *et al*. 2023). The various tariff and non-tariff barriers to international farm trade hurt countries like Australia, and they also hurt all those potential agricultural-exporting countries in the developing world.

Those trade barriers tend to fluctuate through time. That is not helpful for farmers, because they can't guess what's going to happen next year. If there's suddenly a spike in international prices, some countries will put on export restrictions and others will lower their tariff barriers. Each of those policies exacerbates the international price spike, *and* they offset each other so that there's no alleviation to the domestic price, which still spikes upwards. while there's a bigger increase in the international price (Martin & Anderson 2012; Jensen & Anderson 2017). Countries doing nothing face more instability. Thankfully, that lesson seems to have been learned by policy makers and their advisers. Cary Fowler this morning (Fowler, this Proceedings) said that the US, for example, has been encouraging countries not to do that in the current price spikes we have seen. Nonetheless, as Figure 3 shows, there have been a lot more of these spikes in this past decade or so than there were in previous decades.

Reducing price-distorting policies would improve global economic welfare, and they would alter activities within the agricultural sector to where they could best make use of existing resources.

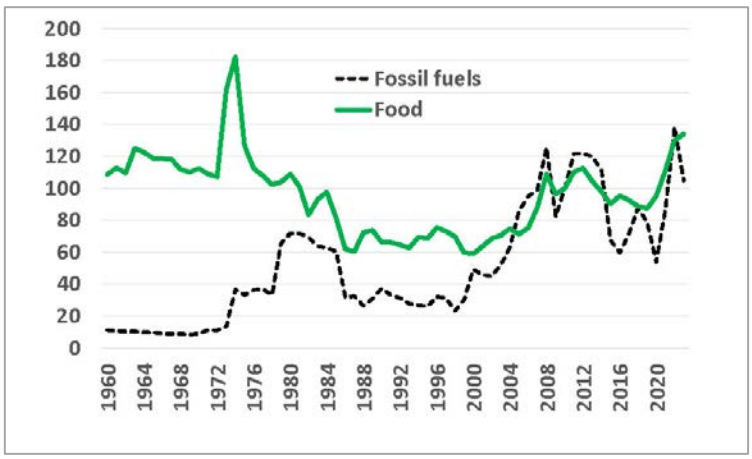

Figure 3. Real international food and energy prices are spiking more frequently this century.
Source: World Bank Pink Sheets, to July 2023.

However, they wouldn't boost global overall food availability very much (Gautam *et al*. 2022). There's been a lot of effort by the World Bank and IFPRI over this last couple of years to look at how we could boost global food and nutrition security, and sustainability of food systems, with other methods: that is, by repurposing the current assistance to agriculture so as to boost global food and nutrition security and gain better economic, environmental and social outcomes for the money being spent.

Policies that support agricultural market prices tend to be not only very inefficient but also inequitable, as well as anti-trade on average. They are biased towards the least-competitive farm industries in each country, and they shrink world trade. That then increases the volatility of international trade quantities and prices.

If agricultural market price support could be lowered, that could lower the environmental costs of supplying the world's food. By becoming more open to trade, those countries would not only reduce price instability but also boost economic growth and reduce poverty in agrarian economies by boosting demand for farm outputs.

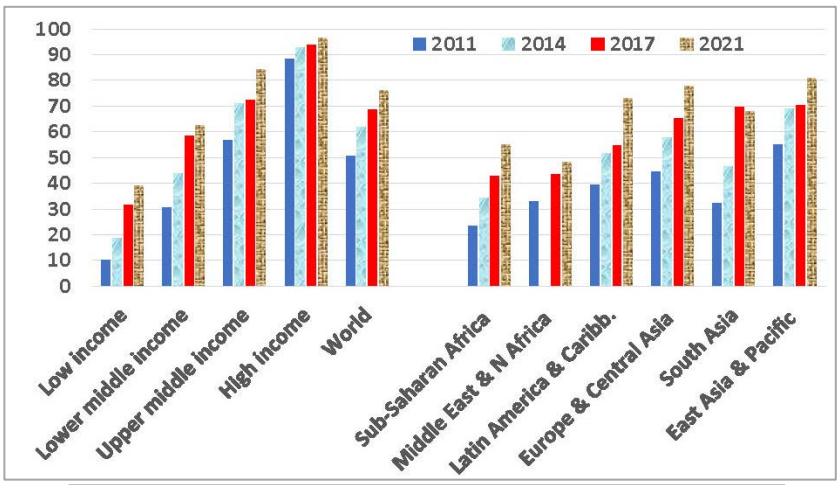

Figure 4. Share (%) of adults with a bank or mobile-money account.
Source: www.worldbank.org/en/publication/globalfindex

4. Other ways to reduce poverty

Direct payments are possible now in developing countries, in a way that wasn't possible until a decade ago. Now, like farmers in rich countries who all have bank accounts, more and more people in developing countries hold either a bank account or a mobile money account, thanks to the IT revolution. That has made it much more possible for governments to pump money into individual peoples' accounts to help a particular region. In Figure 4, the first set of columns show that in low-income countries a decade ago only 10% of adults had one of these types of accounts, but now 40% have them. In the lower-middle-income countries, the proportion has gone from 30% to over 60%. So, this idea of supporting households directly is not only possible, it also bypasses possible corruption from the village leader or whoever, who previously might not have diverted money that was due to particular poor households. This solution can address poverty very directly. The government can then focus its spending on something more efficient than farm price support programs – such as building rural infrastructure or expanding agricultural research investments.

5. What else is wrong with current agricultural policies?

As we know, farm production itself is contributing to some of today's major global problems, particularly greenhouse gas emissions (IPCC 2020) and biodiversity loss (Dasgupta Review 2021). As well, farmers themselves need to be incentivised to reduce both.

One way they can do that is through carbon trading. Making carbon taxing more common, and emissions trading more common including across borders, can facilitate the opening up of this. But there's a new OECD paper that came out last week that looks at the challenge in front of us as we seek to improve environmental impact reporting. Australia is just now getting into that process. Other countries have hardly started. Deconinck *et al*. (2023) has a comprehensive list of the things that need to be done to meet that particular challenge.

Of course, farmers need to adapt to climate change as well. We've heard a lot about that because climate change is lowering their productivity (especially in the tropics). It's also raising consumer prices of food and it's adding to the volatility of quantities and prices of agricultural outputs. Hence R&D has to be focused on generating more climate-smart innovations to deal with that issue.

6. Implications for the Crawford Fund

Finally, what are the implications of all this for the Crawford Fund? What it has been doing is fantastic. Their volunteers, as they retire, get out there and complement the sort of work that ACIAR is doing in our neighbourhood, and that's certainly contributing to agricultural growth and to reducing poverty (World Bank 2007; Headey & Hirvonen 2023).

But perhaps the Crawford Fund could be thinking a bit more about whether its people could contribute to the policy area too, for example by disseminating alternative policy options in developing countries where current policies are wasteful or where tighter environmental standards are required to retain market access abroad.

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Emeritus Professor Kym Anderson AC FAAEA FASSA DFAARES DFESA has contributed to economic development in the overlapping fields of international trade and political economy, with a strong focus on agriculture and products of importance to developing economies. His work and outputs, prodigious and varied, have been widely recognised for their quality and significance, in Australia and abroad, including by leading international agencies. Kym is the George Gollin Professor Emeritus in the School of Economics and Public Policy and formerly foundation Executive Director of the Centre for International Economic Studies at the University of Adelaide, where he has been affiliated since 1984; and he is an Honorary Professor at the Australian National University's Arndt-Corden Department of Economics where he was a Research Fellow during 1977–1983 and a part-time Professor of Economics during 2012–2018. He has held senior research leadership positions at the World Trade Organization and the World Bank; and a large number of significant research advisory positions, including in Australia. He is highly respected internationally for his knowledge, understanding and leadership, with an excellent citation rate that indicates his international leadership in agricultural economics. Kym has also played major roles on the ACIAR Commission and Policy Advisory Council and has chaired the Boards of the International Food Policy Research Institute (IFPRI) and the International Centre of Insect Physiology and Ecology (*icipe*).

Q&A with Emeritus Professor Kym Anderson AC

on 'Addressing off-farm impediments to global food security'

Chair: Dr Cate Rogers, Assistant Secretary, Climate Financing and Programming Branch, Climate Change and Sustainability Division, Australian Department of Foreign Affairs and Trade

Chair: Cate Rogers

First, thank you for a fantastic presentation in which you raised so many issues. You are not just talking about agricultural research and climate-smart agriculture in isolation; you are connecting it to so many other things and so many of the policy challenges. Macro-economic changes can make a big difference to food affordability, as just one example. Research has shown that the additional cost to developing countries of food imports as a result of the US dollar strengthening was $9 billion, which is not insignificant during a global food crisis, and puts pressure on the system making it harder for countries to respond with that array of policy tools such as social protection, which you also mentioned.

Q:

A question about extension. My understanding is that public funded extension was a response to the distortion of markets. I wonder if that is something that is going to happen further in the future, if it's something that someone like yourself supports?

A: Kym Anderson

Certainly, in Australia extension has almost disappeared from the public sector. The State departments of agriculture used do that extensively and now that's been dissipated and the private sector has filled that gap. As an initial result, most farmers tended to get less of it because they were not as willing to access it when they had to pay for it as they were when it was free. But now we see more firms providing very sophisticated services to farmers; and even farmers who can't afford to pay for such services can look over the fence and see how somebody else changed their methods as a consequence of using a consultant.

In developing countries, the loss of extension services may have happened less so far, but it's moving in that same direction. To offset that, public–private partnerships may help to get the private sector to upscale at least the best of the technologies that are sitting on the shelf. I'm really impressed by the best of these initiatives, such as what USAID's been doing and now also this new Innovation Commission that's set up at the University of Chicago: they offer a way of filling that gap.

Q: John Angus, Charles Sturt University in Wagga Wagga NSW

Thanks for your talk. I'd like your comments on farm cooperatives. The background is that grain growers in Australia sell grain to multinationals, whereas many grain growers in the United States market grain through a co-operative. I'd be grateful for your comment.

A: Kym Anderson

Australia has had a long history of cooperatives, starting in the 19th century and expanding during the depression of the 1930s. But now they've almost disappeared. They were taken over, or

became private companies, or went on the stock exchange or whatever, and found they could operate more efficiently that way than having farmers on the co-op's board who may not have known much about exchange rates or interest rates or markets in distant countries. That's been the evolution here in Australia.

Many developing countries still have cooperatives though, and it's partly because they may have had lenders of finance – as for example in a local monopoly situation – who were exploiting farmers, and the farmers could see a benefit from getting together and forming their own co-operative. But again, over time, as costs of doing business decline with IT, with better rural infrastructure, with more transport between cities and country areas, we see a relative demise of cooperatives or even their absolute disappearance in some settings. They still have a place while ever there are these unfortunate situations of monopoly or monopsony, though.

Q: Sibjan Chaulagain, a Crawford Fund Scholar at the Australian National University

I come from Nepal, from a smallholder farming family. We talk here about technology, technological uncertainty and policy uncertainty. My question is a bit away from the climate challenges and similar problems. If I was in Nepal now, I would be asked to go to the field to guard the crops against monkeys. Raiding by monkeys, and by invasive species is a big problem in Nepal (even discussed in the parliament), and in other countries as well. There is no long-term solution. Sometimes farmers fire a gun or similar noise-making device, but its effects don't last long. What can be done with policy? For example, in Australia there is policy about culling kangaroos. Can that sort of policy be applied to monkeys in Nepal, and problem animals elsewhere? I would like to hear from any experts who are here. Have you come across any thoughts about technological innovations to deal with this kind of thing, or any relevant policy solution? I am raising this question here where there are so many experts aiming to help farmers in developing countries, because if I do not raise this issue here I will have missed an important opportunity for a solution.

A: Kym Anderson

Well, you might be surprised to know I'm not an expert on monkeys! But I think this is a common issue throughout the world. Farmers have to deal with several types of raiding animals in Australia: birds in vineyards or orchards, for example. Growers put nets over the vineyard if they want to keep the birds off, or they plant vineyards where there are very few trees nearby. Those are among the solutions farmers use wherever this type of issue arises. I'm sorry, I can't help you with monkeys in particular though.

Chair: Cate Rogers

I think the broader issue there is that if farmers in developing countries have better access to resources, that can mean they are better placed to find their own solutions. One of our jobs that we take seriously at DFAT is to try and ensure that farmers *do* have access to resources.

Thank you very much, Kym, and thanks very much to the audience for your questions. Let's thank Kym in the usual way.

SESSION 4.1:
SOLUTIONS FOR RESILIENT FOOD AND NUTRITION SYSTEMS ON-FARM

Sustainable intensification: Decoupling resource use from socio-economic benefits in southern Africa

Professor Jamie Pittock

Australian National University

Abstract

Sustainable intensification of agricultural production is needed to feed 10 billion people who have limited land and water resources in a changing climate. In Africa, enormous investment in irrigation schemes has resulted in a build–fail–rebuild cycle that has trapped farmers in poverty. The Australian National University and partners have been supported by ACIAR in 'Transforming Irrigation in Southern Africa' (TISA) from 2013 to 2023, to reboot failing smallholder (average farm size = 0.5 ha; ~15,500 farm households) irrigation schemes in Mozambique, Tanzania and Zimbabwe. We intervened in two ways. First, farmers were provided with simple-to-use soil monitoring tools – the Chameleon and Full Stop (https://via.farm/) – to manage their water application and soil fertility. Farmers at the head end of canals reduced their water application by half to two thirds, increasing crop yields and generating many other benefits. Second, in a social process, farmers formed agricultural innovation platforms. They identified, prioritised and fixed problems that they could influence, including to: grow more profitable crops, lower input costs, better access markets, and in some cases, undertake further processing. This increased household incomes and catalysed many other benefits. For example, during the COVID crisis, food insecurity in TISA schemes was much less than for non-TISA schemes. This is analogous to the resilience required under a changing climate. The TISA project illustrates that:

1. Agriculture systems are complex and require multiple social and technological investments to become more sustainable and profitable;
2. Empowering farming communities and businesses is key to building profitable agricultural systems that deliver lasting benefits;
3. Significant decoupling of resource use from production is possible and this increases resilience to shocks; and
4. Long term (10 years) of research for development investment by ACIAR into community driven research has enabled lasting change.

I have been invited to present a case study on sustainable intensification, to draw out a few lessons. The case study is a program called Transforming Irrigation in Southern Africa (TISA), funded over the last decade by the Australian Centre for International Agricultural Research (ACIAR). This project has been a great partnership between Australian and African research organisations.

The context here is that we have spoken about the need to grow more food for an increasing population, and yet land and water are limited. Irrigated agriculture is one way to produce more food, more reliably, if water supply can be controlled.

However, in Africa there has been a momentous failure of smallholder irrigated agriculture, and so the top-down capital-intensive engineering and technology solutions for building those irrigation schemes have largely failed. I would put that down to some very silly policies, such as directing farmers to grow cheap grains on some of the most expensive farmland in Africa. That has resulted in extensive use of water for very low yields, where farmers are unable to make a profit and have used these irrigation schemes for subsistence agriculture rather than for securing food supplies for these countries. There has been a build–fail–rebuild–fail sequence. Donors build the infrastructure; national governments build the infrastructure. It fails. A decade or two later somebody comes back to pour the concrete again.

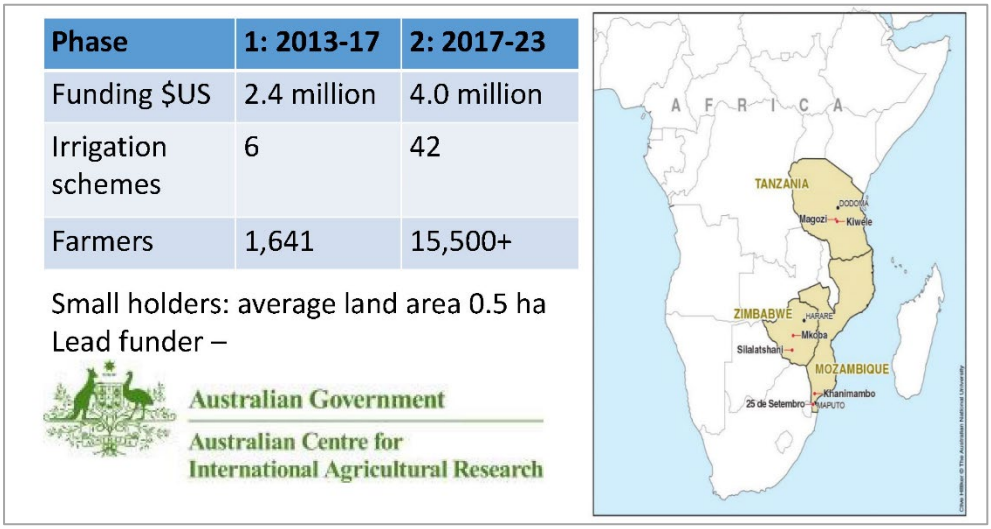

Figure 1. Overview of the program 'Transforming irrigation in southern Africa' (TISA).

The TISA program

In the Transforming Irrigation in Southern Africa (TISA) program we have sought to engage irrigation communities, to rely on their knowledge and help identify solutions that could increase both yield and profitability – which are not the same thing – and, we hoped, decouple production from resource use. The program is active in Tanzania, Zimbabwe and Mozambique (Figure 1) on irrigation schemes for an average farm size of half a hectare. Currently we are working directly in 42 irrigation schemes with around 16,000 farmers, and scaling out and up from there.

We have made two interventions. The first is technological – some tools, developed by Dr Richard Stirzaker at CSIRO in Canberra, that have put the power of information into the farmers' hands (Figure 2). The farmers now can *see* whether there is enough moisture in the subsoil around their crops. If so, they can stop watering. These people are farming in semi-arid areas. When we arrived to begin the project, farmers were 'drowning' their crops by over-watering, washing away the nutrients. That had an enormous cost in terms of their labour and in terms of poor yields.

Our second intervention is 'agricultural innovation platforms' – a term that simply means 'talking to the farming communities and helping them model ways of identifying their problems, and their opportunities, and prioritising them'. The example in Figure 3 is a pair of sketch-maps of an irrigation community, with the 'before' – their current situation (left side) – showing lots of doom

and failure; and the 'after' (right side) – where those farmers envisaged their community could be in five years. We helped them to stop wanting their government to do something, and instead we helped them focus on things that they could directly influence themselves: for instance, negotiating with the input suppliers to buy in bulk and lower the costs; and physically talking to the people who bought their produce to find out what they actually wanted and when, so that the farmers could increase their returns. This combination very quickly led to some very radical changes in farming behaviour.

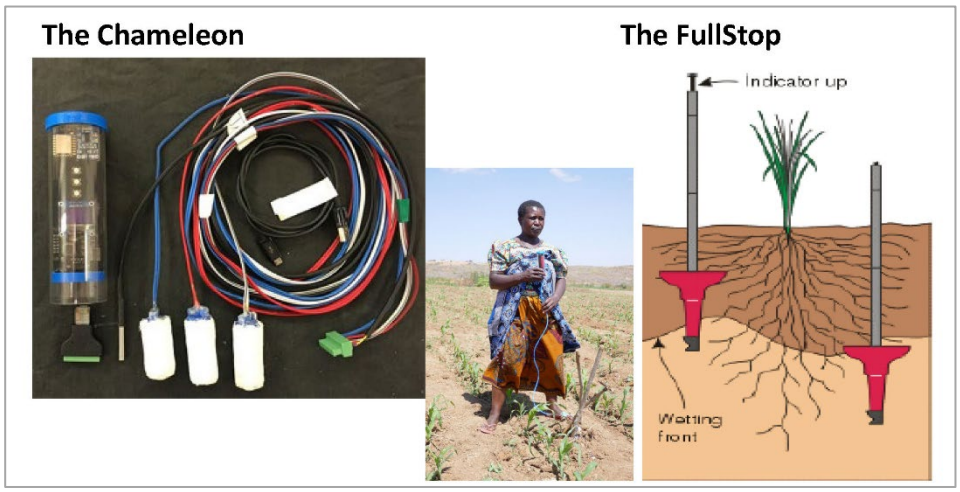

Figure 2. Intervention 1: Simple-to-use soil monitoring tools that increase learning & crop yields, by Dr Richard Stirzaker, CSIRO, https://via.farm/.

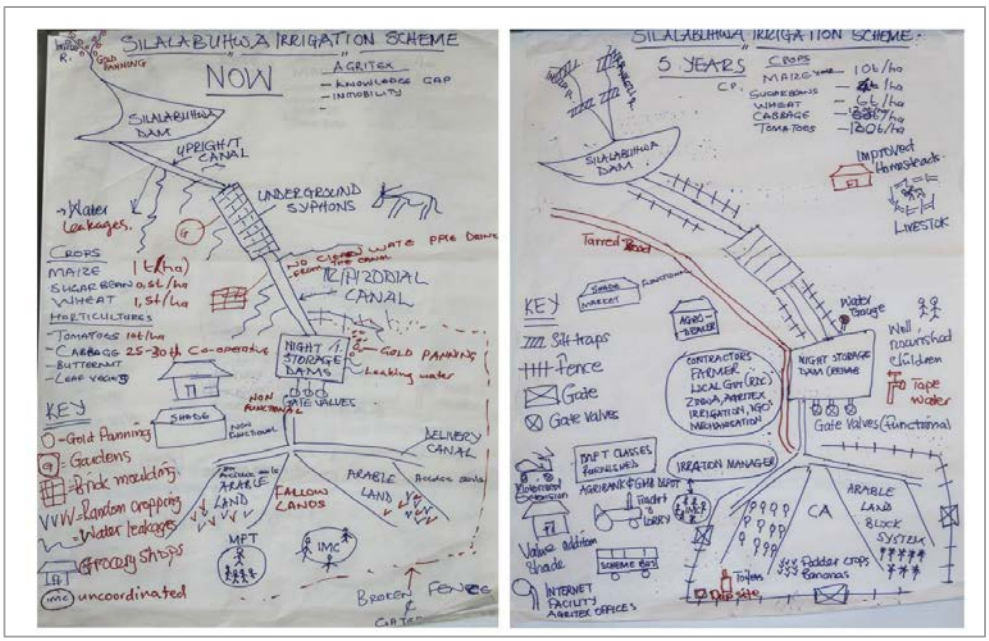

Figure 3. Intervention 2: Agricultural innovation platforms (AIPs) with communities increase farm profitability. Examples of the current situation (left) and desired situation (right) produced from the visioning exercise in Silalatshani, Zimbabwe. *Source: van Rooyen* et al. *2017*.

Results

The change in irrigation frequency is one measure of water use. You can see from this example in Mozambique the interval of watering increased from nine days to around 15 days on average (Figure 4). Much less water being applied.

As you may know, if you don't drown your crops you are likely to increase their yield – and indeed this was the case. Green maize yield, for example, increased from around five tonnes per hectare to over 15 tonnes per hectare (Figure 5).

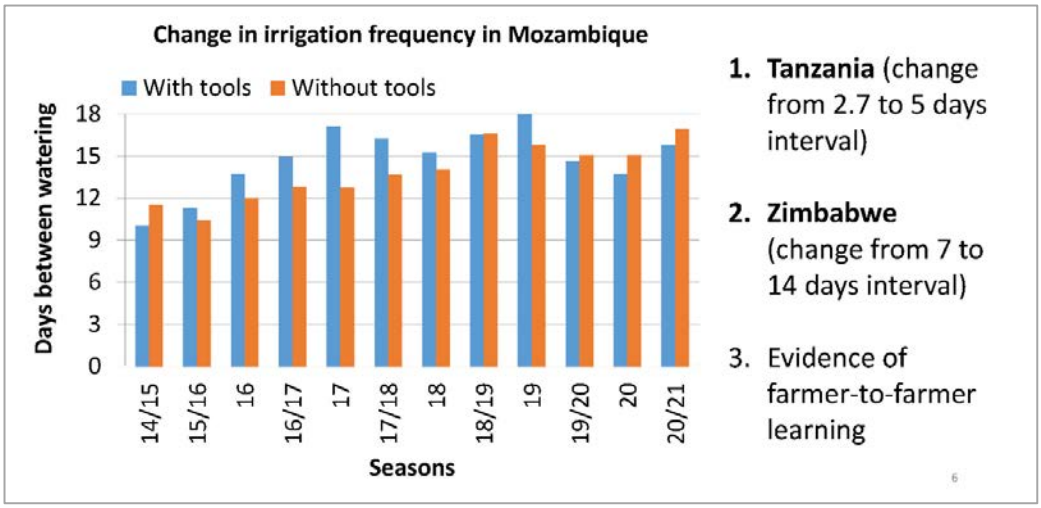

Figure 4. Changes in irrigation frequency (2014–2020) in the three countries.

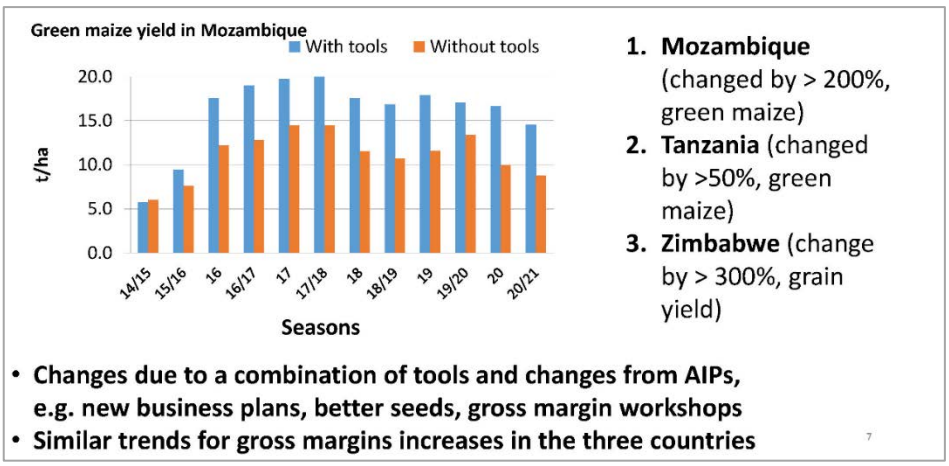

Figure 5. Changes in yields of green maize (2014–2020) in the three countries.

But of course, simply increasing the yield doesn't increase the profitability of the farming system if all you do is flood the market. Therefore, a very important aspect of this program was the social innovation. Technological intervention alone for intensification fails unless there is *also* social intervention to manage the system. In this case, that meant changes such as staggered plantings so that produce was available over longer periods of time.

Figure 6 summarises some of the intensification benefits that resulted from those interventions, including: several ways in which less water was applied; less energy used by irrigators who use electric pumps; increased crop yields. A major benefit was the labour saved: most farmers saved between half a day and three days per week and could spend that time on other productive activities, such as investing in off-farm activities and further diversifying their system. There was more efficient use of fertilisers. One big benefit that we didn't expect (but should have) was the major reduction in conflict between irrigation areas, between farmers, and within households, and that unleashed a 'tidal wave' of collaboration to make these systems even more effective.

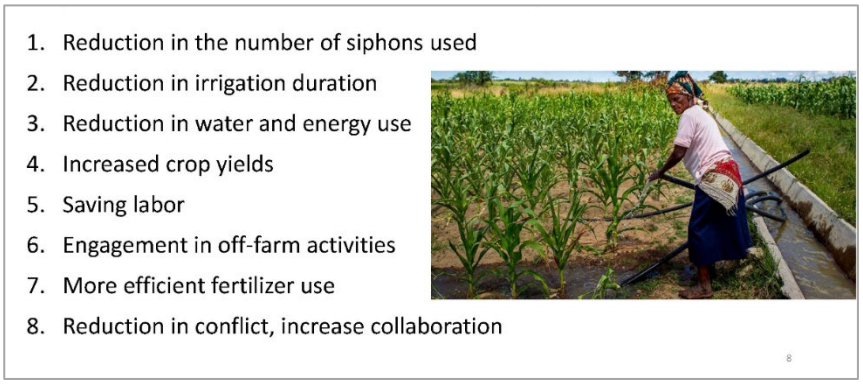

Figure 6. Intensification benefits from interventions in the three countries (2014–2020).

To check that we really did achieve intensification – that is, more crop per drop – one of my PhD students, Michael Wellington, used geographic information systems (GIS) to compare gross primary productivity to evapotranspiration (Figure 7). He was in part funded by the Crawford Fund for his research travel. Congratulations to the Crawford Fund for supporting this excellent research that shows that in functioning irrigation schemes it was possible to produce more food on the same land with less water.

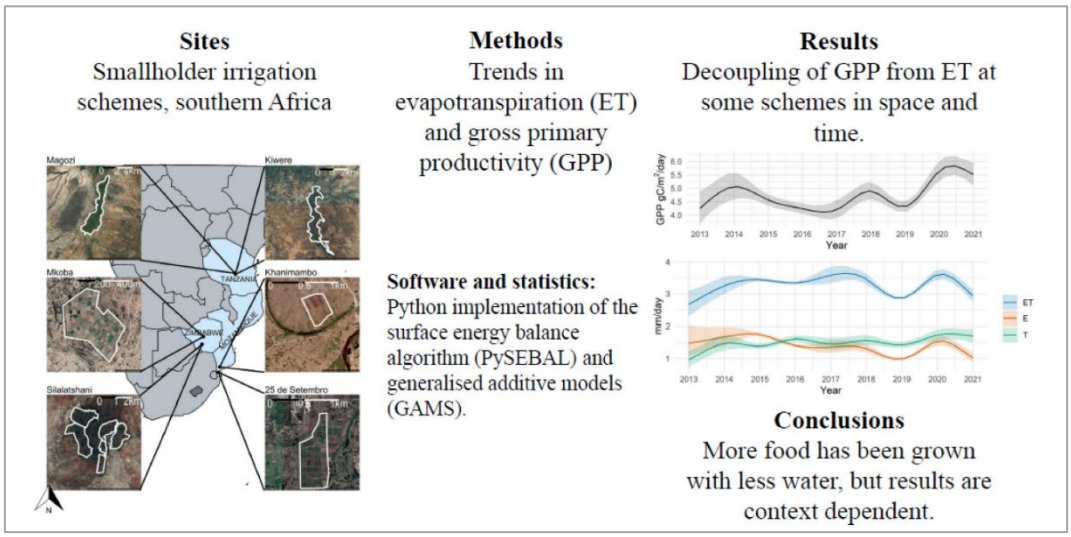

Figure 7. More crop per drop? Independent GIS check. *Source: Wellington* et al*. 2023*.

This program has now catalysed more investment in intensification. There are plenty of bespoke examples, such as one from Kiwere, Tanzania (Figure 8), where farmers are now diversifying their production system by moving into dairy cows based on feed from the irrigation scheme. So we are getting a beneficial feedback of intensification.

Figure 8.

Conclusion

- We believe multiple social and technological interventions are needed to improve sustainability and profitability: that is, a technological intervention alone is not enough.
- It is essential to empower the farming communities and businesses so that they can push against some of the silly policy prescriptions from governments, where needed.
- Significant decoupling of resource use from production is possible, as I think we have shown with water, with the smallholder irrigation schemes, and
- I strongly commend ACIAR for its approach to funding teams doing this kind of research over long periods of time and for being flexible in enabling us to learn and follow new opportunities rather than being unduly prescriptive with that.

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Project website: http://fennerschool.anu.edu.au/research/projects/africa-irrigation-and-water-project-increasing-irrigaton-water-productivity-3

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Dr Jamie Pittock (BSc, Monash; PhD, ANU) is Professor in the Fenner School of Environment and Society at The Australian National University. Jamie worked for environmental organisations in Australia and internationally from 1989 to 2007, including as Director of WWF's Global Freshwater Programme from 2001 to 2007. His research from 2007 has focused on better governance of the interlinked issues of water management, energy and food supply, responding to climate change and conserving biological diversity. Jamie directs research programs on irrigation in Africa, hydropower and food production in the Mekong region, and sustainable water management in the Murray–Darling Basin.

SESSION 4.1:
SOLUTIONS FOR RESILIENT FOOD AND NUTRITION SYSTEMS ON-FARM

Future Smart Crops: the key to improving dietary diversity and fighting hunger and malnutrition

Professor Kadambot Siddique AM FTSE

Hackett Chair and Director, The University of Western Australia Institute of Agriculture

Abstract

Asia and the Pacific continue to suffer from a high prevalence of malnutrition. An estimated 479 million undernourished people, 58% of the worldwide total, live in this region. Chronic undernutrition is due to the persistent inability to meet minimum micronutrient and macronutrient requirements, or the frequent recurrence of acute malnutrition episodes, or a combination of both. Food-based approaches that address malnutrition, especially micronutrient deficiencies, are embedded in evidence-based healthy diet patterns, but they are disconnected from the current agricultural production system. Neglected and underutilised species (NUS) are fundamental to improving dietary and production diversity. These species are nutrient-dense, climate-resilient, profitable, adaptable, and locally available. 2023 is the UN International Year of Millets. This program, along with the 'Future Smart Food Initiative', is being led by the Food and Agriculture Organization of the United Nations (FAO) to harness the enormous benefits that millets and other NUS offer in the fight against hunger and malnutrition. Recognising that NUS cover crop, livestock, fisheries and aquaculture and forest, FAO sets *crop* as an entry point among NUS to address hunger and malnutrition. Many NUS can tolerate various stresses, which would make production systems not only more diverse but more sustainable and climate resilient. Their resistance to climate change implies that NUS can provide food when other crops fail. The book *Neglected and Underutilized Crops: Future Smart Food*, edited by Muhammad Farooq and Kadambot H.M. Siddique, was published in November 2022.

Thank you to the Crawford Fund for the invitation to this conference. The topic, Future Smart Crops for improving dietary diversity and fighting hunger and malnutrition, has already been mentioned by Cary Fowler and others. In this talk I'll add some numbers; and briefly touch on the global hunger and malnutrition situation, particularly malnutrition; the prevalence of an unhealthy diet – what it is causing, and how; challenges facing the food system and nutrition security; and diversification; and I will draw some conclusions and look at a way forward.

Looking back to 2019, 'Sustainable Development Goal 2: Zero Hunger', we thought then that we could achieve it, but it is getting extremely difficult. As Figure 1 shows, the number of hungry people could be 840 million or even 900 million by 2030. The coronavirus (COVID-19) has probably added 150 million to the number of undernourished people. Although there has been a reduction in hunger and improved nutrition security in the Asia Pacific, still it is very high with 93 million children under five years old stunted, 30% of the population. And in sub-Saharan Africa there is still a lot more work to be done, perhaps by ACIAR and US agencies and others.

Figure 2 shows seven sub-regions where there is very high or high malnutrition: in Oceania, South Asia and also East Africa and Middle Africa it is very high (2019 data). There are 30–40% of children under 5 years of age stunted in some of those countries, while the world average is 21.3%. As

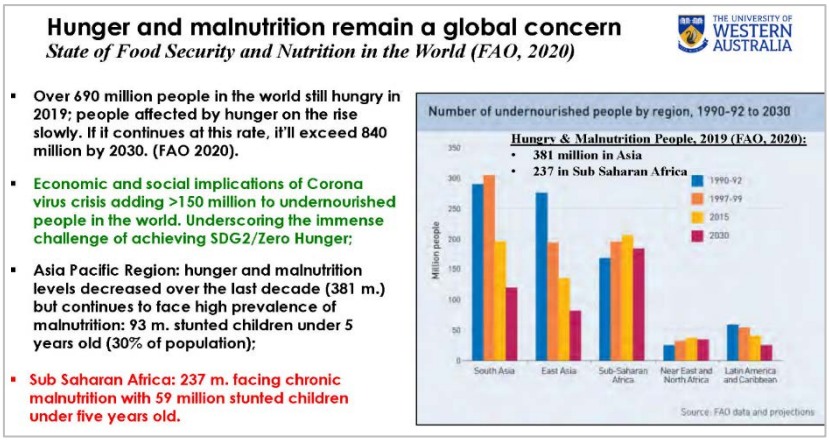

Figure 1.

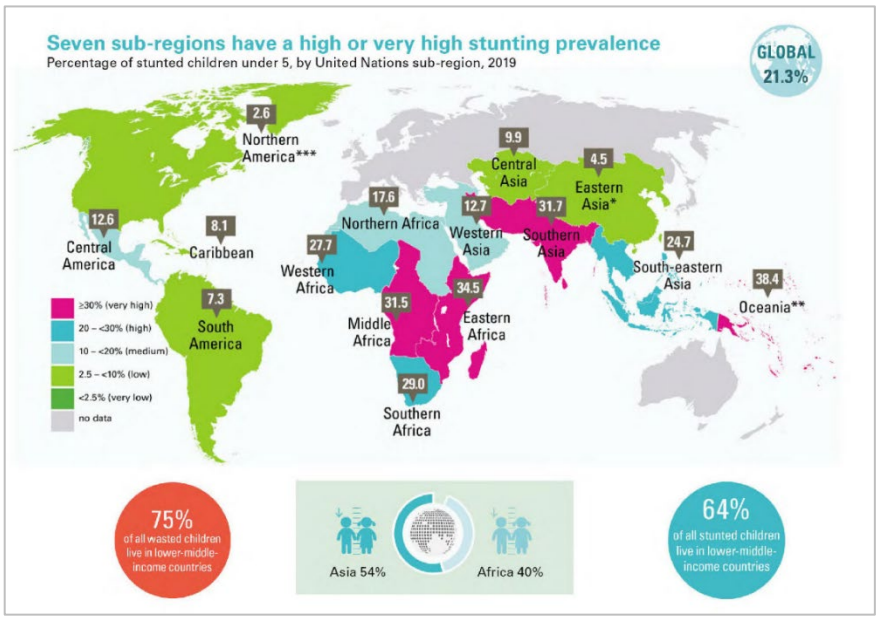

Figure 2. *Source: UNICEF/WHO/The World Bank Group 2020.*

already mentioned by Cary Fowler and others, those children will not develop very well, and are unlikely to get jobs since they will not complete their primary school education, and the vicious cycle will continue. This is a serious situation, with about 54% of children under 5 years old in Asia (in 2019) stunted, and about 40% in Africa.

In Figure 3, from 2005 the percentage of people undernourished was declining, but since 2019 the trend is upwards. It could reach 760 million, 820 million. To achieve SDG 2 by 2030 unfortunately is going to be difficult. That means we cannot be complacent. We have to start working hard on this.

More than half, about 425 million, of the people in the world affected by hunger or malnutrition are in Asia, and one-third, 278 million, are in Africa (Figure 4). Those are the numbers.

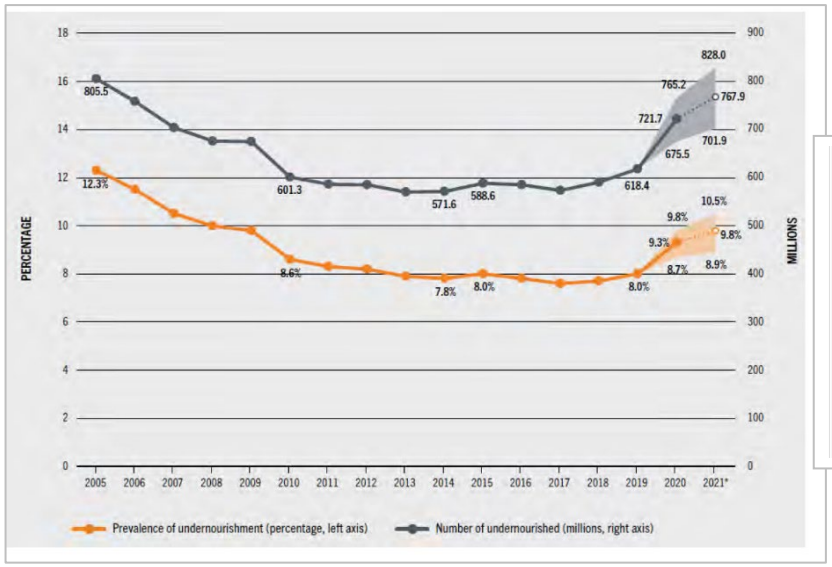

Figure 3. Between 702 million and 828 million people in the world faced hunger in 2021. **Considering the middle of the projected range (768 million), hunger affected 46 million more people in 2021 compared to 2020**, and a total of 150 million more people since 2019, before the COVID-19 pandemic. *Source: FAO*

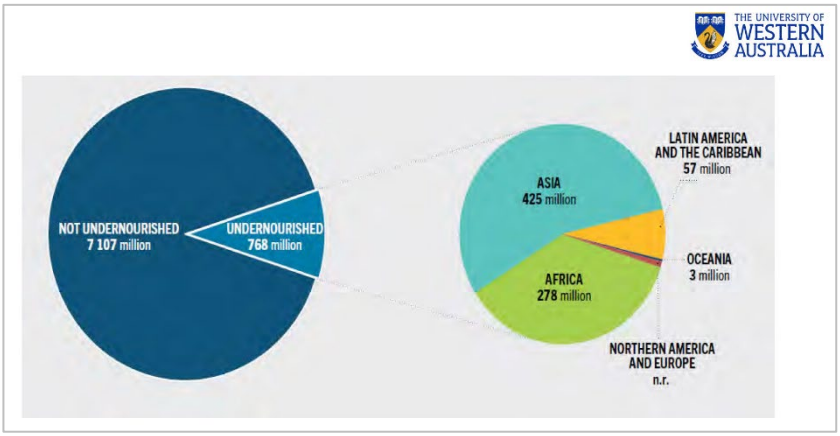

Figure 4. *Source: FAO*.

The food system

The food system is very complex. As defined by the High Level Panel of Experts on Food Security and Nutrition (HLPE) and the UN Committee on World Food Security (CFS), 'A food system consists of all the elements (environment, people, inputs, processes, infrastructures, institutions) and activities that relate to the production, processing, distribution and marketing, preparation and consumption of food, and the outcomes of these activities, namely nutrition and health status, socio-economic growth, equity and environmental sustainability'. That means we just can't have a silo type of project. We have to look at an integrated larger project, involving all the elements and all the activities listed in this definition.

What are the desired outcomes? As defined, we want to have better nutrition, health status, socio-economic growth. If people produce more vegetables, will that help them? Yes, it will help them, as we have heard today from Kym Anderson and others. Equity and environmental sustainability are increasingly important outcomes.

The problem is that we have done extremely well because of the Green Revolution, but three major crops – wheat, rice and maize – are dominating. I know that Tony Fischer will say that this is

important, and yes, it has been important. Those crops have fed the world. More recently there has been interest in oil crops – e.g. soybean, sunflower, oil palm – and for those who can afford meat and dairy products their consumption is increasing, and it's increasingly difficult to get aquaculture, fish and wild catch.

The current unhealthy food consumption (Figure 5), which is leading to malnutrition, is due to two things: the high consumption of the so-called 'bad' foods – processed and/or salty, starchy; and the low consumption of 'protective' foods – fruits, vegetables, whole grains. Among protective foods are crops that are being neglected and underutilised. Malnutrition is leading to risk of non-communicable diseases and stunted children, and also increasing obesity in many of the developing countries.

The current agricultural system is based on a few staple crops, and they are environmentally vulnerable. Where a region relies on one variety of, say, corn and something happens to that crop, there is disaster. The ecosystem, food, diversity and health are all affected. Limited diversity in the food system means less diversity in the diet, and ultimately malnutrition. So, we *must* diversify the food system to enable balanced diets and to enhance adaptation to climate change.

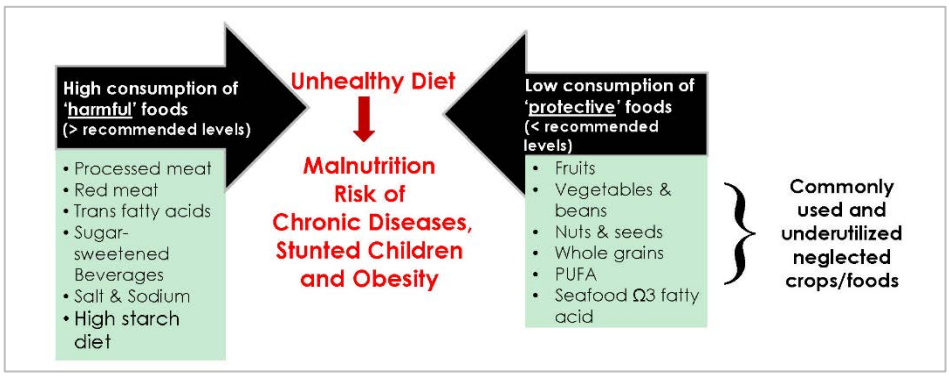

Figure 5. The unhealthy current food consumption patterns.
Adapted from Afshin et al. *2015.*

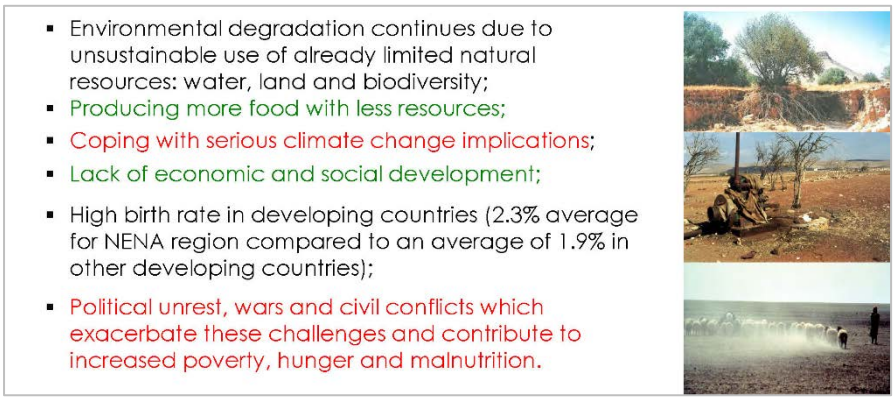

Figure 6. Major global challenges to enhance food security and nutrition.

Global challenges and solutions to enhance food security and nutrition

Figure 6 lists some of the challenges. Environmental degradation is continuing: there is less water, less land and bad effects on biodiversity. We need to produce more per unit area, per unit resources. We must cope with serious climate change. There is a lack of economic and social development in rural areas in developing countries. Birth rate has declined but it is still at an alarmingly high level in the Near East and North Africa (NENA) and many other countries. And political unrest is going to continue, and we must be prepared for that.

To address some of those challenges:

- we must bridge the production gap. We need about 50–70% more food, and I think existing technology can produce that, in many parts of the world. However, the potential for higher yields in traditional major crops is limited despite considerable investments in improvement. The yield increases possible via genetics have declined, and are now slightly more than 1% per year, which is not enough.
- The nutrition gap is widening because of the reliance on existing staples, but crop diversification is one solution that should produce healthy diets to reduce malnutrition.

As I have summarised in a 2021 article in *Nature Plants* (Siddique *et al*. 2021), we need to look back to Asia's forgotten crops to fight chronic and hidden hunger. I am not talking about domesticating wild crops; I am talking about the crops that used to be farmed in these landscapes. They were taken away by commercial agriculture.

Under the auspices of the United Nations we convened a workshop in Bangkok a few years ago, where we asked experts from each country to list potential neglected underutilised crops. They came up with a list of 150, which we then narrowed down 30 (Figure 7) – cereals, roots and tubers, pulses, fruits and vegetables, nuts, seeds and spices, and they vary from region to region. For example, **foxtail millet** (*Setaria italica*), **drumstick** (*Moringa oleifera*), **elephant foot yam** (*Amorphophallus paeoniifolius*), and **taro** (*Colocasia esculenta*) – which can tolerate waterlogging and drought and is a wonderful tuber crop rich in macro and micronutrients, iron, zinc, selenium and calcium, and rich in many vitamins including carotenoids, vitamins K, C and so on. The United Nations General Assembly declared 2021 as the International Year of Fruits and Vegetables.

Cereals	Roots and tubers	Pulses	Fruits and vegetables	Nuts, seeds and spices
• Sorghum • Pearl millet • Finger millet • Teff • African rice	• Cassava • Yams • Sweet potatoes • Taro	• Cowpea • Lablab Beans • Pigeon Peas • Chick pea	• Guava • Loquarts • Baobab • Amarula • Nightshades • Spider Plant • Amaranth • Pumpkin • Moringa	• Macadamia • Cashews, • Bambara nuts • Cumin • Saffron • Rosemary • Ginger • Nutmeg

Figure 7. Potential future smart foods. *Source: Siddique* et al. *2021*.

We have all heard about **quinoa** (Figure 8). It has been grown in the Andes for 5000 years, and now is recognised as a wonderful food all over the world through simple promotion and the right approach. It has a lot of nutrients, is good for the environment, and Andean farmers are still growing it there as a cash crop.

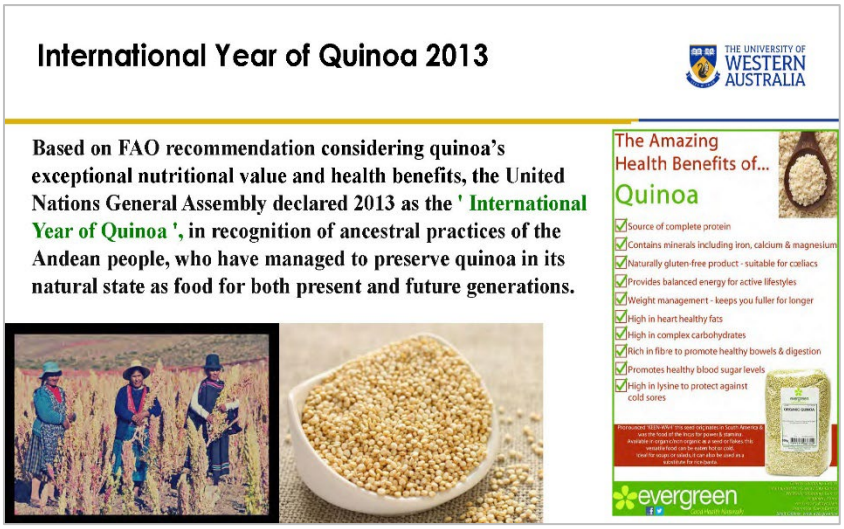

Figure 8.

The UN General Assembly declared 2016 the International Year of Pulses (IYP), based on FAO recommendation, to raise public awareness of the nutritional benefits of **pulses** as part of sustainable food production, aiming for food security and nutrition. They are very important crops, but we were ridiculed in Australia 20 or 30 years ago when we talked about pulses. I was designated as the ambassador by the UN. We aimed to promote production and consumption of pulses worldwide, improve crop rotation and improve trade in pulses – and they are now mainstream crops. So that's how you bring new foods into the system.

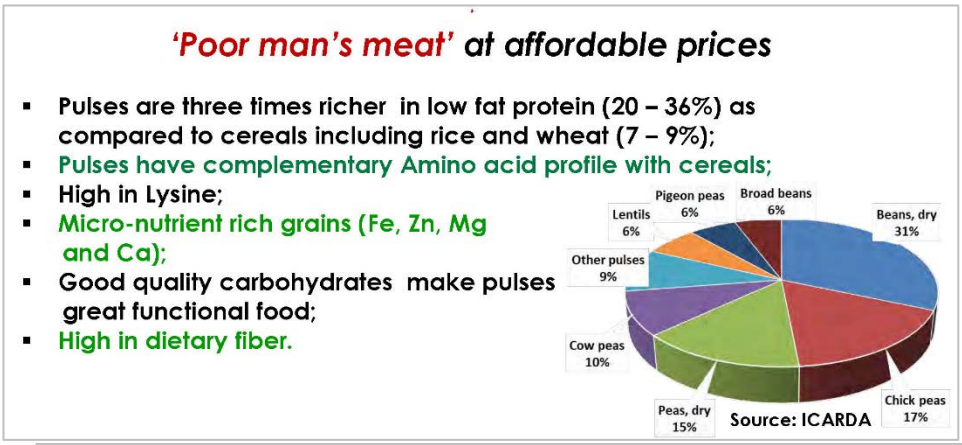

Figure 9. Pulses offer many nutritional benefits.

Pulses (legumes) not only have many nutritional benefits (Figure 9) but they also can replace or supplement the nitrogen requirements of cereals in a crop rotation, while also improving the carbon footprint by putting carbon back into the soil (Figure 10). There is a lot of information on those topics.

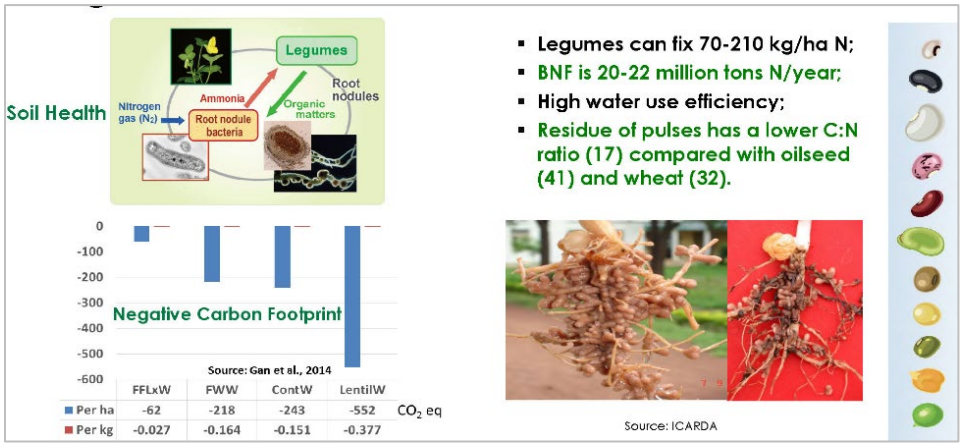

Figure 10. Legumes are essential for sustainable agriculture and soil health.

I want to emphasise that for these underutilised crops the investment in research, development and extension is still *too low* compared to the massive investment in rice, wheat and maize. I am not saying we should not invest in those. Rather, that we must *also* invest in some of these legume crops (see Foyer *et al*. 2016).

Millet is another major commodity that can make a huge difference, if it has the right promotion (Figure 11). It's now reaching mainstream agriculture. The Government of India proposed that 2023 be the International Year of Millets, and it is now being taken very seriously by a number of countries. There are different kinds of millets (Figure 12). Australia is already a good producer of sorghum, and there are other potential opportunities, such as in the northern part of Australia and the summer rainfall regions.

Figure 11. Why millets.

The point is that millets must be integrated within the existing farming system, not replace existing crops. One of our studies has shown that integrating new crops into the existing system improves yields and returns to the farmer, and more importantly it also reduces the environmental footprint (Chai *et al.* 2021). All this is summarised in a free book (Li & Siddique 2018), and we have recently also published another book on neglected and underutilised crops (Farooq & Siddique 2022).

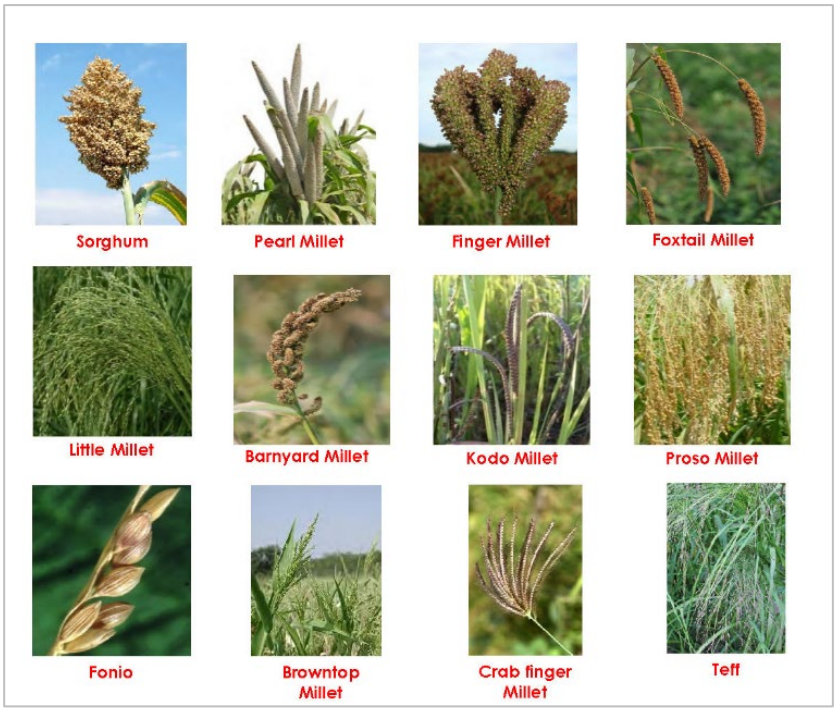

Figure 12. Millets

Transforming food systems for healthy diets

Figure 13 shows an approach for transforming a food system, via production, processing and distribution, marketing and consumption, and examples of interventions for healthy diets such as in a midday meal program, a school breakfast program, for indigenous and low socioeconomic communities.

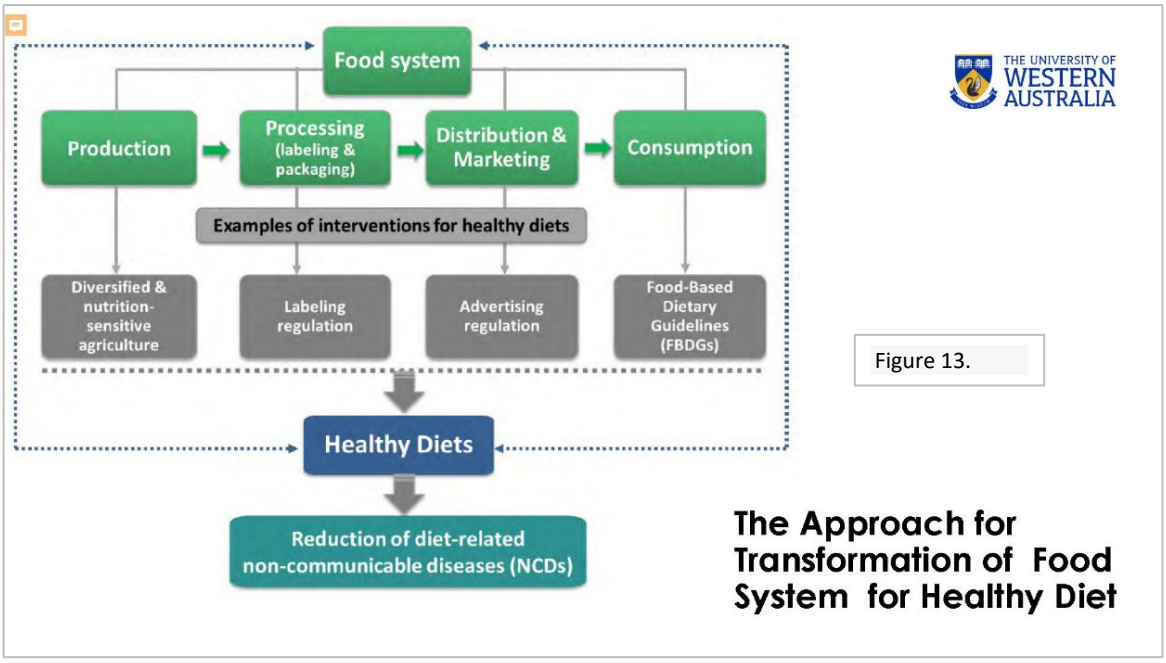

Figure 13.

In summary, traditional underutilised local crops offer these benefits:

- food and nutritional security;
- resilience to climate change;
- adaptation to harsh environments and low inputs;
- conservation of biodiversity;
- cultural diversity and heritage;
- improving livelihoods and rural development; and
- economic and social development.

Current food systems need to be transformed and diversified by incorporating Asia's and Africa's traditional crops to achieve healthier diets. Healthy diets will provide more protein, more macro- and micronutrients, and vitamins to reduce malnutrition, hidden hunger, stunted children and obesity. Traditional underutilised crops also offer adaptation to harsh environments, marginal land, low-input agriculture where they can be integrated into existing cropping systems, and resilience to climate change.

It is important to enhance policy makers' awareness of the value of diversified food systems: that they will raise national food security and nutrition. There needs to be investment in scientific research by public and private organisations, and increased awareness among producers and consumers about the nutritional, health, economic and environmental benefits available from these foods. There needs to be coordination and capacity development of stakeholders in the food chains and value chain, as well as greater access to information and technology transfer. You can't have research for each and every crop, so you need to have a coordinated approach and develop the platforms where we can share this information.

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Professor Siddique has over 30 years' experience in agricultural research, teaching and management in both Australia and overseas. He has developed a national and international reputation in agricultural science especially in the fields of crop physiology, production agronomy, farming systems, genetic resources, breeding research in cereal, grain and pasture legumes and oilseed crops. He has published >850 scientific papers, books and book chapters. Professor Siddique was the Highly Cited Researcher in Agricultural Science in 2018, 2019, 2020, 2021 and 2022. He is the Highly Cited Researcher (Hi Ci) in 2021 and 2022 in two categories: (i) Agricultural Sciences (ii) Plant and Animal Science (Thomson Reuters/ Clarivate Analytics). Google Scholar h-index: 104 and citations: 41,949 (15 May 2023). He is a Fellow of the Australian Academy of Technological Sciences and Engineering; Australian Agricultural Institute; Indian National Academy of Agricultural Sciences; Foreign Fellow of the Pakistan Academy of Sciences; and Fellow of African Academy of Sciences (first Australian to be elected to the Academy). Professor Siddique was designated by United National FAO as Special Ambassador for the International Year of Pulses 2016. Professor Siddique is the recipient of national and international awards including: Urrbrae Memorial Award, Member of the Order of Australia (AM), 2014 Western Australian Year of the Award (CitWA), the Dunhunag Award by China's Gansu Provincial Government. He received the Friendship Award from the Chinese Central Government (the highest award for a foreign expert) in recognition of his outstanding contributions to agricultural science and education in China over the years, and was the Western Australian Indian of the Year 2021. Professor Siddique was one of the three finalists for the Western Australian Scientist of the Year 2022 Award. He received the Sanquin Friendship Award from the Shaanxi Province China in April 2023. Professor Siddique has also trained numerous Honours, MSc and PhD students. He has developed an extensive network of scientists within Australia and has also established a diverse range of overseas (China, India, Turkey, Syria, Iraq, Iran, Saudi Arabia, Oman, Malaysia, East Timor, Nepal, Bangladesh, Pakistan, Europe, Canada, USA) collaborative research and educational projects. He holds a number of national and international committee positions.

SESSION 4.1:
SOLUTIONS FOR RESILIENT FOOD AND NUTRITION SYSTEMS ON-FARM

Biofertilisers and enhanced efficiency fertilisers – solutions for the future

Dr Roya Khalil

Director of Research and Development, Incitec Pivot Fertilisers

Abstract

The rising costs of fertilisers, disruptions in supply chains due to COVID-19 and global conflicts, and a focus on soil health have led to increased interest among growers in using alternative inputs for improved cropping systems. Recycled organics derived from intensive livestock operations and food waste contain valuable nutrients and organic matter, which can enhance soil characteristics, increase crop productivity, reduce reliance on inorganic fertilisers, and promote resilient farming systems. The Incitec Pivot Fertilisers' (IPF) Australia biofertilisers (ABF) is made with a sterilised and dried organic waste materials from poultry sheds, combined with inorganic chemicals, resulting in organo-mineral granules that provide necessary nutrients, organic matter, and labile carbons in a single granule. ABF technology is one example of efficient waste recycling where most of the nutrients and carbon are retained from the waste as opposed to being lost to the atmosphere as greenhouse gases, in alignment with the principles of circular economy. The main barriers to adoption are the high capital cost of building in Australia and the cost of renewable energy to run the process. Similar challenges are faced by other emerging technologies such as green ammonia. Perhaps the greatest opportunity for farmers is to adopt inhibitors which can minimise gaseous and leaching losses from existing nitrogen fertilisers. Nitrogen fertilisers are essential to crop production, but more than half of the fertiliser applied to crops is lost due to leaching or volatilisation. The IPF inhibitors can reduce greenhouse gas emissions by up to 80% from fertilisers and in some cases allow rate reduction without impacting yield and quality of produce. IPF conducted a study comparing their patented technologies of biofertilisers and nitrification inhibitors with standard farming practices for celery cultivation in East Victoria, demonstrating similar crop yields, reduced emissions and providing application efficiency.

My talk is about the future fertilisers, focusing on nitrogen inhibitor technologies and biofertilisers developed in line with the principles of circular economy. It is my first time attending a Crawford Fund conference and I must say I am very impressed with the organisation itself and the people behind it. I really hope that one day the Crawford Fund can help set up research & development in the region of my original home, Afghanistan, helping them restore their agricultural economy.

I am here representing Incitec Pivot Fertilisers (IPF), to tell you about some future fertilisers, and current fertilisers, that are having an impact on the future for the industry. In case you are not already aware of our business, for over 100 years we have been an Australian manufacturer and distributor of fertilisers, with outlets throughout Australia and exporting to a range of other regions. We annually manufacture about 1 million tonnes of fertilisers, as ammonium phosphate, and sulfate of ammonia, and we distribute about 2 million tonnes. That amount includes our own manufacturing and exports, as well as fertilisers we import into Australia for local consumption. In other words, although we operate predominantly in Australia, we are part of the global agriculture system (Figure 1).

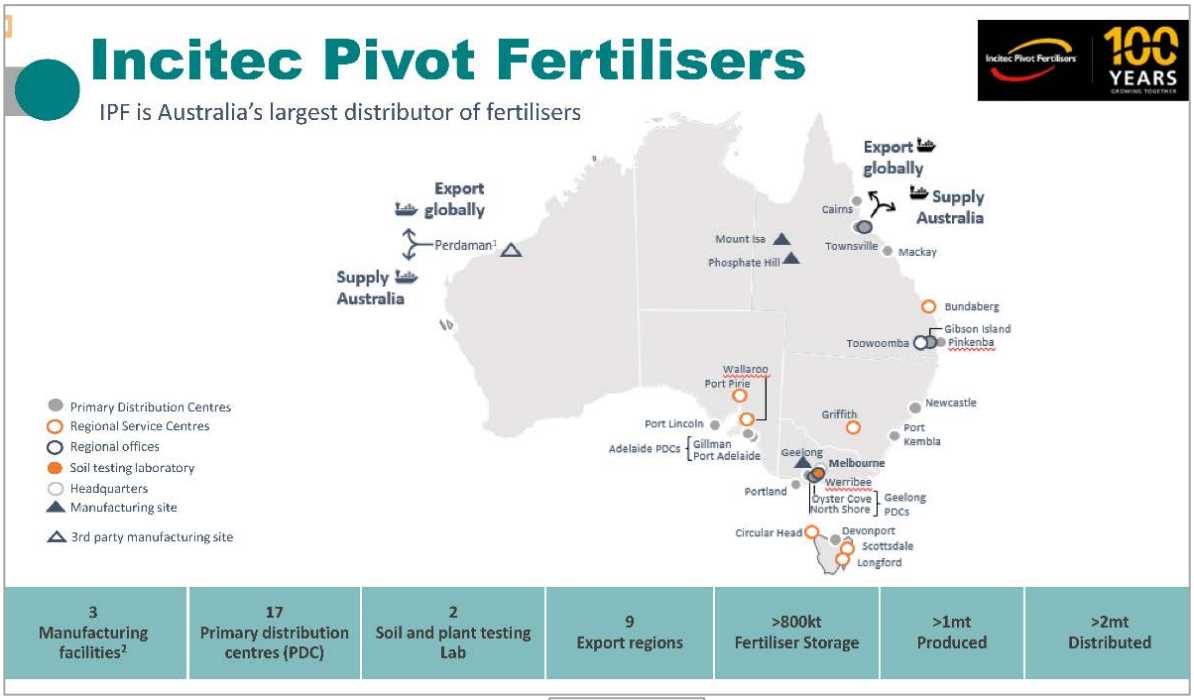

Figure 1.

Our fertiliser technologies

Figure 2 is an overview of two of our fertiliser technologies. Nitrification and urease inhibitors are not new: they have been in the industry for at least 20 years, and Incitec Pivot has had the products in Figure 2 available for about ten years. However, they have a new-found purpose because they benefit the environment by reducing gaseous losses. ***eNpower***® is an Incitec Pivot technology developed and IP-patented under the *eNpower*® trade name. It's a nitrification inhibitor that slows down the conversion of ammonium to nitrate when the fertiliser is applied

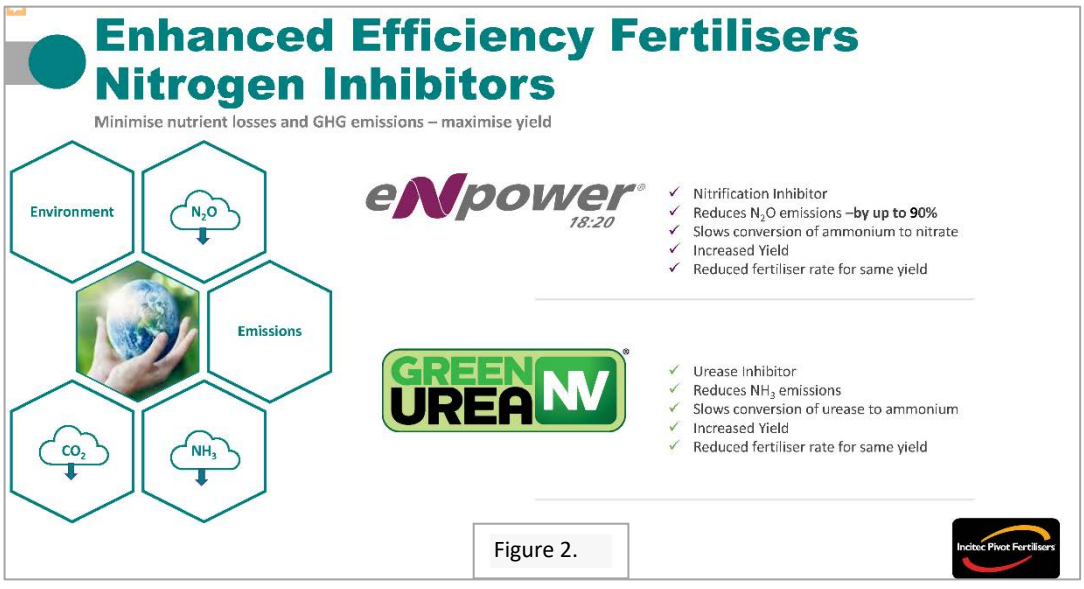

Figure 2.

into the soil, making the nutrient available to the plants for a longer time; and as a result it also reduces nitrous oxide emissions by up to 90%. The technology is available as a coating to be added to granular nitrogen fertilisers – such as urea, sulfate of ammonia, and ammonium nitrate – but it can also be added to liquid nitrogen fertilisers. **Green Urea NV®** is a urease inhibitor specially made for urea fertiliser. It slows down the conversion of urea to ammonium, making nitrogen available to the plants for a longer time, and as a result it reduces the emission of ammonia gas into the atmosphere. Again, it is available as a coating for granular urea, but it can also be added into urea as a liquid fertiliser.

They are important technologies because on average only 50% of nitrogen fertiliser applied into the soil is used by the crop; the remainder can be lost in leachate or as ammonia gas or nitrous oxide escaping into the atmosphere. Ammonia gas is an air pollutant. However nitrous oxide is more serious because it is considered a greenhouse gas, having a global warming potential almost 300 times that of carbon dioxide, and also being responsible for ozone layer depletion. Nitrous oxide has been under discussion lately in the industry and by governments. Figure 3 illustrates Green Urea NV® reducing ammonia gas volatilisation, and *eNpower*® reducing nitrous oxide emission. We have a database of the details of trials with these products in different cropping systems, different soils, and different regions in Australia.

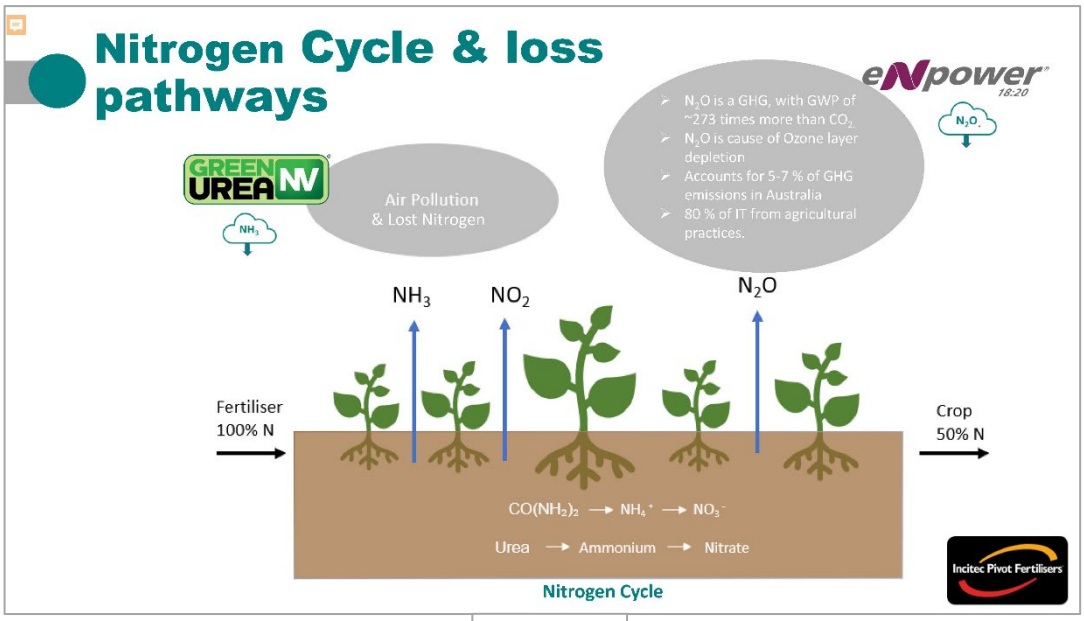

Figure 3.

An independent study published by CSIRO (Schwenke & McPherson 2018) used anhydrous ammonia (an IPF product) as a pre-plant fertiliser with and without *eNpower*® as an inhibitor, to grow cotton in Gunnedah (in New South Wales) and in Emerald (in Queensland) in two Vertosols (Figure 4). The key messages from Figure 4 are that: (i) yields were the same with or without the addition of *eNpower*® – that is, treatments T1 and T2 in the table in Figure 4. (The third treatment in the table used a different inhibitor – Nitrapyrin – not one of IPF's products.) And (ii) there was significant reduction in nitrous oxide emissions from the soils: 86% reduction at the Emerald site, and 77% at Gunnedah. This old technology definitely presents great potential for the future.

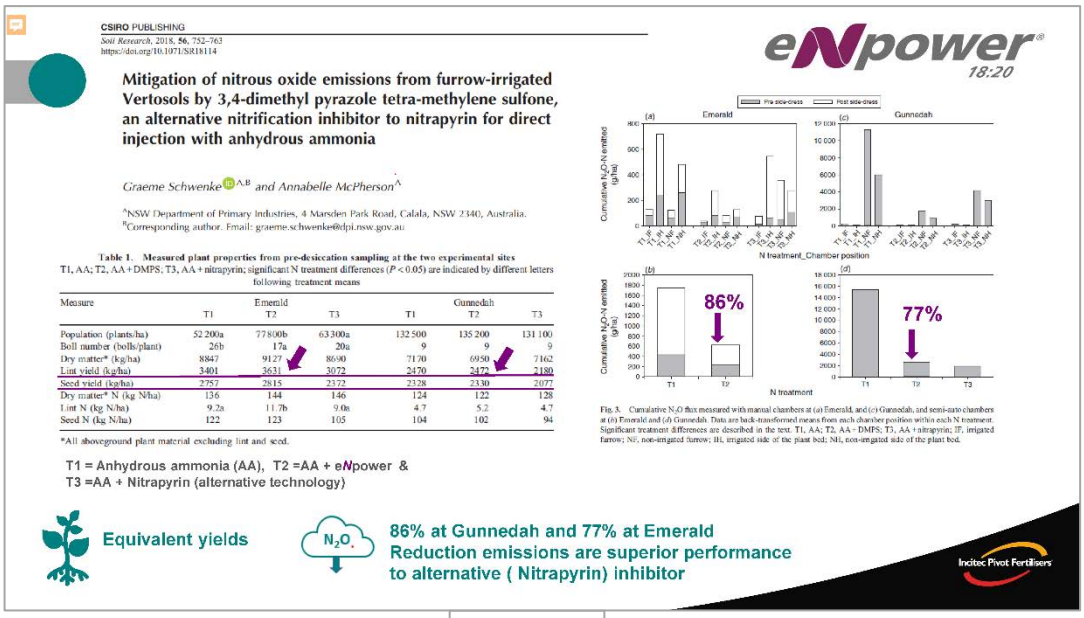

Figure 4.

Bio fert is another new technology, patented globally, which we have developed in recent years. It's a granular organo-mineral fertiliser made from poultry manure that has been sterilised, dried and mixed with inorganic mineral nutrients and some extra functional types of carbon (Figure 5). It looks exactly like an inorganic fertiliser, but has the added benefit of active (labile) carbon as well as stable carbon to stimulate microbial activity in the soil and promote carbon sequestration respectively. There is a range of formulations (Figure 5), created to match the kinds of chemical

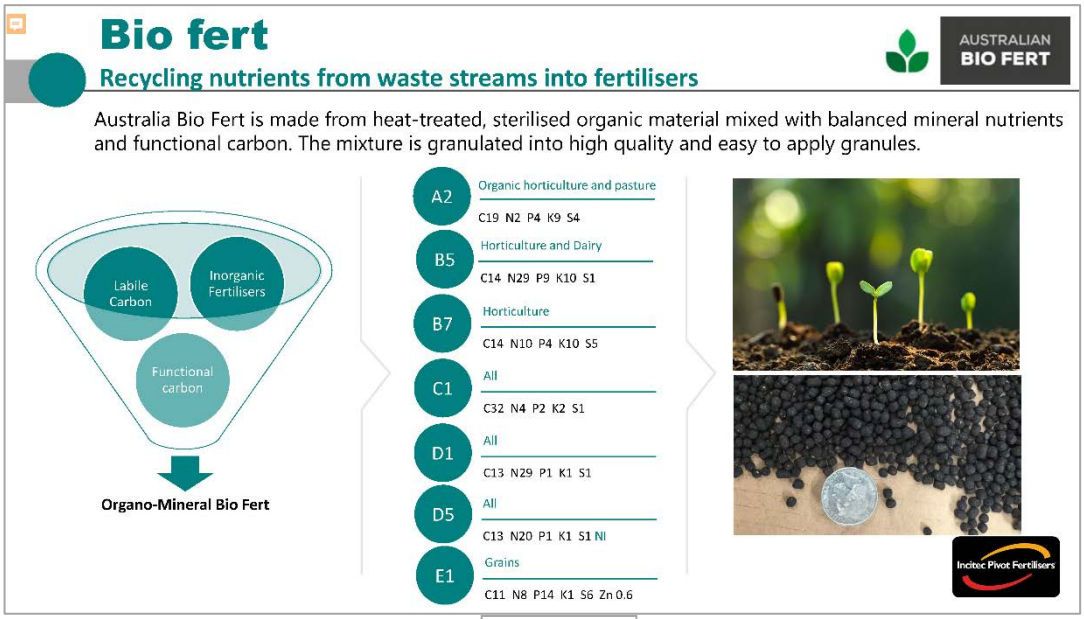

Figure 5.

fertilisers already available for different segments of the market. The technology is very versatile, so we can formulate any nutrient analysis, any carbon : nitrogen ratio that we want. Also we can use other waste streams, such as manures from cattle sheds, or food waste, or other forms of waste. Results from many field trials in various cropping systems have shown that applying Bio fert alone results in yields that are equal to or better than those obtained using inorganic NPK fertilisers with or without added manures.

An independent study by La Trobe University in 2022 combined our inhibitor technology with our Bio fert technology to test nitrous oxide and carbon dioxide emissions from celery crops, grown with standard manure + inorganic fertiliser with or without added *eNpower®* and/or Bio fert (Figure 6). You can see that the yields are very similar with all the treatments. However, adding eNpower®, and/or Bio fert with its functional carbon and stable carbon, reduced nitrous oxide emissions and CO_2 emissions. It appears these new technologies can work together to help reduce emissions into the future.

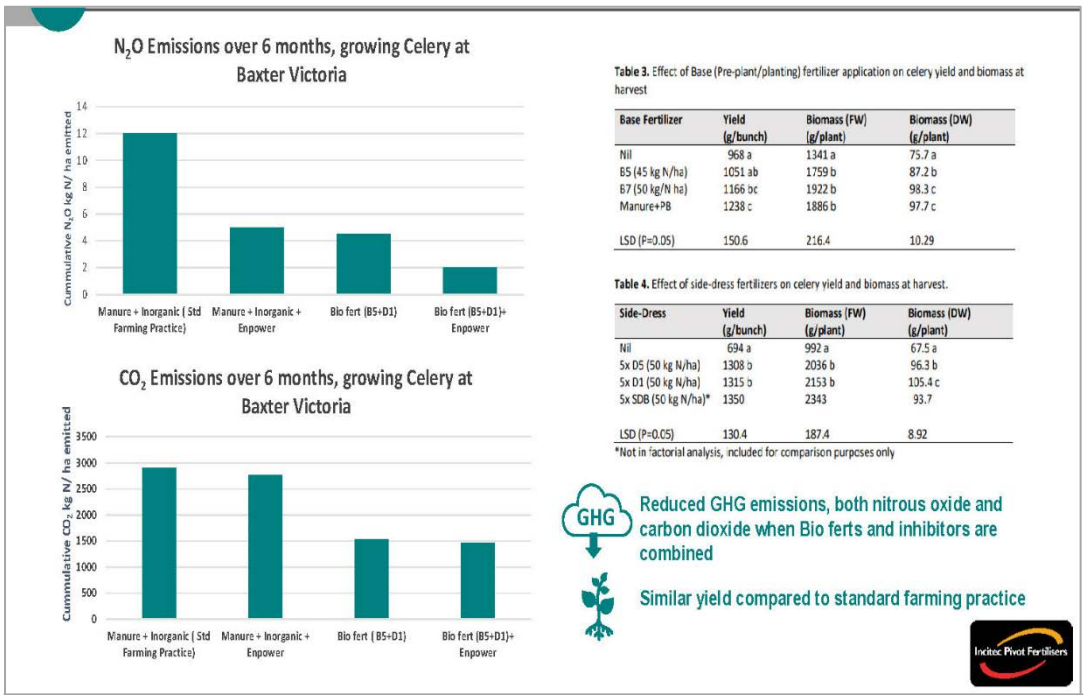

Figure 6. Study by La Trobe University combining inhibitors with Bio fert technology.
Source: Australian Bio Fert.

Looking ahead

Figure 7 is a futuristic framework or pipeline of innovation for Incitec Pivot, in alignment with Scope 1, 2 and 3 carbon emissions and Net Zero Australia 2050. Predominantly it includes development of new technologies, but also our conversion to renewable energies wherever that is possible and feasible for us, such as in our manufacturing facilities and in the footprint of our vehicles and equipment.

We will continue to develop new and improved inhibitor technologies, both in-house – we are just launching a new dual action inhibitor fertiliser into the market this year – and also through

collaborative research partnerships. For instance, The University of Melbourne has a smart fertilisers hub developing new inhibitors that are more suited to Australian soils, and further developing bioferts using recycled nutrients and validating different wastes for that bio-technology. We need a range of waste streams to make sure we will have enough raw materials to continue with that technology at commercial scale.

More important, in the long term, is green hydrogen technology. Incitec Pivot is the only group in Australia in a joint development program with Fortescue Future Industries – which is Andrew Forrest's initiative to validate the production of hydrogen through the electrolysis of water. The first stage of this technology will be green hydrogen for fuel and energy, but we hope we can take the technology further to produce green ammonia for fertiliser, not only in Queensland where we manufacture urea, but also later expanding into our other Australian facilities.

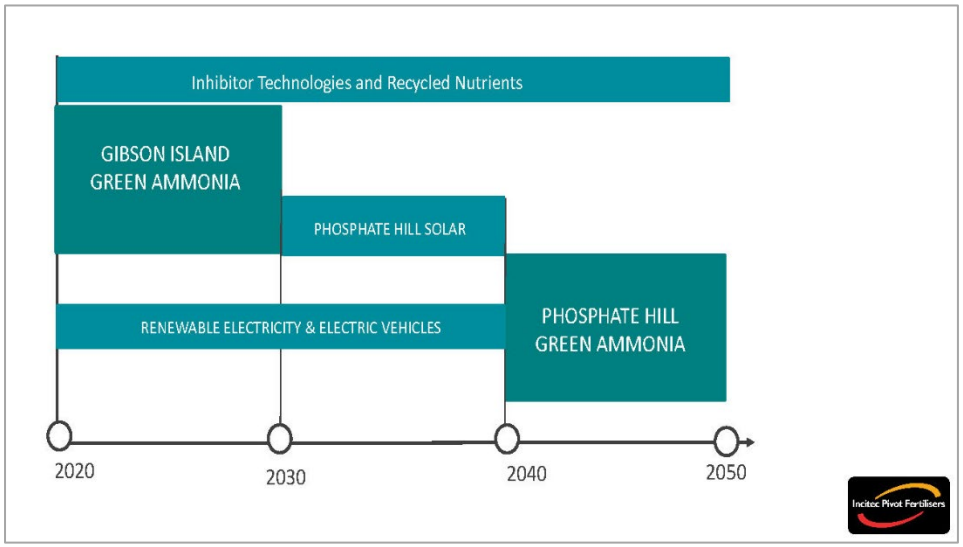

Figure 7.

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Dr Roya Khalil is an accomplished business leader with over 19 years of experience in R&D and innovation management across diverse industries, including FMCG, Dairy, Chemicals, and Agriculture. Qualified with a bachelor's degree, a PhD in Chemical Engineering, and an MBA specialising in strategic innovation, she has held key positions with industry leaders such as Incitec Pivot Limited, Orora Packaging, Bega Cheese, Coca Cola Amatil, SPC Ardmona, and Plantic Technologies delivering several commercialised patented technologies. Currently, as the Director of Research and Development at Incitec Pivot Fertilisers, Roya leads the R&D function, focusing on developing enhanced efficiency fertilisers, recycled nutrient-bio based fertilisers, soil health technologies, greenhouse gas emissions benchmarking, and mitigation strategies for the benefit of Australian growers. She actively contributes to cutting-edge research and commercialisation as a Partner Investigator at the ARC research hub for smart fertilisers at The University of Melbourne. Additionally, as an Industry Adviser at the ARC Research Hub for nutrients in the circular economy, Roya is committed to promoting sustainable practices and driving innovations fostering the reuse of nutrients from waste

aligned with principles of circular economy. Roya's expertise extends to co-supervision of PhD students and guest lecturing for Master and Bachelor of Food Engineering at Monash University, RMIT University, and UNSW. She has also been involved as a researcher in numerous programs, including CRC-polymers for biopolymers, Dairy Innovation Australia, and the Australia–China Joint Resource Centre with Monash University. With a comprehensive understanding of the entire food supply chain gained through her diverse career, Roya is dedicated to developing integrated solutions and contributing to a more sustainable and innovative future for the industry.

SESSION 4.1:
SOLUTIONS FOR RESILIENT FOOD AND NUTRITION SYSTEMS ON-FARM

Panel Q&A

Professor Jamie Pittock[1], Professor Kadambot Siddique AM FTSE[2], Dr Roya Khalil[3]

[1]Australian National University, [2]The University of Western Australia, [3]Incitec Pivot

Chair: Dr Terence Farrell,
Head of Economics, Grains Research & Development Corporation (GRDC)

Q: Louise Walker, Latrobe University PhD student, Victoria

My question is for Professor Siddique. You mentioned quinoa, which is fantastic. It seems to be somewhat of a success story in terms of taking a traditional Indigenous food and then marketing it towards a Western or international market as well, so it seems to benefit both parties really nicely. Can you describe what allowed that success story to happen – whether specific traits, or the markets that were used? And do you think there is opportunity for other crops where there may be Indigenous knowledge on how to grow them but also potential for international markets?

A: Professor Kadambot Siddique AM FTSE

I think it's a combination of various factors. Certainly, one is identifying the 'goodies' in a food, both in terms of nutrition and also environmentally, and the second factor is the promotion. Having the UN internationally involved has helped for quinoa, and its adaptation to various environments has been tested with a lot of germplasm, including in Australia, which has started production. Bhutan has just started a GIES – geographical information and environmental system – for quinoa and that's getting momentum. It's a combination of factors.

Another example is chia. Australia is one of the largest producers of chia. It is of South American origin. A young farmer went on a Nuffield scholarship – he became an entrepreneur and started producing chia in Kununurra in the Kimberley region of Western Australia. Lentils in Australia is another example, promoted initially by the GRDC; they are now a big commodity in Australia. There are many other examples.

Q: David Guest from the University of Sydney

A number of people have mentioned stunting, and I just want to point out that malnutrition is not the only cause of stunting. In the work that we've done in places like Bougainville and Sulawesi (50% of the children are stunted in Bougainville, 30% Sulawesi), stunting is not because of a shortage of food. It's because they're drinking dirty water and they have chronic dysentery. And that is something that is very easy to address.

A: Professor Kadambot Siddique AM FTSE

I agree. Again, there is a combination of factors in this, but that is why holistic approaches are required and the root causes need to be identified first and addressed. That is a priority.

Q: University of Tasmania Masters student.

My question is for Jamie. You talked about the soil monitoring tools that farmers are using. How do farmers decide how much water they need to apply, from the data of the moisture meter? Do they have the help of experts, or can they decide by themselves? And another question: in Tasmania, farmers are using moisture meters but some farmers have complained they get in the way of the cultural operations needed in production.

A: Professor Jamie Pittock

The tools were designed to provide the simplest information for farmers to use to make decisions. The soil moisture reader summarised the soil moisture into three classes: red, green and blue. It was then up to the farmers to interpret how to water that ground, that field, for a particular crop. There was no manual. Nobody needed to tell the farmers what the reading meant. The tools were so simple that the farmers very quickly learnt how to apply them themselves. If anybody wants to find out more about the tools, you can look at the website https://via.farm/, Virtual Irrigation Academy farm.

The moisture meters commercially available in Australia are vastly more expensive and much more complicated – you would need some technical knowledge to know how to interpret them. That's why CSIRO developed these tools that are much more simple to use.

Sadly, in many cases, farmers who have started off using these sorts of soil moisture probes stop using them after a period of time. Perhaps they have developed a different practice and feel that is sufficient without spending time monitoring the soil moisture? I am not sure that is wise, but that's what's happened in practice.

Q: Dr Shahin Rahman, Department of Primary Industries & Regional Development, Western Australia

My question is for Roya. I am very interested in the biofertilisers. I would like more information on the adoption rate of biofertilisers in broad agriculture, and if there are any disadvantages that these biofertilisers possess over the chemical fertilisers.

A: Dr Roya Khalil

As I said, we have tested this product and made various formulations of biofertiliser available for different segments of the market: pasture, broad-acre and, more importantly, horticulture – for lettuce, cauliflower, celery, etc. The main reason for the interest from the horticulture segment is because traditionally they have been users of fresh manure and compost. Unfortunately, with fresh manure, pathogens are a big challenge. Even compost is not really 100% compost: there is still a risk of pathogens. With compost there is also loss of nutrients, because it takes so much time to form and there is volatilisation of ammonia. Because those farmers are more interested in using this product, we have more results for its use in horticulture.

Compared to inorganic fertilisers, we haven't seen any disadvantages, because nothing in these formulations is new to the soil. Manures and compost were all already in use in the agriculture system. What we have done is remove the pathogens, and we have dried it a bit to make it easier to transport. The inorganic fertiliser in the product provides nutrients and the functional carbon comes from mined products that are already in use in the fertiliser industry. The innovation in the

product is that it combines materials already in use in standard farming practices and turns them into single granules for ease of application. I don't see any disadvantages in that.

As with any new technology, the investment is expensive; there is significant cost in building infrastructure and introducing it to the market, so at the moment it costs us to make these products, and that's why the products are not aggressively in the market. There has only been a 'soft launch'. If we can produce it at commercial scale, at an optimised rate and cost parity, I think that biofertiliser will be available at a cost that is achievable for the farmers, and I think that will benefit everyone.

Q: Dr Terence Farrell (Chair)

Most nitrogen fertilisers can acidify soil, and you need to use a lot of lime, which also affects emission of greenhouse gases. What are you doing to mitigate the extra nitrogen use with lime to neutralise those acid soils? Is biofertiliser any more acidic than urea?

A: Dr Roya Khalil

Biofertilisers are no more acidic than urea. Biofertilisers have been designed to be very similar to the inorganic fertilisers, in chemical and physical performance. We do, however, have other products that are specifically designed for acidic soil.

Q: Warren Lee, FAO

My questions are to Professor Siddique. First: the future smart foods that are identified by countries have a lot of advantages, for nutrition and for farming and for the environment. How good is the uptake of these foods in those countries, and what challenges face the farmers in growing these kinds of crops for food production and for profit?

Also, in relation to the introduction of quinoa to Asia, a colleague in my office is very keen on quinoa and is trying to promote quinoa production in different populations. But he has told me he has noticed a bottleneck in the availability of good quality germplasm from the countries where they produce quinoa. How do we solve this issue of getting good quality seed so that people can be growing quinoa in Asia's soils?

A: Professor Kadambot Siddique AM FTSE

Your first question is how well these foods, these smart food crops, are being adopted and what are their values.

Basically, there's no problem in growing them because the countries have identified them as important crops from previous times in those landscapes. The problem is that in most of those Asian countries rice, for example, is dominating, along with maize and wheat, so the profitability of those crops is very high and yields are very high, and the governments are giving subsidies (as Kym Anderson has said earlier today), and there is less incentive to grow smart food crops.

Therefore, it is important to integrate these smart crops into the mainstream cropping system. Also, governments need to support their production, and promote their benefits, and then city-based consumers will buy them. In Nepal, for example, there's a commodity called large cardamom that is being integrated into the farming system. And there are examples elsewhere of that happening.

There is a bottleneck: we need to overcome that through various strategies. Quinoa genetic resources are available in a number of countries. For example, India is not the origin of quinoa, but they have been able to get it. In Australia we have a number of lines. Saudi Arabia also. I'm not sure where the major genetic resources are available, but it can be brought into a country through following appropriate procedures and evaluated.

Chair:

We must stop there. Thank you to our three presenters for a diverse range of topics. You managed to combine them very well.

Please join with me in thanking everyone who has contributed.

SESSION 4.2:
SOLUTIONS FOR RESILIENT FOOD AND NUTRITION SYSTEMS OFF-FARM

Supply chains in a modern geopolitical environment

Ben Fargher

Environmental Markets Lead, Cargill Asia Pacific

Abstract

Global food security in a riskier world is a vitally important topic. Nearly 830 million people are food insecure – there are real and urgent challenges facing the global food system. Topics such as market access and the empowerment of people, especially as it relates to smallholder agriculture in the Asia Pacific region, are critical. As Cargill sits at the centre of the global agricultural supply chain, working alongside farmers, producers, manufacturers, retailers, governments, and other organisations, the presentation will raise solutions for resilient food and nutrition systems, with particular emphasis on the supply chain. It will explain the Cargill experience of the implications for farmers of disruptions to global supply chains in a modern geopolitical environment including from rising demand, climate and geopolitical conflict. Experiences from COVID-19 lockdowns and the more recent disruptions due to the war in Ukraine, have had significant implications for farmers and agribusiness and strategies for diversification of markets, more flexible and resilient supply chains, and planning for resilience to reduce future vulnerability for the benefit of consumers and growers will be considered. One if not the most urgent challenge is the climate crisis. Cargill is committed to reducing the climate impact of agriculture and agriculture is part of the solution to this challenge. Working with suppliers, customers, and partners, action-oriented, lasting solutions and several practical examples will be outlined.

It's a privilege to be here to talk to you and share some thoughts with you today about practical ways that we can build resilient supply chains in the agri-food sector – and not just *resilient* supply chains but also *sustainable* supply chains.

Before I start, I would like to take one moment to acknowledge the passing in June of Mike Taylor, who was a friend and a colleague of mine and of many people in this room. Mike made a substantive contribution to this country and around the world in regard to policy – in agriculture, and transport, and agricultural development. He also mentored many, many people in the industry; and I would like to pay my respects to him.

In this 10-minute talk about a very big subject, I'm going to highlight some themes that I hope you will be interested in following up and talking about. In fact, I *need* you to do that, because the conclusion of my talk will be about partnerships: new partnerships that, as an industry, private, government and research community, even ten years ago, we would not have thought possible. We see a different dynamic now in terms of the capability that we need to build to overcome the challenges facing us, and no one company, even a company like Cargill, can do that alone.

I will briefly introduce Cargill, and then talk about the resiliency of supply chains and our involvement in that; why we have such an interest in resilient sustainable supply chains from the private sector. Then I will give some practical examples about building sustainability in the supply

chains: not the theory or the concept of it (you know that better than me) but practically what we can do. I want to end by speaking about *people*, because we need to work together.

About Cargill

Cargill had a humble beginning 157 years ago at a grain elevator in the Midwest of the United States. We are now the world's largest private company, and we are proud that the world's largest private company is not a technology company, nor a mining company: it's an agricultural company. We work in over 70 countries, and I and my 160,000 colleagues seek to drive a safe, responsible and sustainable integrated supply chain (Figure 1), because we are in the supply chain business!

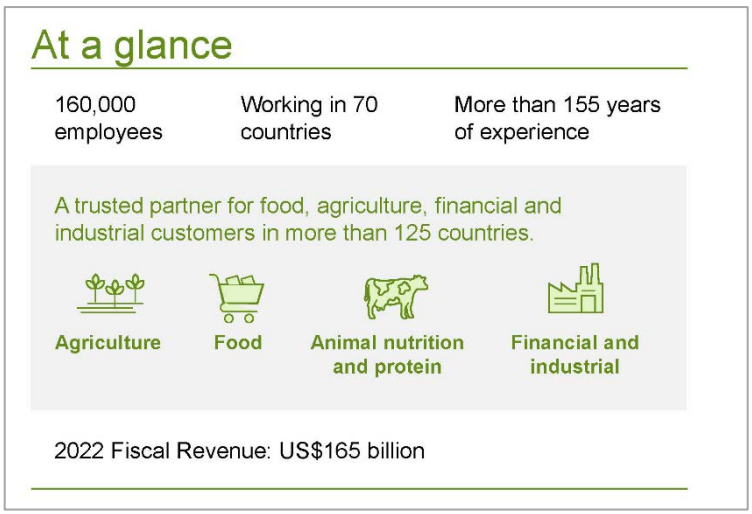

Figure 1. Overview: Cargill's purpose is to nourish the world in a safe, responsible and sustainable way.

Our customers are companies that provide consumers with food, ingredients, consumer packaged goods; and our customers are farmers producing the food and fibre that the world relies on. For a company like Cargill and others like us our job is to connect that food system. We provide insights to our partners. We transform raw materials into finished goods. We move products around the world. If we don't have a resilient, sustainable food system, then a company like Cargill doesn't have a business.

People often look at large companies like Cargill and say, 'Well, what's your vested interest? What are you trying to do? Why are you involved in that project? Why are you investing in that community? Why are you involved in that pilot?'. Well, we *do* have a vested interest in a resilient, sustainable food system, because that is our business. That's what our family owners expect, and what our 160,000 employees expect, and what the communities in which we work expect, and what our customers expect. So, yes, I admit we *do* have a vested interest. Cargill's ambition is: 'To have the most sustainable food supply chains in the world. Through our long history, we have seen agriculture be part of the solution to the world's most urgent challenges. We know that we must address climate change and conserve water and forests, while meeting the rising demand for food.' We need to work together because we all know that the challenges to the global food system are real and getting worse, as has been said multiple times in the address last night and by speakers today. There are significant challenges in the world and in this region that are unique in regard to smallholder agriculture, and not easy to address. Certainly, we at Cargill don't know how to address these alone.

Open markets

Trade is our best means to end hunger. Price signals are important for encouraging farmers to manage supply. Food should never be used as a weapon.

Trade restrictions only worsen hunger. We need to keep markets open. Our job as Cargill is to take food from areas of surplus to areas of deficit around the world through our supply chain system, and we cannot do that efficiently if we face restrictions in markets. That's the reality of it. It is not just economics. It is cold, hard reality that it is in our interest to keep markets open.

As a private sector company, we have to continue to advocate and make the case to our governments and policy makers about that because trade and price signals are not in our control.

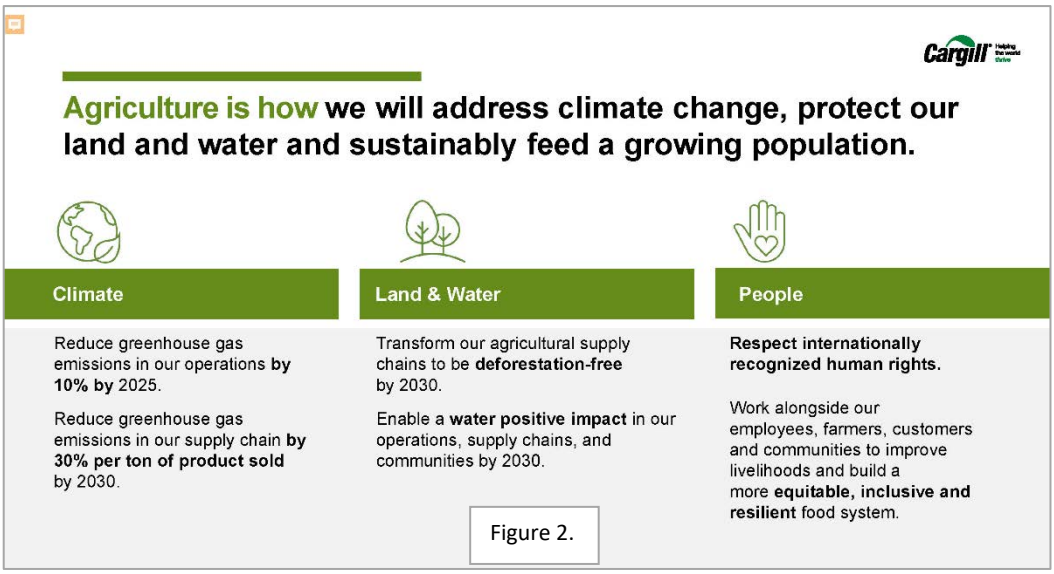

Figure 2.

Sustainability throughout the supply chain

One thing we can practically do is seek to make our supply chains more sustainable. You would expect us to do that. Our customers expect us to do that, and in fact, we make specific corporate commitments in that regard, and have set priorities in the areas of climate, land & water, and people (Figure 2).

For example, in our operations, we would seek to reduce our emission profile from our plants and operations (Figure 3). There are a few ways we can do that. One is simple operational efficiency. If we can produce more with less, if we can get our throughput and our yields and our operational efficiency in our plants higher, then we will in effect produce more food or more product or process more product with less energy use. We spend millions and millions and millions of dollars on that, and our people think about that every single day. We also look at the energy we use in our plants and we innovate around that, whether it's solar projects in Australia that we've just completed, or wind projects in China that we've just completed, or our biomass projects in our palm plantations in Indonesia that we've just completed. We are innovating in that area all the time, so as to drive that emission profile out of our direct Scope 1&2 control.

Figure 3.

But that is not enough. We must also work along our supply chain, because a big proportion of emission profile exposure of a company like Cargill comes from the farm sector direct and through our transport supply chain. Therefore, we need to seek to influence that, not just our direct operational control (Figure 4).

Figure 4.

Here are some examples of how we would do that. We now pay – not just encourage – farmers, direct, for environmental services. We pay farmers, direct, per tonne, to sequester carbon in parts of the world. We incentivise farmers to optimise nutrient management. We incentivise and support farmers to use nitrogen-inhibitor and urease-inhibitor technology (see Roya Khalil's paper, this Proceedings). Why do we do that? Because we need to produce yield with a smaller emission profile. We need to do that to meet own corporate commitments; and our customers expect that. They want to know what their emission profile is, from us, and they want to know how to

decarbonise against it. They don't just want it: they expect it. So we are setting up programs all around the world directly incentivising farmers and working on environmental markets to make sure that those markets can have integrity and credibility and transparency, and grow and provide new revenue markets and new revenue streams to farmers.

It is certainly not easy, but it is easier to do that in the Midwest of the United States and in southern New South Wales than it is in smallholder agriculture in China or India or many of the countries in which you, here today, do research.

That is why we need your expertise to help us do that.

We also work in our transport sector to try and seek to reduce the emission profile of transport. One example is that in the last couple of weeks we have begun putting 'sails' (such as BAR Technologies WindWings) on ships to reduce the energy consumption from ocean vessels (we have about 600 ocean vessels on the water any one time). We are seeing emission reductions as a result of that. It is not easy to do, but this is the type of new innovation that is happening in agricultural supply chains globally, in order to decarbonise our supply chains.

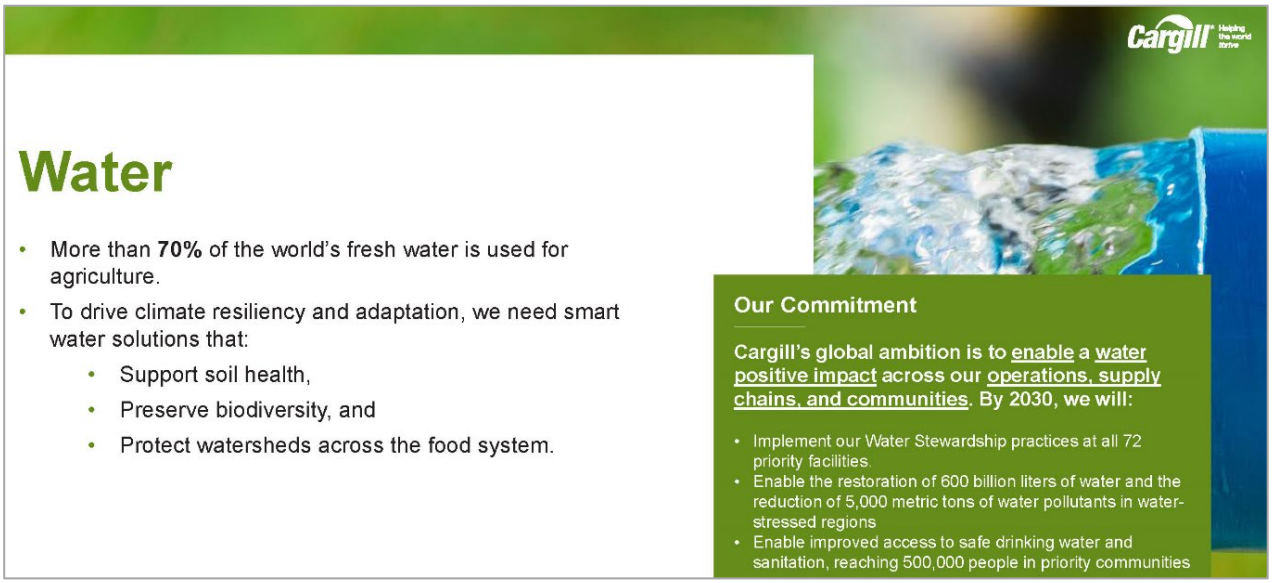

Figure 5.

Water

Figure 5 outlines Cargill's water policy. Agriculture is a system. Farmers understand the system and we need to understand the system like farmers do. So Cargill's has water policy and water commitments and projects. Because of our position as a connector of the food system, Cargill has the unique ability to develop holistic solutions that drive impact-at-scale, delivering water-positive impact across our operations, supply chains and the communities in which we operate.

People

Lastly, people. Private sector companies like Cargill know that, despite our scale and our balance sheet (our annual revenue is about US$165 billion), we have some specific challenges and opportunities in the Asia-Pacific in regard to our communities, and Cargill is investing to make a

difference. One particular challenge is the empowerment of smallholder agriculture. Within the Asia-Pacific there are 450 million smallholder farmers who produce 80% of the food.

We are committed to working alongside farmers to increase the economic, social and climate resilience of farming households and communities (see Figure 6). For example, since 2017, more than 886,000 farmer training sessions have been delivered across 30 countries – from regenerative agriculture practices to biosecurity measures that keep livestock healthy, to information sharing, technical resources and financial support.

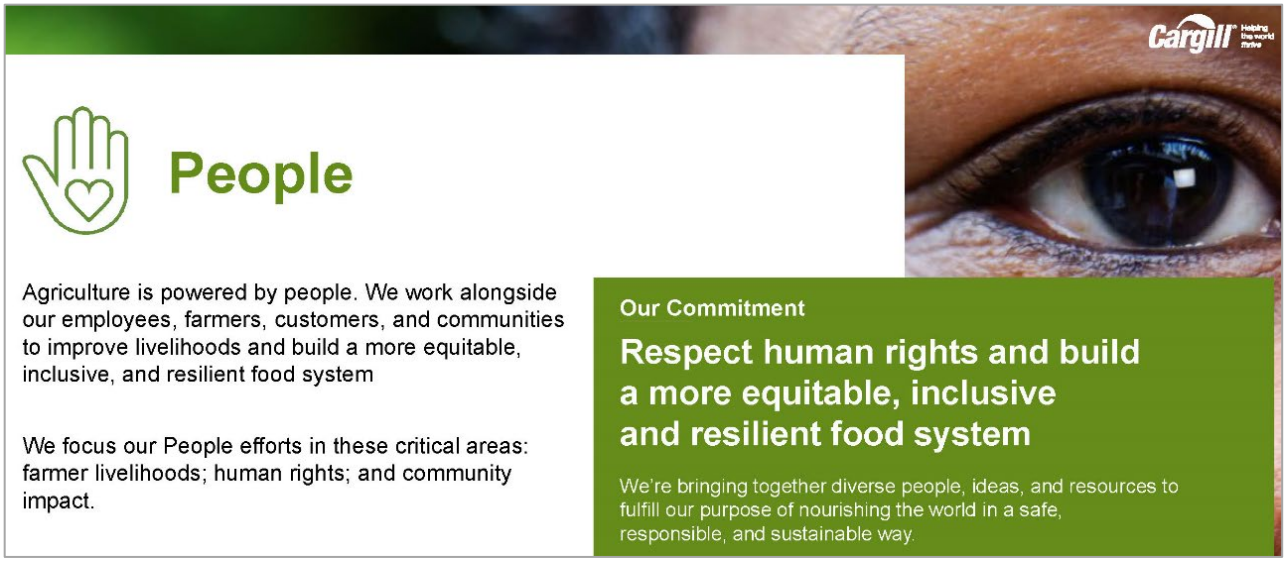

Figure 6.

When we focus on *people* and combine that with access to new technology, we can make huge progress. Smallholder farmers typically lack access to technologies, and the fragmented market makes it harder to collectively implement technologies. Providing access to technologies can help improve farmers' productivities, thereby improving their livelihoods. We cannot do that, and it wouldn't be in our interest to try, so we need to work along the supply chain, in partnerships that include smallholders in Asia-Pacific.

We, as Cargill, would seek to work with you on that.

Ben Fargher is the Lead, Cargill Environmental Markets, in the APAC region. In this role he is responsible for a customer-focused Sustainability portfolio, including carbon and water projects, in this part of Cargill's business. Ben is also the Country Representative for Cargill in Australia. Ben recently (Feb 2022) returned from living in the United States, where he held various Managing Director roles in Cargill's North American grain and oilseed supply chain business over several years. Prior to that Ben was the General Manager for customers and grain origination in the Cargill Australia grain and oilseed business. Before working at Cargill, Ben worked as the General Manager of Operations for a publicly listed cotton and grain agribusiness. He was also previously the Chief Executive Officer of the national farm lobby group in Australia, the National Farmers' Federation. Ben, who grew up on a farm in Australia, has a Bachelor of Agricultural Science from The University of Adelaide and a Masters degree in Economics from the University of New England.

SESSION 4.2:
SOLUTIONS FOR RESILIENT FOOD AND NUTRITION SYSTEMS OFF-FARM

Food systems solutions for healthier diets, better nutrition and health amidst climate change

Dr Warren T K Lee

Senior Nutrition & Food Systems Officer,
Food and Agriculture Organization of the United Nations (FAO)
Regional Office for Asia and the Pacific

Abstract

Food systems have a great potential to fulfill food security and nutrition for providing year-round healthy and affordable diets for all. Currently, however, our food systems have not yet delivered their full potential, leaving billions of people food insecure and unable to afford healthy diets; millions of children are stunted and wasted; and there is rising prevalence of obesity and non-communicable diseases. Hence, food systems in many parts of the world fail to deliver their missions! In the Asia-Pacific, the situation is exacerbated by population growth, urbanisation, changing consumption patterns, COVID-19, and the Ukraine war, and it is further complicated by climate change leading to unhealthy diets, poor nutrition and health, as well as unsustainable livelihoods and environment. Climate affects agri-food production which, however, is also a contributor to climate change. One-third of GHG emissions are generated from food systems. Climate change influences the entire food systems: poor soil fertility and reduced crop yield, biodiversity loss, pest diseases, reduced density and bioavailability of nutrients in foods, etc. Thus, climate change may increase malnutrition and health risks, deteriorate livelihoods and unsustainable environment. Sustainable and resilient food systems transformation coupled with nature-positive solutions, including climate-smart agriculture aligned with contextual ecosystem function, biodiversity and environmental conservation are warranted to ensure healthier diets and optimal health, and to mitigate and adapt the impact of climatic and food system interactions on diet, health and environment. Food systems transformation can harness the power of food systems to benefit humanity and the earth.

It is my pleasure to be invited by the Crawford Fund to speak at the Crawford Fund 2023 Annual Conference. This is the first time I have participated in a Crawford Fund conference. I'm impressed by the objectives of the Fund. I concur with Dr Cary Fowler, this morning, that the Crawford Fund is unique in the world, bringing together agriculturalists, people working in food security and nutrition, and also young people, to exchange ideas and experiences in improving food security and nutrition around the world using the food systems approach.

Today's topic is about agri-food systems solutions for healthier diets, better nutrition and health amidst climate change. I will talk about agri-food systems for healthy diets, nutrition and health, and a bit on the impact of climate change on the agri-food system, nutrition and health. We have heard a lot about how biodiversity loss threatens resilience of the agri-food system and the environment under climate change. Therefore, I will also touch on ways to make our agri-food systems work for health, nutrition and the environment.

I will suggest some key entry points for agri-food systems transformation. Because the agri-food system is so vast, with so many actors, drivers, and stakeholders, we need to start from the very beginning or we can do it bit by bit and join the dots together in order to transform or reshape our agri-food system for better food security and nutrition and the environment.

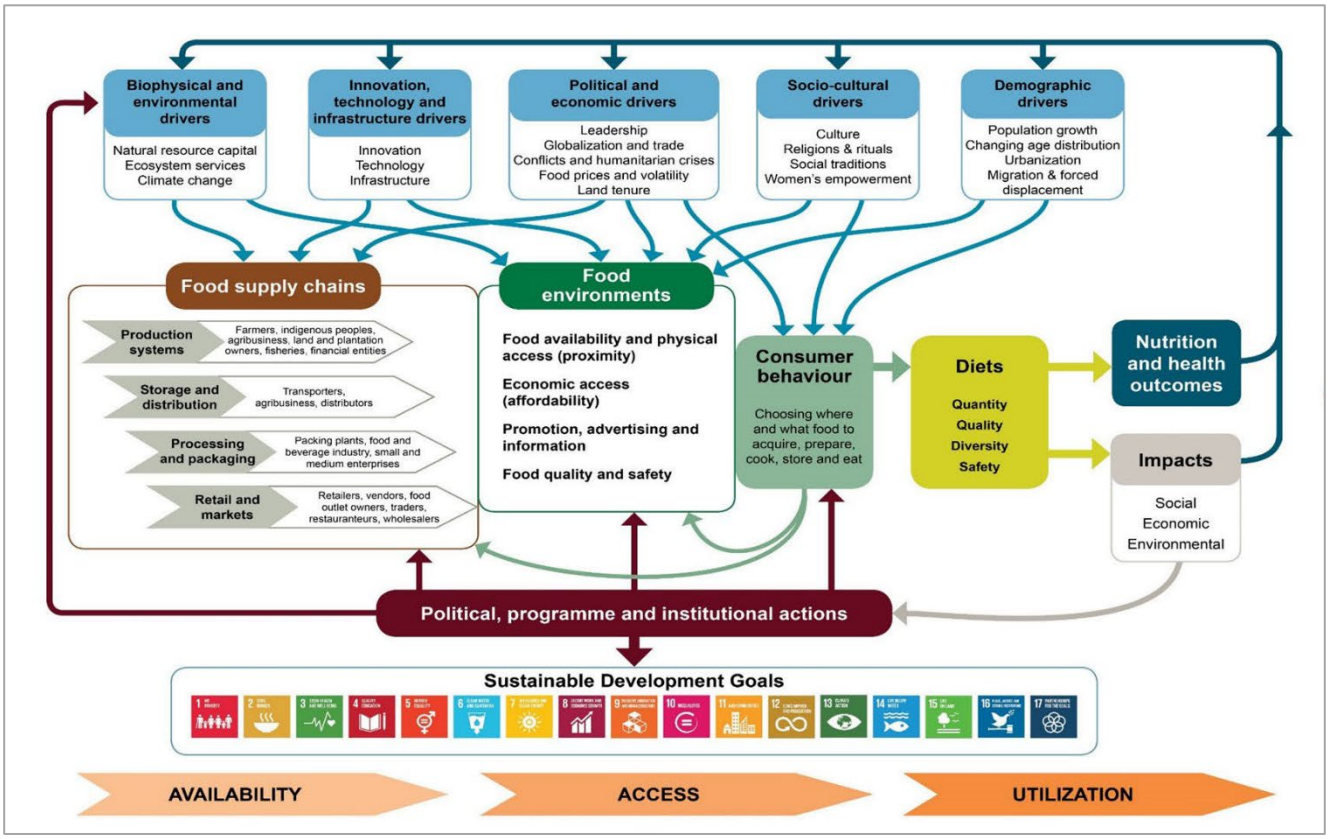

Figure 1. Potential of agri-food systems for healthy diets, nutrition and health to produce year-round nutritious food for healthy & affordable diets. *Source: CFW HLPE Nutrition & Food Systems 2017.*

An agri-food system is vast; it is like machinery (Figure 1). In order to produce healthy diets, we have different drivers and actors, and also various components: the producer, supply chain, food environment, and also our beneficiaries – the consumer who needs enough knowledge and skills to plan a good diet for themselves, their families and children for improved nutrition and food security. If any of these components are absent, or not connected, or the chain is being blocked, then the production of nutritious food for human consumption will be affected.

The current agri-food system fails to deliver its full potential for healthy diets and nutrition, and leads to billions of people being food insecure and unable to afford a healthy diet. As a result, millions of children are stunted and wasted. Over half the children in the world who are stunted and wasted live in the Asia-Pacific region. Figure 2 gives an overview of 2022 Asia-Pacific food security and nutrition situations. You can see a mega scale of hunger and malnutrition in this region. On the other hand, overweight and obesity are also rising rapidly, particularly in the Pacific region. This rapid upsurge of overweight and obesity needs urgent intervention.

According to the United Nations, countries in the Asia-Pacific are off-track to achieve the Sustainable Development Goals' targets for hunger and malnutrition (Figure 2). The average cost for a healthy diet in the Asia-Pacific is US$3.98 per person per day which is unaffordable to 1.9 billion people (i.e. 44.5% of all the Asia-Pacific population) living in this region. We need to take urgent action to improve the appalling situation in the Asia-Pacific region.

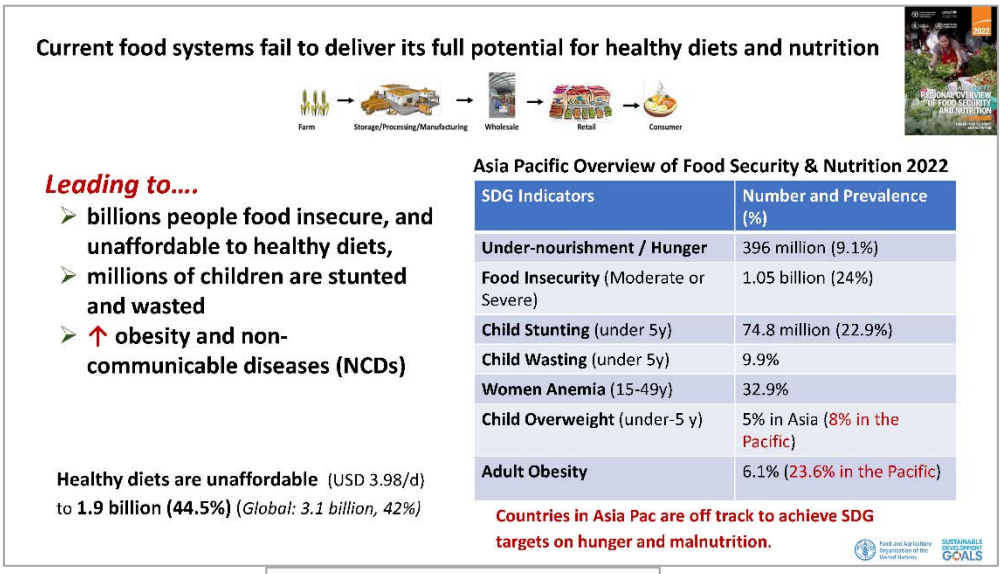

Figure 2. *Source: FAO et al. 2023.*

Climate change and the failure of agri-food systems, nutrition & health

Climate change affects agri-food production; but the agri-food production system can also contribute to climate change (Figure 3).

The impact of food production on climate change and the environment is mainly driven by greenhouse gas emissions and food losses and waste. As we have heard in today's and last night's keynote addresses, intensive agri-food production for meeting the global demand for more foods

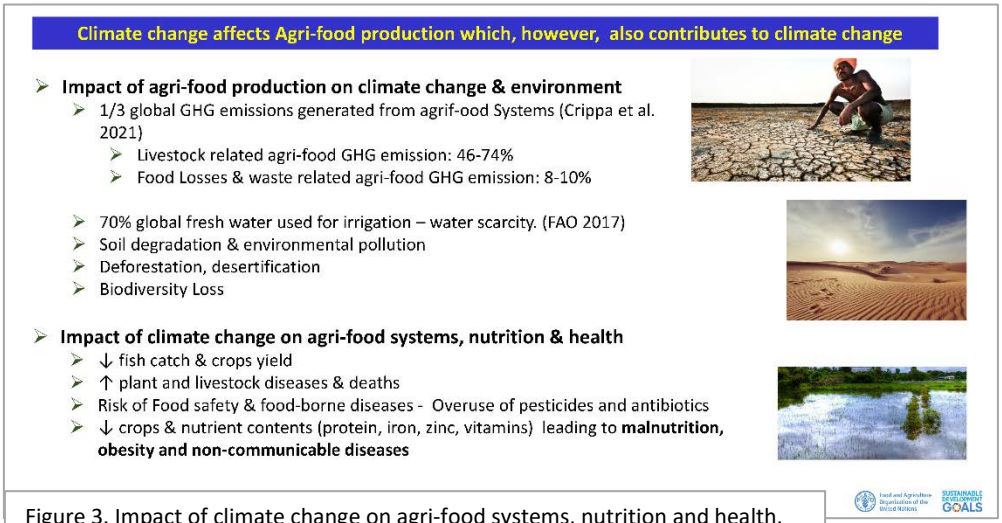

Figure 3. Impact of climate change on agri-food systems, nutrition and health.

exacerbates soil degradation, environmental pollution, deforestation, desertification and biodiversity loss. On the other hand, climate change affects agri-food systems, nutrition and health, reducing fish catch and crop yields, increasing plant and livestock disease and deaths, and adding more risks to food safety through food-borne diseases. Farmers overuse pesticides and antibiotics to boost yields, while the extra heat and carbon dioxide concentration in the atmosphere reduce the nutrient concentrations in food: protein, iron, zinc and vitamins in particular. Therefore, people need to eat more food to make up their nutrient requirements, i.e. more carbohydrate and more energy in the diet, which may result in more obesity.

Limited food diversity for human consumption contributes to biodiversity loss, resulting in less dietary diversity, and less resilience in agri-food systems: 75% of human foods are based on a narrow range of commercialised staple crops and animal foods, and the limited biodiverse food cultivation reduces the power of genetic diversity to support the resilience needs of agri-food systems and the environment in order to cope with climate threats. Making food and agri-food systems support nutrition, health and the environment

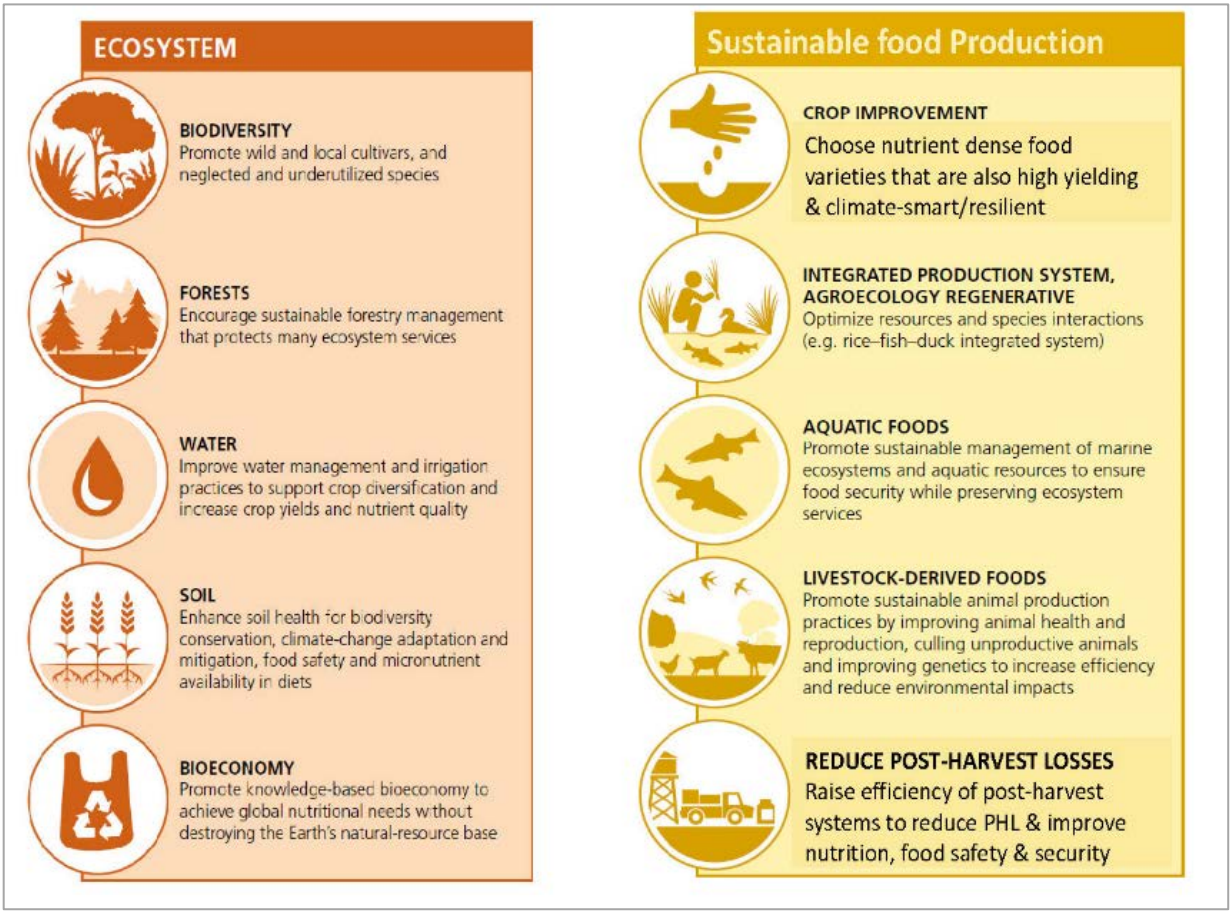

Figure 4. Key entry points for on-farm agri-food system transformation.

Making food and agri-food systems support nutrition, health and the environment

Food is the strongest lever we have for optimising health and environmental sustainability, but currently it works against both of those. However, agri-food systems have the potential to enable solutions to climate change, biodiversity loss, healthy diets and better nutrition, food safety and health, animal and plant health, sustainable and resilient environments, and so on. Figure 4 shows ways of transforming agri-food systems *on*-farm, that previous speakers have already talked about.

Now, consider *off*-farm solutions, mainly in relation to **nutrition-sensitive food production and value chains**. For example, we need:

- nutrition-sensitive value chains, with better storage, processing and preservation that aim to retain the nutritional values of food, rather than investing in highly processed non-nutritious food; also
- shorter, localised value chains linking farmers to local markets and consumers; this should reduce running costs (middle-men, transportation, storage, etc.), GHG emissions, and food prices. It should improve food access by people, and urban links to peri-urban production for better food security and nutrition; and
- to reformulate food products that have low nutrient values – high in trans-fats and other fats, sugars and salt – for the prevention of obesity and diet-related non-communicable diseases (NCDs). We need to work with the private sector to produce food products with less sugar, salt and fats, and at the same time to improve their nutrient content.

Agri-food policy needs to be involved, via:

- infrastructure investment: a lot of developing countries produce nutritious food in one geographical area, but most of these foods cannot reach people living in other areas because of poor electricity and transport networks; this leads to more perishable foods that are nutritious being lost due to a lack of cold storage, and that also increases post-harvest losses as a consequence;
- better access to technologies and innovation, enabling family farmers to produce nutritious food at a lower cost and thereby maintain profitability: for example, via e-platform, e-commerce, blockchain; and Geographical Indications (GI) to preserve the local identity of food products so they are more sustainable and more profitable;
- government policy to stimulate income-generating economic activities while enhancing employment and social protection, in order to close the poverty gap and income inequality – such as through eco-tourism and GI; and
- public procurement for school meal programs: schools can be used as a medium through which to feed children with nutritious meals, and to promote nutrition education to children. Local farmers can also be trained to supply safe and nutritious food to schools.
- promoting urban farming, edible landscapes, vertical farming, school gardening programs and homestead gardening for better access to more affordable and nutritious food in urban areas.

Also, we need to create **consumer demand for healthier diets**, for example, by:

- establishing 'healthy-eating guidelines', to advise people what to eat, and to inform agriculture policy so that farmers can diversity their food production to feed and nourish people;

- nutrition education, via social and behaviour change communication (SBCC), public campaigns, mass media and social media, counselling, and ante-natal training in nutrition, etc.;
- nutrition-sensitive social protection schemes for vulnerable groups and mothers to access nutritious foods for feeding the children properly, perhaps by conditional cash transfer, community kitchens, cooking demonstrations, food banking, etc.;
- regulation and legislation on advertising and promotion of foods high in fat, sugar and salt, especially those targeting children and adolescents, and better labelling of foods to give guidance on nutritional values; and
- repurposing fiscal policies to promote nutrition-sensitive food production, healthy affordable diets, and trade policy to produce positive impact on diet and nutrition.

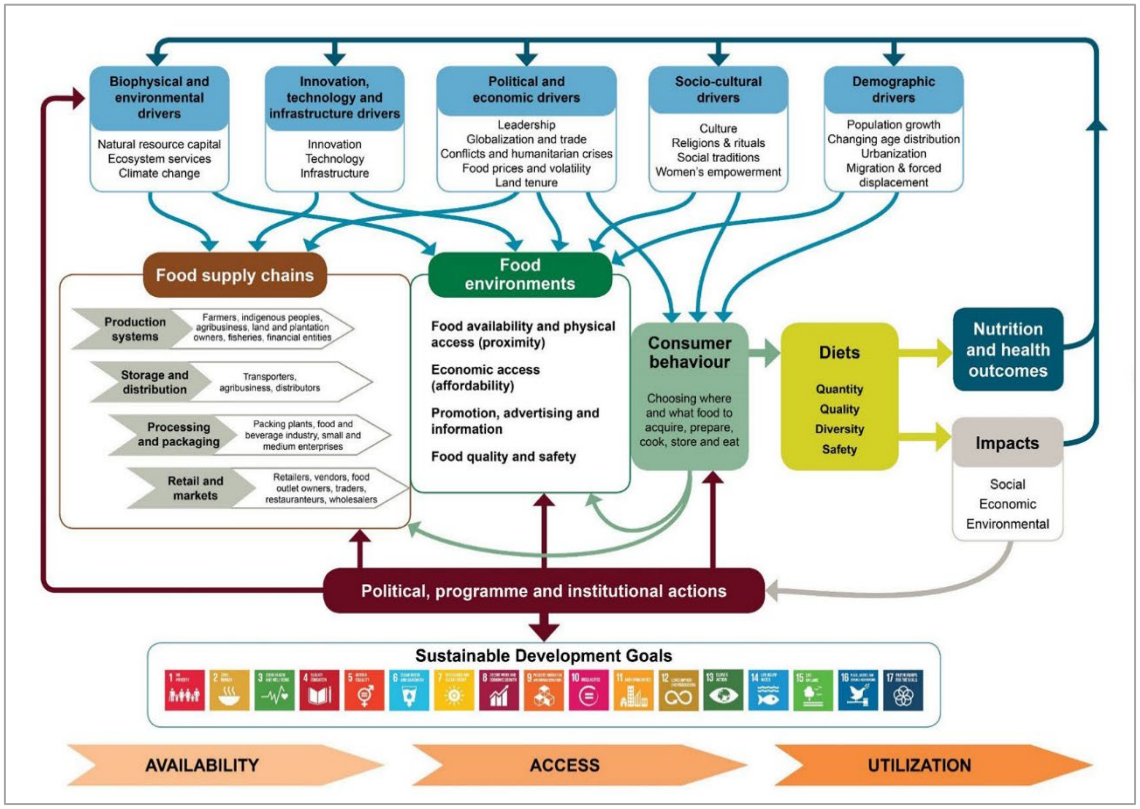

Figure 5. Agri-food systems transformation can harness its power to benefit humanity and the earth! *(HLPE 2017)*

Challenges and opportunities

The **challenges** that we are facing are: the current agri-food systems fail to deliver their full potential for healthy diets and nutrition; and that climate change affects the whole agri-food system and threatens sustainability and resilience; and that biodiversity loss threatens agri-food systems and environmental resilience under climate change.

However, there are **opportunities** to make better use of the agri-food systems, and this would be the solution to our problem.

- We need to transform agri-food systems to be sustainable and resilient in order to increase dietary diversity (including food biodiversity) and nutritious food production.
- We need nature-positive agri-food production systems for environmental resilience and social sustainability under climate change.
- We need to develop effective policies and actions, and also R&D to address the challenges of climate change on agri-food systems and to mitigate and adapt the impact of climate change on diet, health and the environment.
- We need to create an enabling food environment – this is very important – to empower consumers to eat healthy diets, and for responsible consumption aligned with environmental sustainability.

Conclusion

We need to be optimistic. If we can contribute in our own areas of expertise, and with concerted effort, we can collectively make agri-food system transformation possible, and harness its power to benefit humanity and planetary health (Figure 5).

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Dr Lee co-ordinates food systems and nutrition related policy, programs and research in the Asia Pacific region of FAO. He supports countries to implement food systems and nutrition related programmes. Dr Lee is also interested in undertaking scientific and implementation research to generate evidence-based nutrition policies and programs. While working at FAO headquarters, Rome (2012–2018), Dr Lee headed the Nutrition Assessment and Scientific Advice Group at the Nutrition and Food Systems Division, FAO. He coordinated programs on nutrition assessment, human nutrient requirements and Codex scientific advice on nutrition. Before joining FAO, Dr Lee has been a faculty member at University of Surrey, UK, The Chinese University of Hong Kong and University of Newcastle, NSW, Australia. He is recognised for his research contributions to public health nutrition, nutrition and bone health in particular.
Dr Lee holds a BSc in Human Nutrition from Trinity College, Dublin, Ireland, and a PhD from The Chinese University of Hong Kong. He is also a UK Registered Dietitian and Registered Nutritionist (Public Health).

SESSION 4.2:
SOLUTIONS FOR RESILIENT FOOD AND NUTRITION SYSTEMS OFF-FARM

Insect farming: a circular economy solution to create value for food loss and waste

Dr Fathiya Mbarak Khamis

Senior Scientist, International Centre of Insect Physiology and Ecology (*icipe*)

Abstract

The Food and Agriculture Organization (FAO) projects the global population to reach 9.7 billion by 2050. As such, food demand is expected to increase by 70% to meet food and nutritional security of the expanding population. Globally hunger is widely prevalent in the Africa, South Asia and in some Oceania islands. Therefore, population expansion and rapid urbanisation, coupled with the effects of the three Cs – COVID-19, climate change, and conflicts – are impacting food security in most of these regions. By 2050, 68% of the global population is anticipated to live in cities resulting in rising food prices, unemployment, and environmental degradation through massive accumulation of organic wastes, with only a very small proportion of it appropriately recycled in developing countries. Increasing income of urban dwellers has significantly increased the demand for crop and animal products, while lack of cost-efficient inputs such as fertilisers and feeds is constraining crop and livestock productivity. Ironically 33% of the food produced globally never manages to feed the people due to various post-harvest losses. These diverse and interlinked developmental challenges call for innovative solutions to address them. Use of insects such as black soldier fly, *Hermetia illucens*, for recycling organic wastes into nutrient-rich organic fertilisers for crop productivity, while also supplying high-quality insect biomass which is rich in crude proteins, fats, gross energy, well-balanced amino acids and vitamins for the feed sector to enhance livestock productivity, is one of these approaches. This is an innovative, eco-friendly and circular solution that contributes to environmental sustainability (mitigation of waste), food security (enhanced crop and livestock production) and has the potential to contribute to critically needed employment for youth and women in Africa, South Asia and the Pacific Islands. Furthermore, the high quality and locally produced insect protein and insect-based organic fertilisers can be excellent substitutes for often imported feed protein additives and synthetic fertilisers, and have the potential to reduce the import bills of several developing and underdeveloped nations.

In brief, *icipe* is the centre of excellence for research and capacity building in insect science and its application in Africa. The centre is an intergovernmental organisation (13 countries), over 50 years old, with over 570 staff of more than 30 nationalities. It has been governed by four directors and is currently under the stewardship of Dr Segenet Kelemu. Our head office is in Nairobi, Kenya.

The Food and Agriculture Organization of the United Nations (FAO) projects global population to reach 9.7 billion people by 2050, from the current 8 billion, and the effect of this will be a rise in food demand, though we are still grappling to meet SDG 2 (Figure 1). Agricultural production has to increase by 70% to meet food and nutritional security of the expanding population. Urbanisation, of course, will be rampant, and by 2050 seven out of ten people will be residing in the cities. Population expansion will lead to increased built environments for human settlements, which will drastically decrease land available

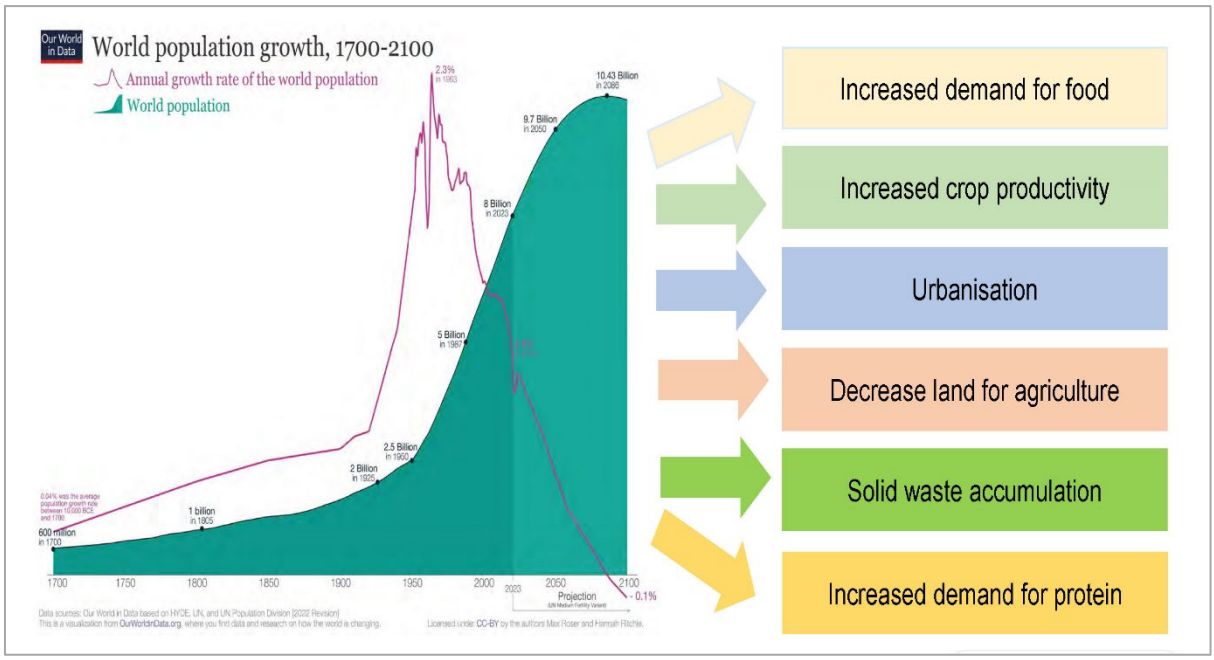


Figure 1. Population growth and food security.

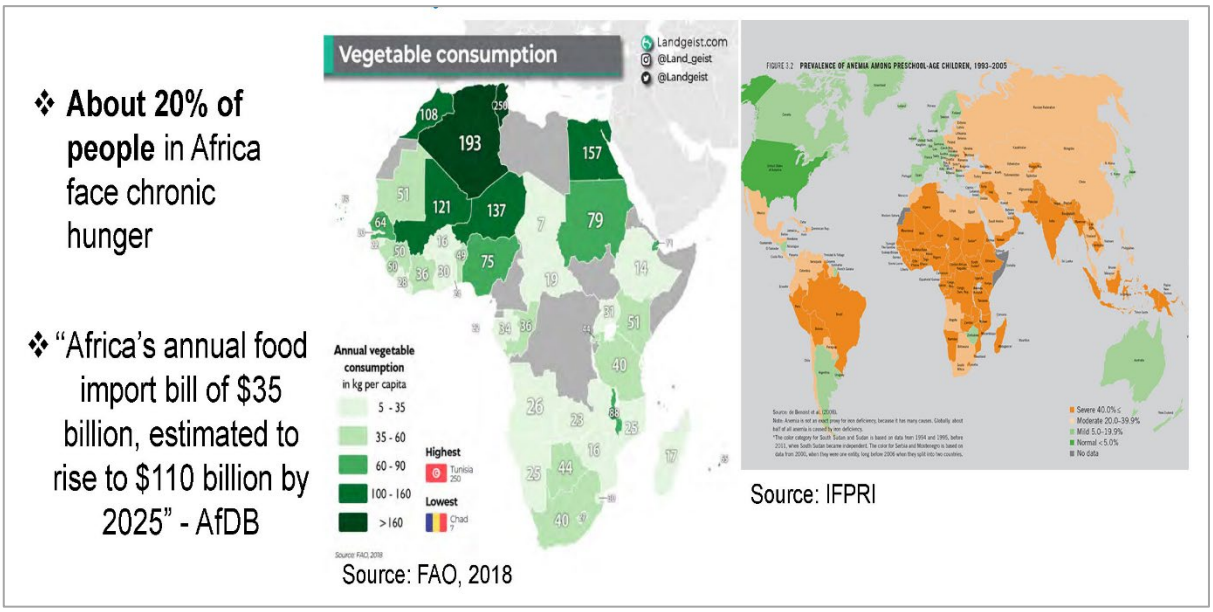
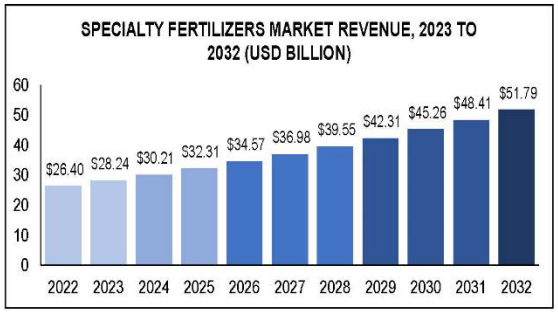


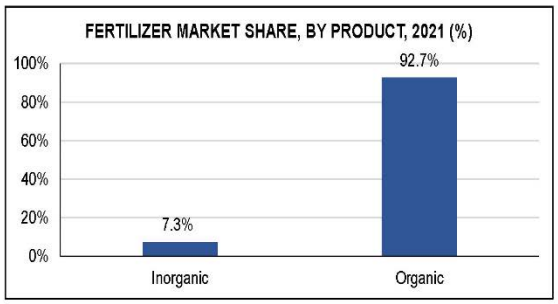
Figure 2. Challenge 1: Food and nutritional insecurity. Consumption of nutrient-rich vegetables vs hidden hunger in Africa. Anaemia across the world.

for agricultural productivity. And of course, all this leads to rising food prices, high levels of unemployment, and environmental degradation through massive accumulation of solid waste, especially organic waste.

Globally, hunger is widely prevalent in Africa, South Asia and in some Oceania Islands. About 20% of people in Africa are facing chronic hunger (Figure 2), with 90% of African countries yet to meet the average annual per capita vegetable consumption of around 88 kg. Across Africa the annual cost of importing food is US$35 billion, which is predicted to increase almost three-fold by 2050. Also, most of the regions of the world are currently facing anaemia.

Therefore, population expansion and rapid urbanisation, coupled with the effects of the three C's – COVID-19, climate change and conflict – are impacting food security. These effects will be intensified with the current trends in population growth.





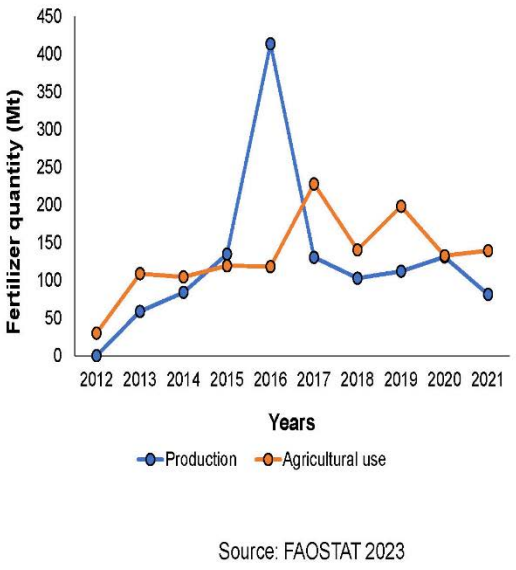


Figure 3. Challenge 2: Demand for fertiliser.

To increase agricultural productivity, demand for fertiliser is on the rise (Figure 3). Currently, demand is higher than supply due to political conflict. With the current shift towards regenerative agriculture, demand for organic fertiliser is rising and demand is expected to increase further.

Urbanisation and increasing incomes of urban dwellers will have significant effects on diets, with shifts especially towards animal-based proteins (Figure 4). The demand for animal products has drastically soared and is projected to almost double by 2050. This will in turn raise demand for feed for livestock production. Therefore, alternative sources have to be devised to meet this deficit and reduce reliance on sources such as soya bean, sunflower seed and fish.

A key challenge of population growth, urbanisation and increasing productivity is waste accumulation (Figure 5). Of the food produced globally, 33% never manages to feed people, due to various post-harvest losses, which means the bulk of municipal solid waste is foods and greens. Certainly this can also be used, and offers an opportunity when fully utilised.

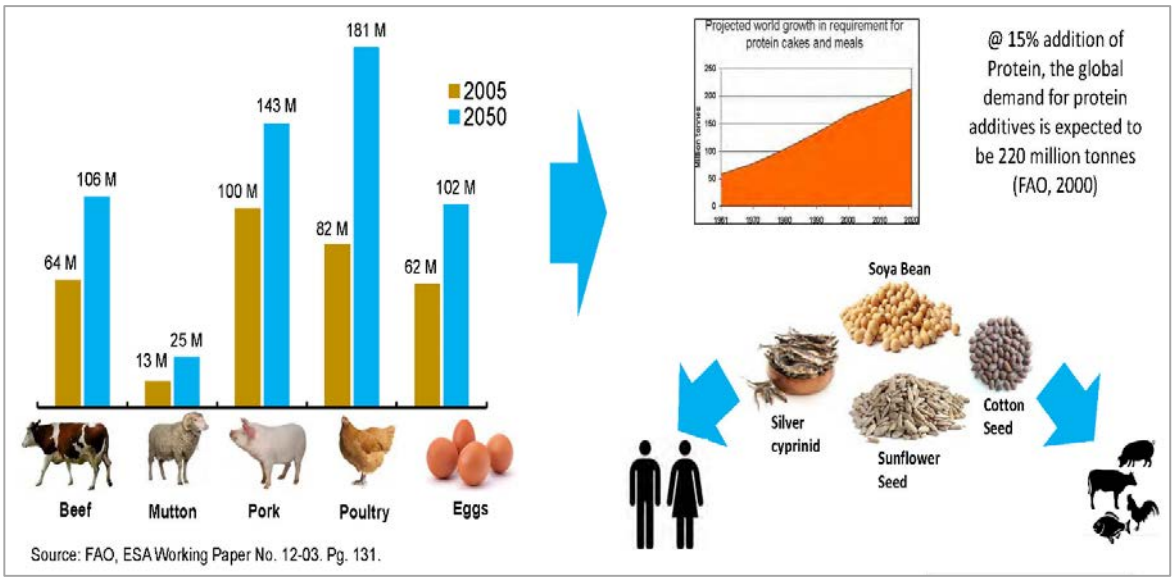
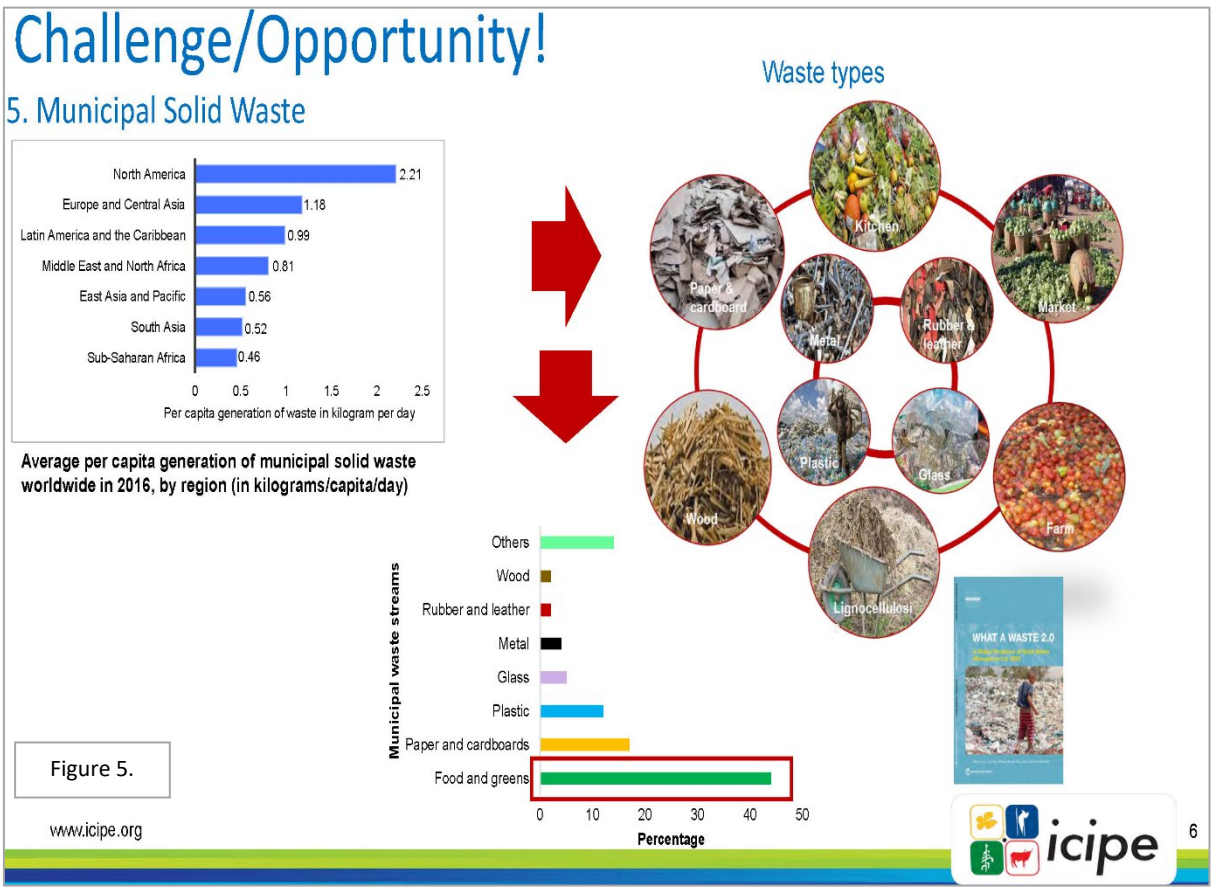


Figure 4. Challenge 3 (left): Global demand for meat protein (tons) (Alexandratos & Bruinsma 2012); Challenge 4 (right): Global demand for animal feed protein (FAOSTAT 2000).



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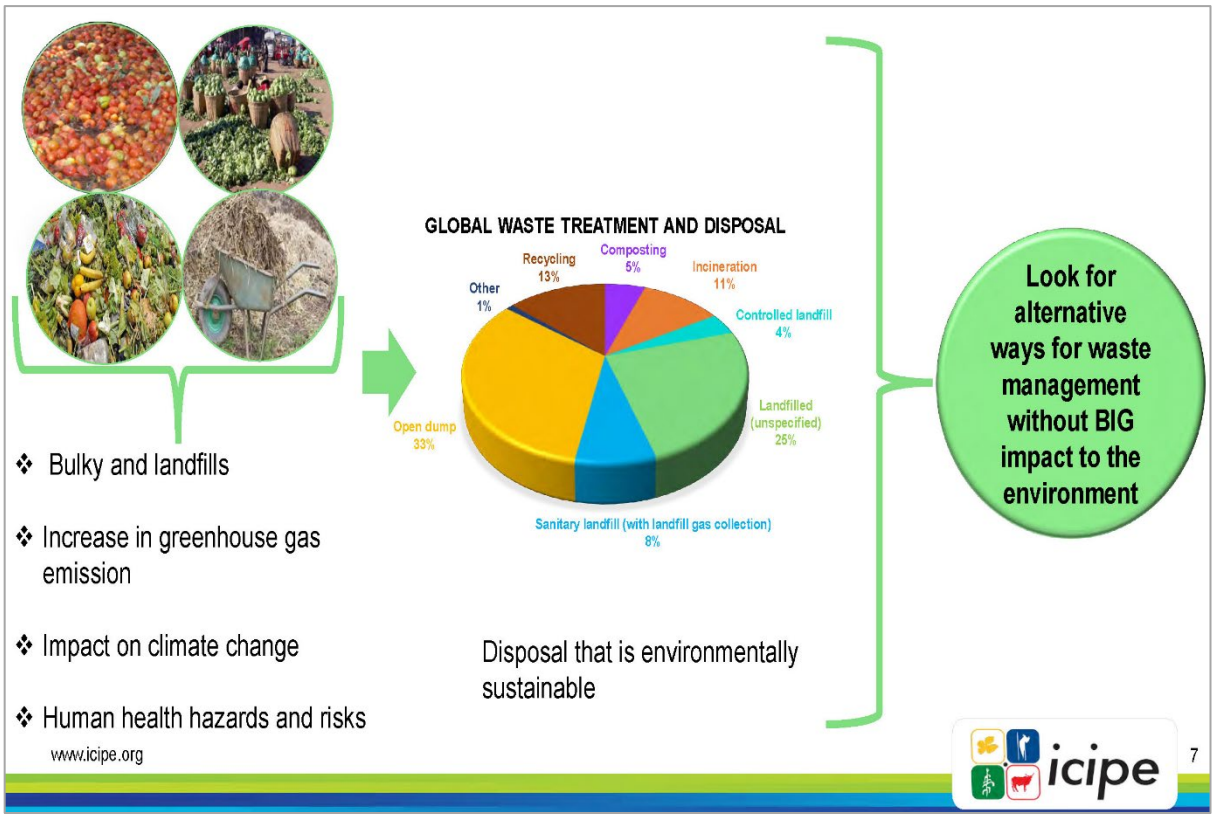

Figure 6. Need to manage waste in a sustainable way.

Waste disposal methods (Figure 6) can have many repercussions for the environment. For instance, open dumping can be hazardous to the environment and can pose serious health risks to humans and animals. So, alternative methods should be employed that are ecologically sound.

Black soldier flies: so many uses

One versatile approach that is plausible is the use of black soldier flies (BSF) *Hermetia illucens* (Figure 7). They can be used to recycle organic waste into nutrient-rich organic fertiliser for crop productivity, while also supplying high quality insect biomass that is rich in crude proteins, fats, well-balanced amino acids and vitamins.

The insect has so many advantages: it is cheap to maintain on various organic waste streams, reducing microbes; it has a short lifespan and a high reproductive rate; and is easy to rear and maintain. BSF has a global distribution with a wide introduced range. Many farmers are rearing BSF for farm use and also for small-scale sales especially to their peers and to big players in the field. It has been adopted by many key global players in all regions of the world (Figure 8), including the Asia-Pacific region, for various uses – such as protein additive for feed, for fertiliser, for oil production and waste streams.

A key development in insect farming is that recently *icipe* collaborated with development partners AgriFutures Australia and ACIAR (Australian Centre for International Agricultural Research) and created the Emerging Insect Technology Hub (EIT-Hub). The aim of the platform is to foster

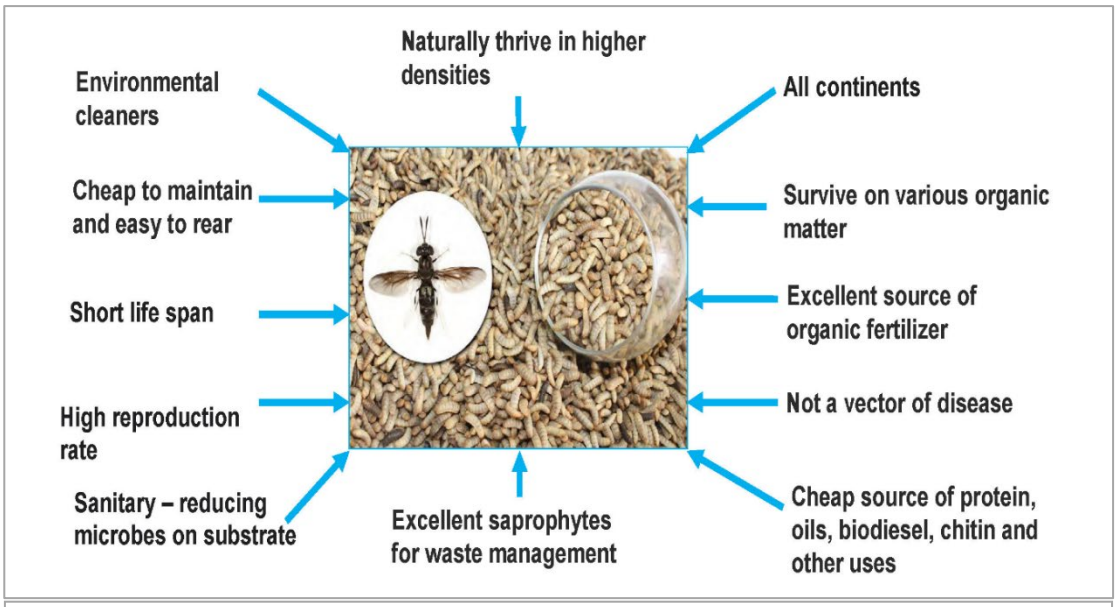

Figure 7. Black soldier fly, *Hermetia illucens*.

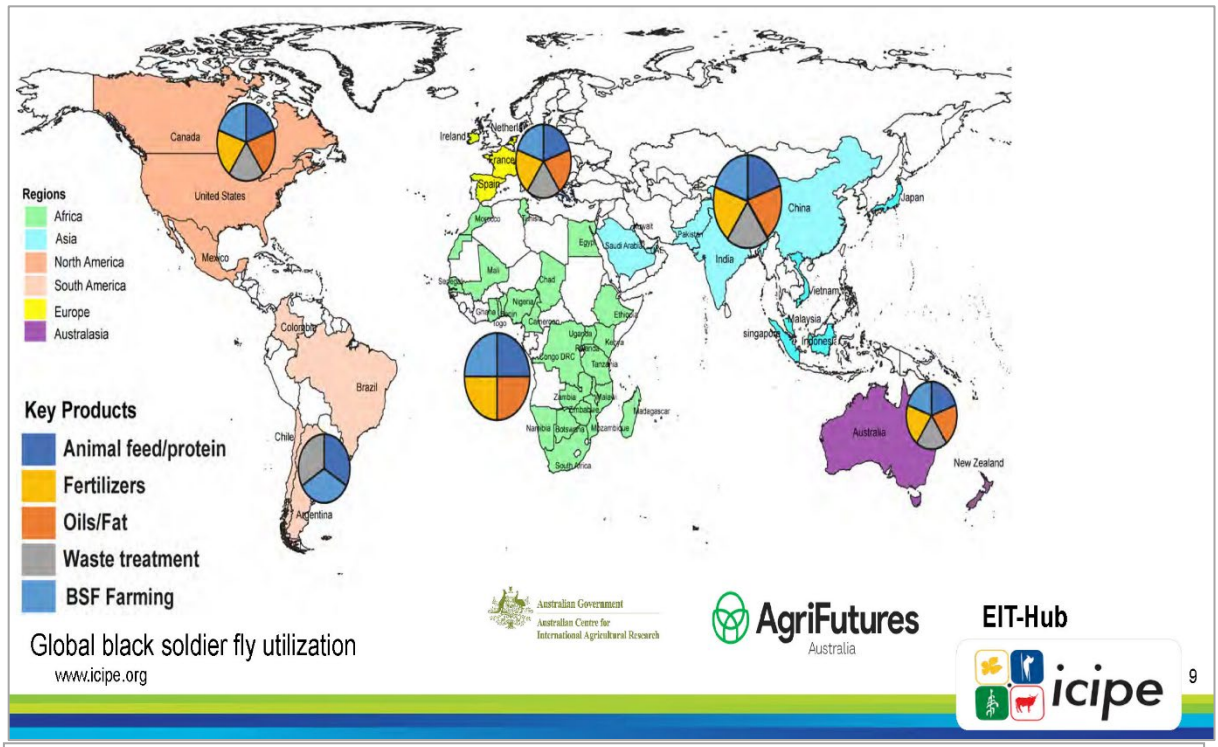

Figure 8. Current global distribution of black soldier fly.

collaboration and knowledge-sharing among research and industry partners, scientists and investors in Africa and Australia. The Hub is capitalising on the goal of promoting insect farming in Australia by AgriFutures.

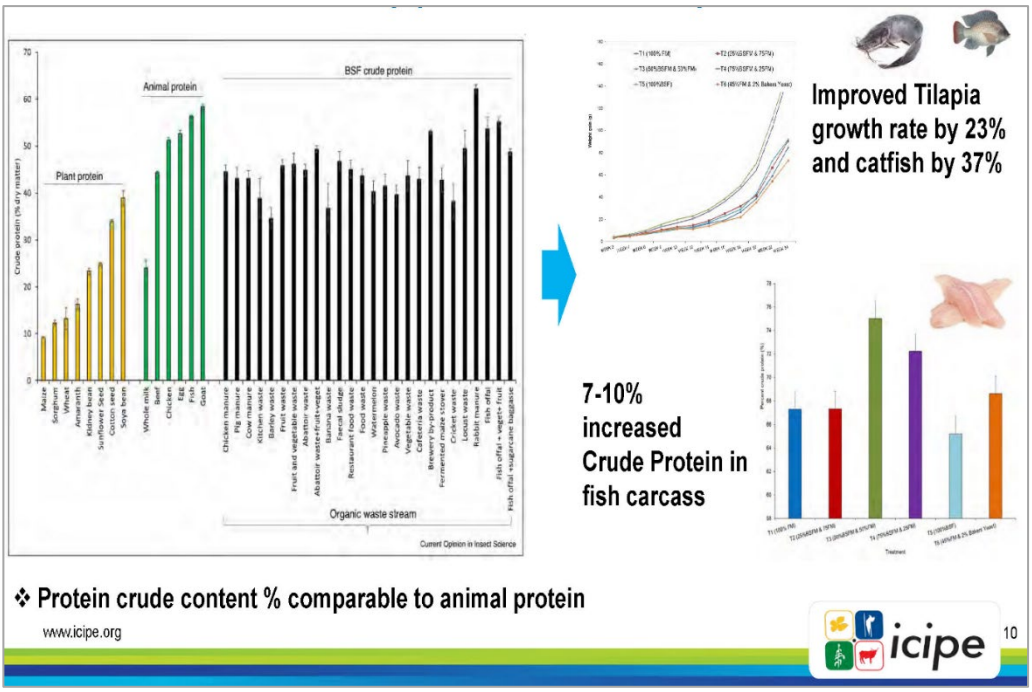

Figure 9. Crude protein – application in aquaculture.

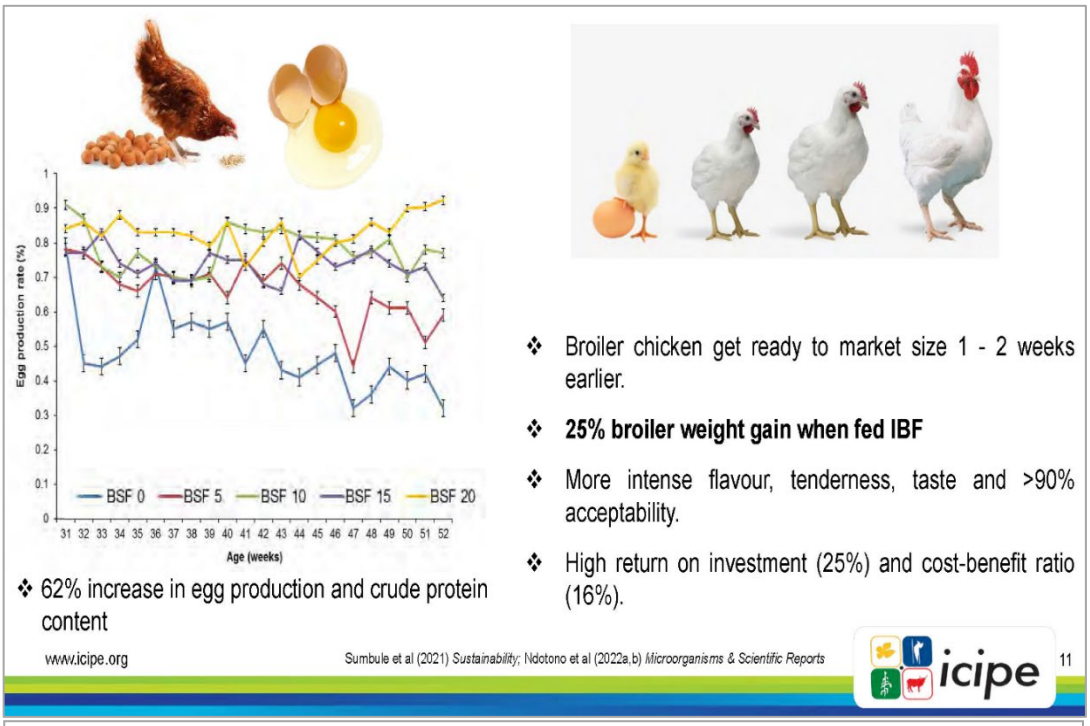

Figure 10. Application in poultry farming (Sumbule *et al*. 2021; Ndotono *et al*. 2022a,b).

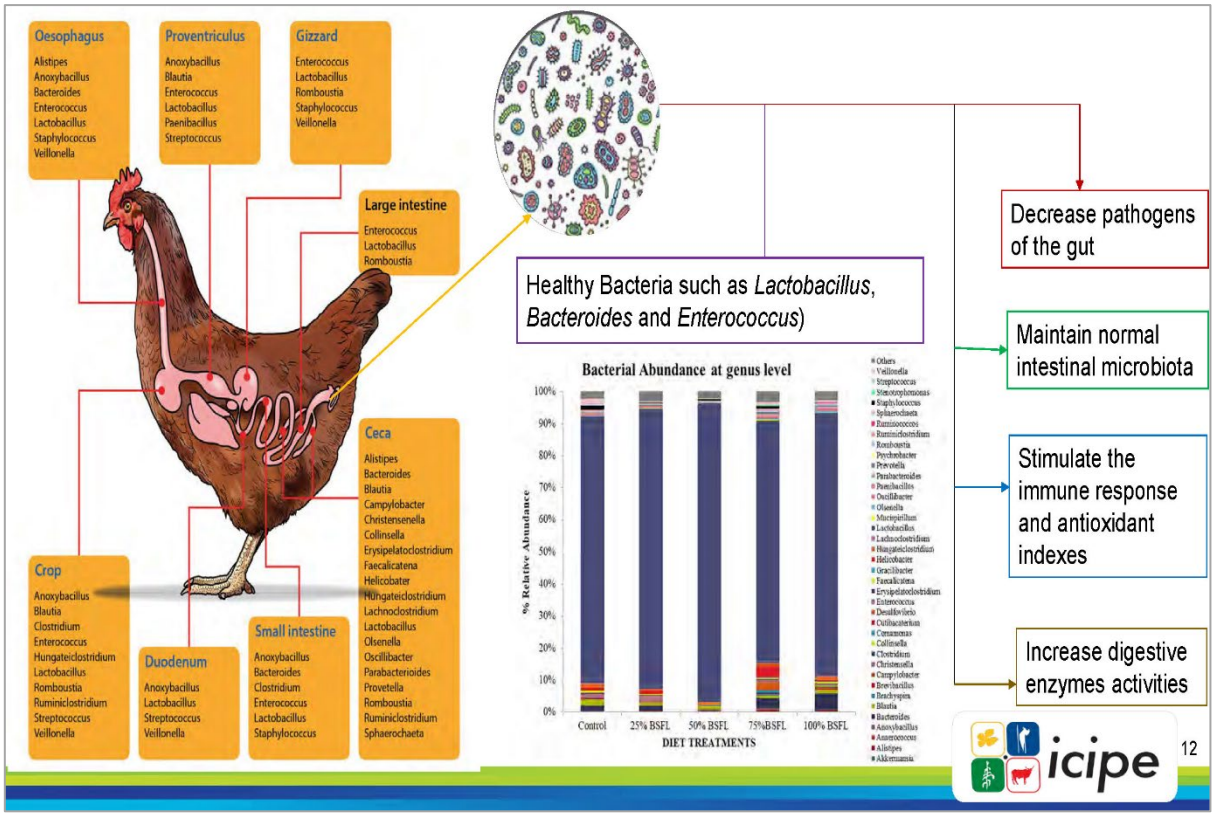

Figure 11. Insect-based feed improves chicken gut health.

While utilising and valorising organic wastes into usable fertilisers, we can produce BSF larval biomass with high protein content which is comparable to animal protein. This can be used as feed, for example in aquaculture (Figure 9). Our previous research has shown that insect-based feeds improve the growth of fish and increase the crude protein content of fish carcasses.

Similarly, in the poultry industry (Figures 10, 11), inclusion of BSF-based meal increases egg production by over 62% and raises the crude protein content of the eggs. It also increases the weight of broiler chickens by 25% while improving the quality and flavour of the chicken carcass. BSF also improves the gut health of poultry through increasing the abundance of beneficial bacteria such as *Lactobacillus* in the chicken gut, thereby promoting health and also growth without reliance on antibiotics.

Furthermore, soil amendments using insect chitin fertiliser suppress pests and diseases in vegetable cropping systems, while frass fertiliser improves yields of vegetables such as tomato, French bean, kale and staple crops such as maize (Figure 12). Those are the areas we have done experiments on, so far, and in general profitability increased by over 44%.

BSF larvae are a good and affordable source of excellent oil that can be used in the beauty industry, pharmaceuticals, for food and for biodiesel production (Figure 13).

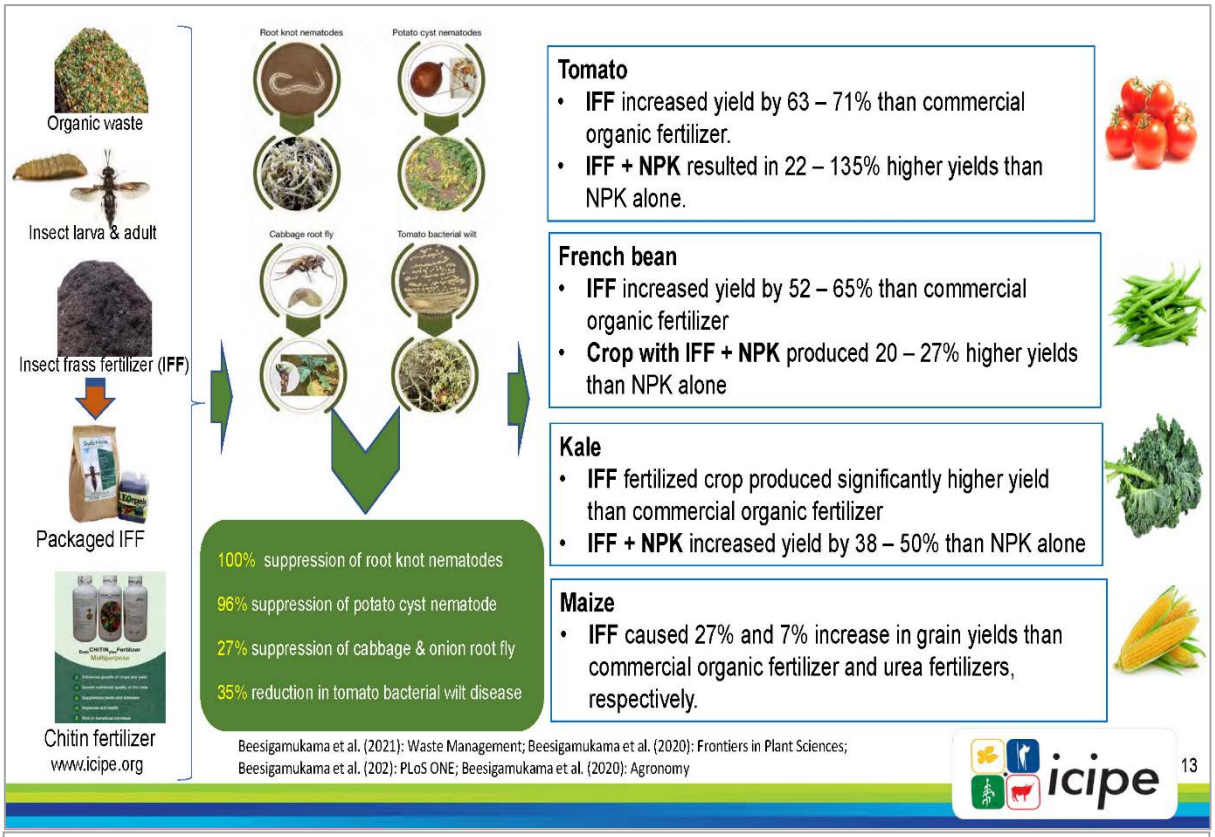

Figure 12. Chitin fertiliser and insect frass fertiliser, IFF (Beesigamukama *et al*. 2020, 2021).

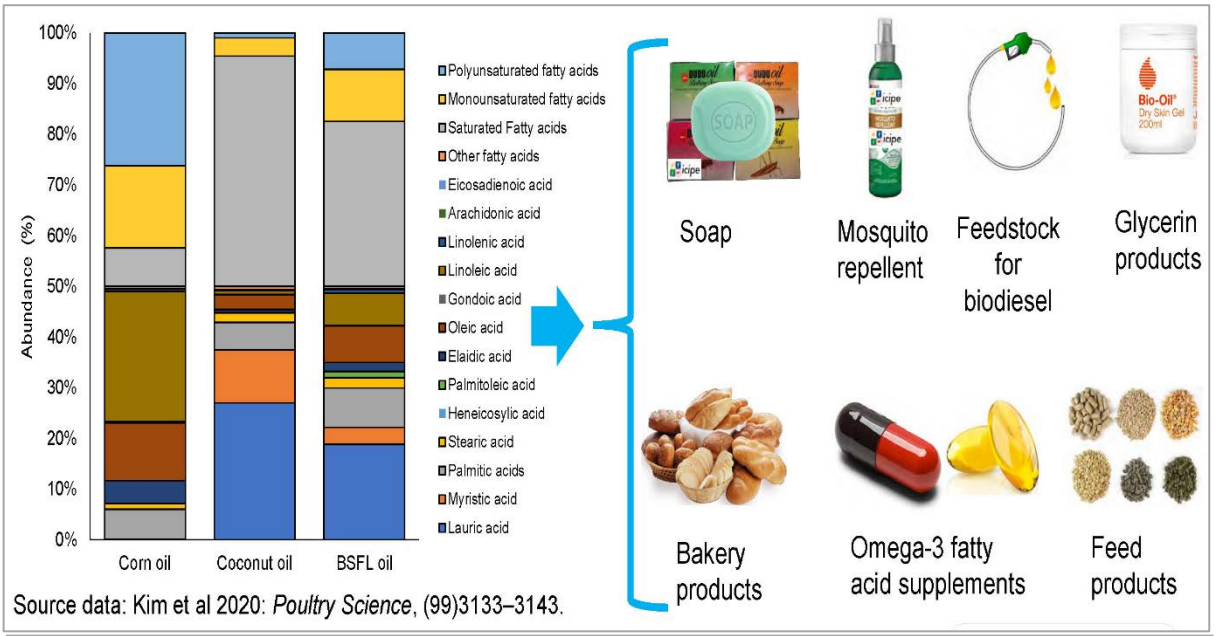

Figure 13. Excellent source of oils for various applications (Kim *et al*. 2020; Cheseto *et al.* 2020).

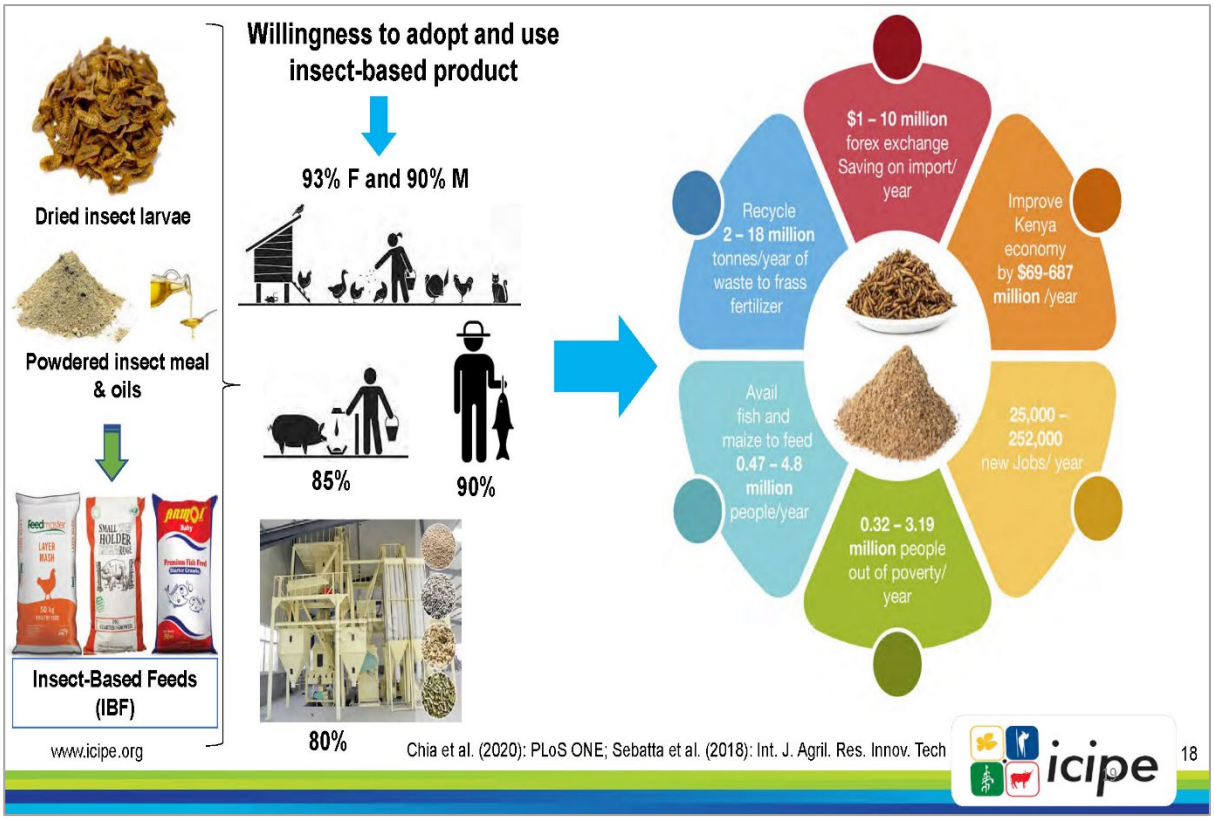

Figure 14. Socioeconomic and environmental impact of insect-based feeds in Kenya (Sebatta *et al*. 2018; Chia *et al*. 2020).

Capacity building and widescale promotion

icipe has built capacity at different levels on BSF. We have trained MSc students, PhD students and postdoctoral fellows. We have also trained trainers, developed training materials and issued starter kits to stakeholders to improve dissemination and adoption of this technology. And we have published widely for the scientific community on BSF and its research in our INSEFF (Insects for Food and Feed) program.

Through demonstration partners and networks of stakeholders, we have built capacity of farmers and small, medium and large-scale stakeholders interested in BSF production and value chains. We have done media engagement for visibility and wider acceptability of the technology.

At the start of our project we suggested using BSF for waste management, and by now the uses have increased to include feed and other uses. This has happened through policy engagement for enabling environments. *icipe* and partners have developed standards for certification of insect-based feed products and we are currently in collaboration with the African Organisation for Standardisation to develop standards for Africa.

Although insect-based feeds have gained traction in most parts of the world, socio-economic assessment is important for policy development (Figure 14). We assessed farmers' knowledge on edible insects as feed, and the acceptance and willingness to pay for the same in Kenya and other countries in East Africa. Our study revealed that farmers are aware and consider insects as a good ingredient for feed, and are willing to buy insect-based feeds for their livestock. And the impact has been tremendous in the economy of the country, through job creation, enhancing food and nutrition security, and improving the general livelihoods of the population.

Summary

In conclusion, BSF farming fits well within the context of the regenerative circular economy for waste valorisation and better agri-business livelihoods. Furthermore, BSF anchors well within the One Health framework where it serves to link all paradigms of health, from plant to human to animal and environment, working towards SDGs 1,2,3,4,5,6,7,8,10,11,13,14,15,16 and 17.

This insect has the potential to accomplish the global quest of transitioning to a greener environment. We have seen that BSF can be used for waste management, while at the same time the insect uses the waste as feed for its growth. The insect biomass can be utilised as sources of various high value products, such as oils, chitin and chitosan, frass fertilisers, antimicrobial peptides, enzymes and biodiesel, among others, which have diverse uses in the energy industry, pharmaceutical, food and crop protection sectors, while safeguarding the environment. All these products offer enterprise lines for creating jobs and sustaining livelihoods. *icipe* in this context won a Food Planet Prize in 2020.

Figure 15 shows the team working on our Insects for Food and Feed program INSEFF. I would like to acknowledge the groups in Figure 16 for funding various aspects of the program and I also acknowledge our institutional donors (Figure 17).

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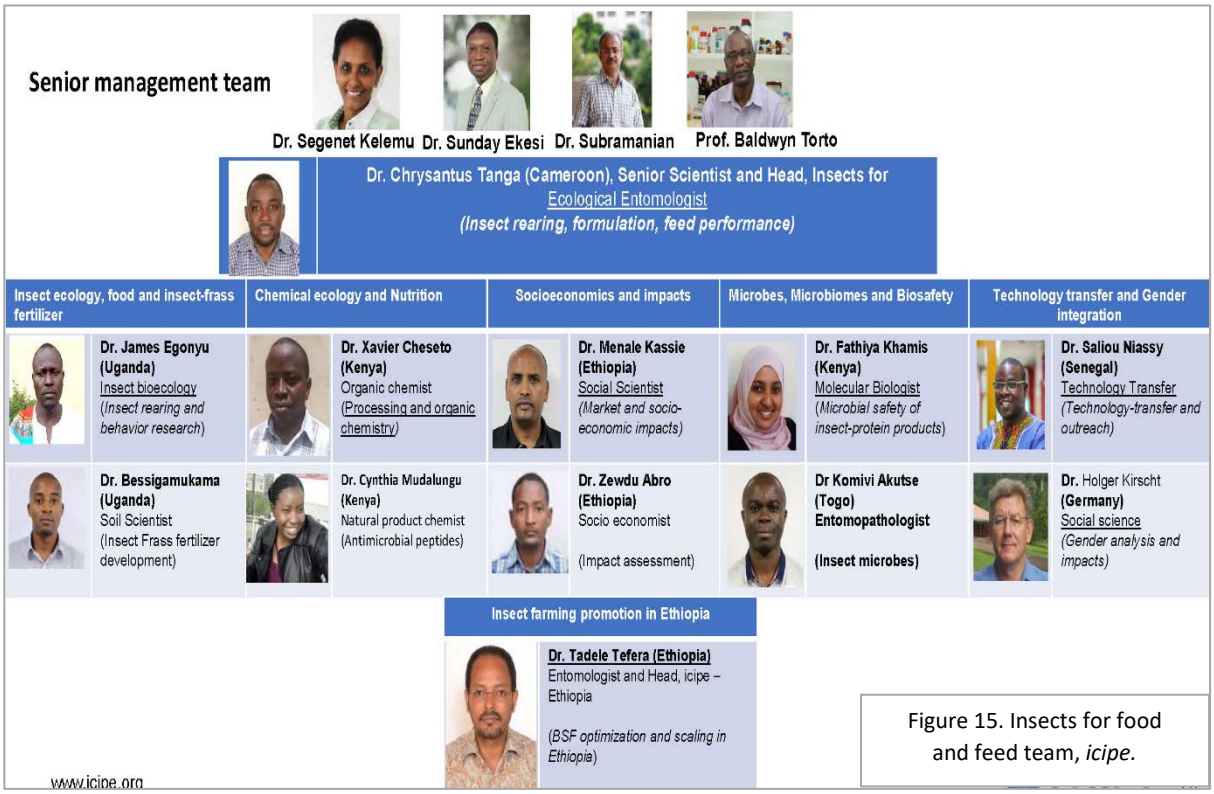

Figure 15. Insects for food and feed team, *icipe*.

Figure 16. These groups fund aspects of the program.

Figure 17. Institutional donors to *icipe*

Fathiya Khamis is a Molecular biologist and a Scientist in the Plant Health Theme of *icipe* working on native and invasive insect pests of fruits and vegetables that are of economic importance for food security in Africa and beyond. Fathiya applies molecular biology techniques for insect pest identification and understanding variabilities in pest populations – essential for the development of sustainable, integrated pest management systems. Fathiya also applies molecular techniques to assess the safety of insects as a sustainable source of nutritious food for humans and feed for livestock. Furthermore, she is advancing her research skills in microbiome analyses to enhance control of crop pests, improve biocontrol and reduce pesticide resistance in pest population. Fathiya is also active in building research capacity in Africa and has contributed significantly to the body of scientific knowledge through authoring and co-authoring more than 100 articles in international peer-reviewed journals and four book chapters.

SESSION 4.2:
SOLUTIONS FOR RESILIENT FOOD AND NUTRITION SYSTEMS OFF-FARM

Panel Q&A

Ben Fargher[1], Dr Warren T K Lee[2], Dr Fathiya Khamis[3]

[1]Cargill Asia Pacific, [2]UN FAO Regional Office for Asia and the Pacific, [3]*icipe*

Chair: Larelle McMillan, Research Director – Sustainability,
CSIRO Agriculture & Food

Q: Tony Fisher, Canberra, ACT Crawford Fund Committee

My question is to Dr Khamis. Wonderful talk. Very exciting. But all those insects look very identical. I'm wondering what genetics are behind the soldier fly and what is the risk of pathogens getting into your black soldier flies?

A: Fathiya Khamis

For the genetic aspects, yes, they are alike. In fact, we did some work to see the differences between the populations from so many regions of the world, but mostly they just genetically link up. There's not much variability because the sources are the same. For the farmers, they have mostly one source of obtaining their starter culture. So diversity or variability is quite low between the populations. For pathogens, yes, of course you can use different waste streams for rearing BSF, but they also have a cleaning mechanism, where after taking them from the substrate, you don't find these pathogens move into the BSF gut because they have a way of cleansing. So, yes, we have some organisms in the gut of the BSF, and normally after making the products we do biosafety checks through microbial analysis. And we have found that the products are quite clean when using the right rearing substrates streams.

Q: female, Charles Sturt University

What is the process of importing black soldier flies? I was recently in Timor-Leste and I mentioned black soldier flies and they asked, 'How do we get them?'.

A: Fathiya Khamis

It depends on the country's policies. We follow the protocols of the Convention on Biological Diversity and also the policies of the countries. Once you have permits, and the country of origin has permits, it's easy to collaborate and ensure that you get the live insects.

Q: Peter Wynn, New South Wales Crawford Fund

A question to Ben. To what extent are you going to use robotics or adopt robotics in your processing chains, and are there any implications for local jobs markets?

A: Ben Fargher

Good question. Certainly, we are looking at all that new technology that's happening around the world, in terms of driving efficiency. Not just robotics, but even AI which is a big topic of conversation now of course. It's about how you can use it for optimal growth. In talking about resiliency of food systems, for example, if you can use that technology to predict and scenario-plan

shocks, impacts, scenario-plan pandemics, scenario-plan conflict events, then you can make your food systems more prepared – and that's another resiliency point. So, any new technology that makes sense, we'll look at. But of course, we need to be conscious of employment. Like many businesses in Australia and many businesses around the world, we are often challenged to find labour, and labour shortage is a massive issue for global agribusiness, let alone global business as a whole. How we recruit and how we induct and how we train and how we support our employees around the world is a big consideration, including the diversity of that employee base: I didn't have time to get that today. Certainly those impacts and how they interface with the regional communities is vitally important to us.

Q: Julia Checco, PhD student, The University of Queensland

I've heard that the technology for insect farming can be expensive. Are there future opportunities for smallholder farmers to do insect farming?

A: Fathiya Khamis

We deal a lot with small- and medium-scale farmers, and we give them starter kits of the insect culture to start with. Actually they find it's cheap to do, because they use the waste from their farms – chicken waste or chicken manure – for rearing the insects. They also use biomass from their harvests and from other waste. So eventually it becomes cheaper for them to maintain the BSF with these wastes that they produce. In turn, they get fertiliser, and the frass fertiliser is better than them using their chicken manure as fertiliser. Also they use the live insects to feed their poultry. They also have other business streams to help cover the costs, so eventually it becomes cheaper for the farmers to do the insect farming.

Chair: Larelle McMillan

Dr Khamis, I think you have instigated quite a lot of questions around the black soldier fly. Your contact details are in the conference app, so for those who would like to follow up further on the circular economy aspects of black soldier fly as a case study, I encourage you to do that.

Please all join me in thanking our speakers today.
Thank you, Ben. Thank you, Warren. Thank you, Fathiya.

SESSION 5

A conversation on policy settings for risk and resilience

Dr Éliane Ubalijoro[1], Dr Cary Fowler[2], Professor Wendy Umberger[3],
& Emeritus Professor Kym Anderson AC[4]

Moderator: The Hon John Anderson AC

[1] CEO of CIFOR-ICRAF; [2] US Special Envoy for Global Food Security; [3] CEO of ACIAR;
[4] The University of Adelaide and Australian National University

Moderator: John Anderson

Ladies and gentlemen, it's my very happy task to loosely conduct a free-flowing conversation with four of our wonderful guest speakers, to whom I say: 'Thank you, Éliane, Cary, Wendy and Kym, for being here'.

I will open by asking a generic question of all four of you. First, though, some background. Talking with many of the younger people in the audience here today, I find they have enjoyed what they have heard and seen so far. But we are confronted, are we not, with a tsunami of difficult issues, and it would be very easy to say, 'There are so many of them; they look so overwhelming; you need only one or two to go wrong and it's all going to come falling down'. My first response would be : 'Remember what you have learned from history. It's not the first time that there have been massive challenges before humanity at large, or before groups of humanity, and with the right leadership in all sorts of fields we have made enormous progress in the past, and particularly in the area we have been talking about. Despite our worry about the declining outcomes in food security and nutrition levels for people, we ought not to forget that proportionately the numbers were far worse 50 years ago. So let's not talk ourselves down, all the time.'

Now here is my generic question to the panel: *From your talk and from your area of expertise and your knowledge of your field, where are the areas in which up-and-coming young people, who want to make a difference, can have the greatest impact? Nobody can take on all the issues at once: you've got to start chunk by chunk.*

Kym Anderson

Well, being an economist, I would sit down and try and work out the benefit–cost ratios of alternative possibilities! I don't have the answer to your question, John, but I would say to those of you in the audience: 'Be enthusiastic about what you do'. There are so many challenges out there, and from a scientist's point of view they are opportunities – opportunities to solve, or at least to help work towards solutions to those challenges. So, pick up the challenge that really 'turns you on'; get into the science of it; make use of your mentors around here and elsewhere; and 'go for it!'.

Moderator: John Anderson

As a quick follow-on from that, in your talk you touched on something else that is very important: the geopolitics. We also need political leadership, don't we? You made the really important point – which is a bit counterintuitive – that profits and global trade are important to lifting people out of poverty. Now, that doesn't quite fit with the zeitgeist which is very wary of profits and thinks

globalisation has been terrible. But you have put a different case, and I think that's important. And it points to the need for political leadership. One young person said to me, 'I'd really love to make a political difference, but it's hopeless. Where do you start?'. It does matter, doesn't it?

Kym Anderson

Yes. Some of you here from ANU may know Professor Anthea Roberts in ANU's School of Regulation and Global Governance. She published a book in 2021 with Nicolas Lamp of the Faculty of Law at Queen's University in Ontario, Canada, called *The Six Faces of Globalization*. It's a fabulous read that gives a sense of the various anti-globalisation pressures. They set up a Rubik's Cube. On the top face are the people like me that say, 'Globalisation is good; it boosts income, wealth and health. If you redistribute that increased wealth appropriately, you also get good social and environmental outcomes.'. There are people on the bottom face, who say, 'Globalisation's bad; everybody loses. It is terrible.'. And then there are four other faces on this cube, and from them you gain four additional perspectives on why different people take alternative views about globalisation.

It's a great way to think about how the politics of international trade and globalisation work, because those four groups and the one on the bottom are the ones who are pushing the politics away from market openness.

Moderator: John Anderson

Wendy, you are five or six weeks into your role as CEO with ACIAR. Where would you see exciting opportunities, if you were a young person here listening to your talk earlier today? What would you pull out and say, 'Here's an area where you can build a real career and make a difference.'?

Wendy Umberger

I am very envious those of you earlier in your careers than I am. I actually think it's more exciting than ever to be working in this area. For instance, I think there are exciting challenges; and the way that we work together is super exciting. But I do recommend that you broaden your disciplines. Those of you with science backgrounds, say, go and learn social sciences, or business, or some other disciplines. I did my undergraduate degree in Animal Science, and I expected either to go back to the farm or to be a ruminant nutritionist. Then I heard somebody speak about markets, and the need for beef cattle producers to connect to markets – and that opened my eyes to wider fields, and eventually this new role. When you keep learning and travelling, you get to understand so much more. I was probably one of those who thought globalisation was a bad thing, before I started to understand wider issues, never imagining that would lead me to Australia.

In short, I think it is important to have an understanding of other disciplines, not necessarily by going and getting a degree, but maybe by reading. There is so much opportunity, with the Internet, to pick up journals and read. I am always reading the science journals, for instance. Scientists need to learn about social sciences, and business, and how our systems work, and so on. I think ACIAR does a relatively good job of pulling together the disciplines. We need to do a much better job and understand the broader world and what drives people. Why do people make the decisions that they do? Think about that. Don't assume you know everything and that the world we live in is the same as everywhere else. We need to understand what drives people.

Cary Fowler

I really like Wendy's response just then. I think all of you are going to face a certain question in your professional life that I have faced in mind, and I'll give you a little story about how, for once in my life, I gave the right response on the spot.

I was giving a talk one day about a certain seedbank that I was associated with, and somebody came up to me after the talk, and they were red in the face and hopping mad. They got right into my personal space, and they said, 'Well, you're doing all this work to conserve seeds, but what are you doing about pollinators?'. (I happen to be a beekeeper myself, so I do appreciate pollinators!)

You know, usually when somebody puts you in that kind of situation, you only think of the correct response two or three days later, when it's too late. But this time, maybe the only time in my life, I thought of the right answer on the spot. I looked this person in the eyes and I said, 'Nothing. I thought I would leave something for you to do.'

All of you out there that are working in a particular profession are going to face these 'what about?' issues. It's exactly what you were talking about, John. The world is big. You may tell somebody that you are doing something that you think is good and constructive, and then you get these cynical responses, such as, 'Well, yeah, but what about *this* and *that*?'. There's never a response to that.

I think the response we should have in our hearts, in our minds, is, 'I'm doing what I can do. I'm focused. I am going to try to solve my problem. I am going to put one foot in front of the other, and count on the fact that other people are doing work too'. Don't be dissuaded. If there's one big key to success in this life, I think it's being *stubborn* and just *persisting*.

Moderator: John Anderson

Éliane, you could have given up when you were young. You could have said, 'This is all too hard'. There might be people out there who are thinking that, particularly about that relationship between agriculture, food production and forestry that you talked about yesterday.

What jumps out at you as an area where we need people who can make a difference?

Éliane Ubalijoro

The reality is we live in an interconnected transdisciplinary world. What I've realised is that it is very important to find your networks, and build them into communities of practice, so you can bring those different types of expertise together. When I was 22 years old, I wanted to do so much. I was in agriculture going towards my PhD in molecular genetics, but I also thought: 'I should get a law degree and look at patent law and intellectual property; and I should go to medical school and look at the interface of One Health, …'. I had all these ideas – and then I realised that *I can work with people from all these different disciplines*!

At CIFOR-ICRAF we harness the power of trees, but we also look at value chains that are going to allow us to build the needed, prosperous economic values that come from harnessing trees, not only for food production, for timber, for energy. How do we do that in a sustainable way?

The answer comes down to connecting the genebanks all the way through the production, the value chains, getting to the customers, and connecting in ways that have enabling policies that allow us to say, 'We can harness sustainable economies that take best of what we all can collectively bring forward'. None of us can do it alone. It's really about the power of all of us.

I have talked to many of the young people here, and you are all doing such great and very different types of work. Make sure you talk to each other and support each other. You never know when you're going to need each other.

We think about how biodiversity became such a critical issue with COVID, and really what it comes down to, as we're looking at our food systems, is that we need to bring back biodiversity so that we make sure we prevent future pandemics. And we need to restore soil health so we can bring the needed productivity to our food systems. So, learn what you're doing; bring passion to it; bring grit, because you never know how long it's going to take to get there.

I realise that on my own journey I have gone through times of deep powerlessness just because of the history of my country, Rwanda, but also times of deep hope. Even today, I think about the Kwita Izina, which is the annual Gorilla Naming Ceremony that was happening last week in Rwanda. This is an opportunity for Rwanda to connect with partners from over the world and locally that are champions of restoration, that are working to elevate green growth that is critical to rebuilding our economy by rebuilding the fabric of society, and also rebuilding our connection to biodiversity, and how biodiversity is critical to our food system – including bees.

Let's *live* our interconnectedness, and build those communities of practice from our networks. That's the power that's going to allow us to *scale* this work and accelerate it towards year 2030 protecting 30% of the planet, and also towards the net zero goals of the world.

Food is absolutely critical in this agenda, and so all the work you are doing can help us accelerate this work. None of it is too small.

Moderator: John Anderson

Cary, it strikes me that you, perhaps more than anyone else in this room, would have a global perspective on the great challenges confronting us: on the one hand, concern about emissions; on the other hand, keeping up food production. In some ways, to a layman, it looks as though there's great difficulty meshing the two.

For example, affordable cheap energy and fertilisers have been something we have taken for granted, and yet they are becoming more expensive, for all sorts of reasons – many of them related to government policies. That's making farming more difficult and it's having an impact on the affordability of food in some areas, along with the other things that we have talked about. We also know that, whether we like it or not, the consumption of coal, gas and oil continue to rise globally quite substantially, setting up even deeper challenges. Australia has a great focus on mitigation, but as a relatively minor emitter (and I say that not to diminish the problem but to highlight the fact that the surveys show the majority of Australians think Australia is responsible for between 10% and 20% of global emissions, which it isn't – and I am certainly not arguing for doing nothing) Australia's capacity to make a material difference to our future is going to be determined by what happens globally.

All that makes me question whether maybe the greatest contribution Australia can make, given our expertise in science and the plant sciences and agriculture, is to work on adaptation, and to make that knowledge widely known here and overseas, because it's going to be a key to mitigation anyway, on a global basis. I guess the question is, should we be focusing more on using our skill set in this country, where we really are amongst the top leaders, on agricultural research and extension abroad?

Cary Fowler

I thought you were going to ask me a question that would give me the opportunity to say, 'I've left something for you to do'!

One of the things that has perplexed me and concerned me about climate mitigation and adaptation is the divisions within the community on those issues. I have encountered people who work on the mitigation side looking quite askance at those of us who work on the adaptation side. That seems weird because, as I mentioned this morning, we have had 533 consecutive months of above 20th-century-average temperatures, so obviously we are already in the realm of needing to adapt. Maybe some people think that if you talk too much about adaptation it makes people feel depressed about their efforts on mitigation.

In fact, you know, we need both. We need to do both.

If I look at countries like Australia and the United States, yes, we do need to work on mitigation, but I think our big value-add, and our comparative advantage in the world, comes from our technology, our R&D. I think the Crawford Fund is very important, and that has a lot to do with adaptation, and we're going to need a lot of it. We are already seeing the effects of climate – and other factors – on agricultural production. We have to remember that there is a lag time with agricultural R&D, but once you get that pipeline started there is also a long, long benefit stream. Phil Pardey at the University of Minnesota talks about a 50-year period in which you get benefits from agricultural R&D, but that depends on keeping the pipeline full. We need to be very careful, as we go forward, to be making those kinds of investments so that we can get that 50-year tail of benefits.

Moderator: John Anderson

Thank you. If I'm honest, my question was loaded. I believe the Australian Government should commit, as never before, to agricultural research in a very big way in this country, because we do it

so well. We know the benefits provided for Australian farmers. Farming has outstripped every other sector of the economy for productivity, year in year out since the 1940s. And now we can extend it globally, in a way as never before. We have already done magnificently, globally, probably feeding as many, or more, people with our science as we do with our actual exports. I think we ought to be building on it. This comment is not party-political, but it is very *political*.

Kym, related directly to what Cary said, we see these 'camps' of mitigators and adapters and the capture and the non-capture people. Many of the non-capture people say that carbon-capture just gives people a way to wriggle off the hook and not do the hard work of reducing emissions. I think Robin Batterham, former Chief Scientist of Australia, would say that we need it all. That we need the energy sector to do carbon capture and so forth, to suck carbon dioxide out of the air. We know that there are ways to store more carbon in soils. The biggest barrier, I'd say, towards doing a lot more of that in Australia is that we don't yet have a system of affordable, reliable, trustworthy measurement. We know you have to measure the carbon stored, on an ongoing basis. You first have to get your benchmark, and then monitor what's happening in the years after that.

Do you have any thoughts on the urgency of providing farmers, here and internationally, with such a measurement system? In my view, there has not been enough urgency from governments in that area of work. It may reflect a 'siloing' problem where the mitigators rather than the anti-carbon-capture people have too much sway over those who say that we need to have capture as well.

Kym Anderson

I think it's clear from the work that's been done so far – where countries have moved down this path and tried to get a sense of how to offer the right incentives for farmers to provide, for example, ecosystem services – that there is enough empirical evidence now, I think, to show that we don't know enough; that we don't know how to capture this information about, first, what the baseline is before somebody starts planting a tree and/or putting stuff into the soil. For measuring those sorts of data, there is very poor science so far.

As I mentioned in my talk this morning, there is an OECD paper that came out last week that does a quick survey across the countries that are aiming to try and do this sort of thing (Deconinck *et al*. 2023). It shows how badly we currently know how to do that. This is partly tied up with our efforts in national accounting, aiming to go beyond just GDP-type measurement, to try and identify the natural capital stock: how much land we have got, how much is arable, how much is forest land, etc., and how much water we have, and similarly for other natural resources.

The ideal is to have those data as a baseline and then monitor how they are changing on an annual or five-yearly basis, for example. Carbon is part of that same story. We need to get much better at doing that.

The World Bank started natural capital accounting a few years ago. They have a system, for 60 or so countries, of putting together data on natural capital. They treat it like a stock of wealth, and then look at how it's changed over time. And in doing that, they take into account not just the physical quantities of land or water or whatever, but also the prices of the things they can be used for, so that when prices change the estimated aggregate value of the stock of wealth changes. The global distribution of this moves around a lot. But we are really at the very beginning of doing this sort of thing, and involving the national accounts people is an important part of what's required.

Moderator: John Anderson

One of the great difficulties is that many farmers have already adopted policies that will have led to much greater levels of carbon storage, but they can't extract the reward for that now because they've already done it. And there are other farmers who ought to be incentivised to do more, who are not getting the baseline work done. That's another issue.

Wendy and Éliane, can I ask you about a different matter. We had a long talk at the board meeting yesterday about being culturally sensitive in the countries where we try to help out and extend knowledge. Government aid from the west often comes with 'tags' attached, which are resented. For example, we may want the aid recipients to meet a target that reflects *our* values, but perhaps it doesn't mesh with the values of the people that we are trying to work with. It's a question really around social sensitivity and willingness to adopt better technologies and real assistance. I would be very interested in an ACIAR perspective on it, and an African perspective on it. Are we doing it well enough, working *with* people rather than working *at* them, if I can put it that way?

Éliane Ubalijoro

This week (4 – 8 September) in Nairobi, it's Africa Climate Week, which is Africa's opportunity to take leadership in terms of visioning how Africa wants to look at mitigation and adaptation and climate finance in general.

What I think is needed is for all countries to have their *own vision of where they want to go*. Then that can support donors who know *what* issues they want to contribute to, to align their donations with the local vision. I think having that synergy will allow us to accelerate the impact of the dollars that are coming in and the purpose-driven possibilities of implementation locally.

In other words, I think we need shared leadership and vision that builds on our collective vision of where we want to go, and of how we know – locally – that the work can be implemented. Because we know that we *all* want *every* donor dollar to have *maximum* impact. We know that ACIAR does that, and I hope you get the extra funding you need right now, because your impact is so wonderful.

What is needed is to *maximise the catalytic capacity of those dollars*. And that comes down to whether or not we can bring shared leadership to that.

Africa Climate Week is that opportunity for Africans to create that leadership around mitigation and adaptation and say, 'World, come and help us'. Whether it's a government, whether it's

private sector, whether it's philanthropy, it's Africa saying, 'Let's collectively work to build that vision'. Aligning the vectors in the same direction will give the R&D funding more power, more force, and accelerate the work we can achieve together.

Moderator: John Anderson

I think that donor countries ought to be careful about saying (in effect), 'Here's some help, but we are going to prioritise it being spent to achieve *our* values, and you (recipients) must fall into line'. What we *should* be saying is, 'Our primary objective is to help you and your basic needs, and we will let you take your own society forward from there'. And I worry that we sometimes want to prove a point bit too much.

Wendy Umberger

ACIAR was very excited to see, in Australia's new development policy, the big emphasis on partnerships. That is something where ACIAR, as an agency, has been ahead; something we are already working on.

We have at least 13 different country network offices, where we have locally engaged staff from the country, speaking to government, speaking to multinationals but particularly to governments, understanding what the needs are for the country's government, for our partners. Different countries are at different stages. We have an initiative called Next Generation Partnerships that is being led by our country network.

Something we have talked about in ACIAR – as research program managers and other ACIAR staff in the audience here know already – is that we need to be doing what is important to our countries. And if we are doing that, we are going to have a much better and much greater impact. ACIAR has already had tremendous impact, but that will be so much bigger if we truly understand the needs of our partner countries.

Éliane and I had an excellent talk earlier this week about how we share this philosophy of partnering, where ACIAR is a broker of research, where we commission research. Our funding of $110 million or $115 million is not huge, so we need to leverage and work on partnerships if we are to have a bigger impact on the ground and an understanding of the local needs, rather than us, ACIAR, coming into a country with our 'Australian hat' on. We really need, to some extent, demand-driven understanding of the local needs, but obviously what we do needs also to line up with Australia's development policy and our Australian goals. But that's pretty easy. That's actually a really easy thing to do.

Moderator: John Anderson
Who would like to ask a question from the floor?

Q: German Puga, The University of Adelaide, and a Crawford Fund scholar
If consumers were to have a more positive opinion on GMOs, what would be the implications of that on food security? And if the answer is that it will have a positive influence, what should governments do in terms of policy?

Cary Fowler
I think it's a mistake to think that biotechnologies are either the solution or the problem. I'm fairly agnostic about technologies. I think – and my government thinks – that the job is really to get the job done. Having said that, there are some very difficult issues with plant breeding of some crops if there are particular obstacles to overcome to improve production or disease- or pest-resistance. I could mention papaya. In some cases, you are not going to get the amount of investment needed to overcome those problems if you can only use traditional plant breeding methods, because: it takes too long; the genetics are too complicated; there's not enough money involved in it; there's not going to be a pay-off; and so the problem is not going to be solved. Therefore, I think we have to be humble about how we approach some of these problems and we have to be at least open to the different kinds of solutions that are increasingly available, such as the genetically modified solution, the gene editing, and of course also the traditional plant breeding.

Q: Julie Nicol, Victorian Crawford Fund Committee, and the University of Sydney Plant Breeding Institute
What are the opportunities for interdisciplinary research for agricultural development with industry R&D, such as the Grains Research & Development Corporation, the Meat and Livestock Commission and ACIAR working together on projects of Australian and global importance?

Wendy Umberger
Even ACIAR projects don't always work well together and do interdisciplinary work. There are huge opportunities, and we have to have a mechanism to get researchers to work together. Something like carrots and sticks. I have been part of a lot of initiatives in my time in Australia that have been meant to be doing multidisciplinary, transdisciplinary research … and it's so hard.

I think we have to put in some sort of incentive, and a bit of stick there, to say, 'Okay, you're going to work together on an interdisciplinary team, but you will need to respect each other and have mutual interest in each other's areas'. I think within ACIAR we need to do a better job of that. I think we need to have even our research management areas working more cohesively. It's something we talk about and that we are going to be sorting out how we can do. But I don't have the answer on how you do that, because I've seen it *not* work probably more times than it *has* worked. On the other hand, for my entire career I have worked in an interdisciplinary way and I think it has been the most fun, the most rewarding, and where we have had the best impact.

My very last ACIAR project, which was called IndoDairy, was entirely interdisciplinary, even though it was in the agribusiness area. It wasn't an agribusiness project. It involved technology, technical science, social science. The big outcomes it achieved were because there was a local milk processor involved. I think sometimes we're hard on ourselves, not realising that we actually do a lot of interdisciplinary stuff. Now research & development corporations (RDCs) are moving towards that in Australia, and universities are also trying.

Moderator: John Anderson
Any international perspectives? Is anybody doing it better than Australia?

Kym Anderson
One thing Australia is doing with its RDC system is taxing each of the RDCs a little bit and putting money into a common pool for some big problems that can't be solved solely by the Grains RDC or the livestock RDC, or whatever. So for those of you who want to work on those big problems, don't just look at GRDC if it's a grains issue. Instead, it might be handled by a climate change group that is working across all pertinent rural industries in Australia.

Q: Kim Russell, Stump Jump Foundation
Does anyone know anything about the Taskforce on Climate-related Financial Disclosures, which is a big-end-of-town development of what disclosures big companies have to make on climate-related data? I fear that it is something that will trickle down to smallholder farmers as well as to farmers like yourself, John. Has anyone heard about it? If you haven't, then 'watch that space'.

Moderator: John Anderson
It's a very good point.

Éliane Ubalijoro
There is a taskforce on climate and also another one on nature. They are about how we can bring natural capital into our accounting systems: true cost accounting. For example, for fertiliser production we should think about the true cost of producing it from the environment it's derived from: that is, how does the fertiliser production process affect the quality of the water and of the soil in those production areas? How are the local communities benefiting?

With the International Sustainability Standards Board having been established in November 2021 (with offices in Frankfurt and in Montreal), we are now in an era of looking beyond profit, at natural capital, human capital and social capital, and how they can be integrated into how we look at our economy. We are trying to move towards what I would call a stewardship economy, where we are all contributing to the betterment of humanity and nature. We want to know how our accounting systems can help us move forward. That's important not only for private sector but also for government procurement around the world, in terms of how we collectively can contribute to growing green economies.

These are the trade-offs we need to look at. This is really about data-driven decision making, and it's about how we can look at the true cost of everything we are doing, in terms of its effect on natural capital and human capital and social capital.

This is innovative thinking that is going to be evolving, and there are mechanisms and consultations happening at government level, at private sector and at micro- and small enterprise levels around the world, to make sure that we can do this. It's not going to be perfect, but it's looking at how we can move forward in a way that will allow us to do a much better job in our accounting systems to be bringing all of these elements together.

Q: Sibjan Chaulagain, a Crawford Fund scholar at the Australian National University
Thank you for these two amazing days and inspiring sessions. I am here from Nepal on a generous scholarship provided by Australian Government, and I thank Australia for giving me this

opportunity. During my study at ANU and through events like this I now feel that I have a wealth of knowledge, skills and networks, and when I return to Nepal next year I want to be able to use these resources for international activities and development.

For people like us who are going back home with knowledge and networks, how can we communicate with institutions like ACIAR or DFAT (Dept of Foreign Affairs and Trade) or the Crawford Fund to get this momentum going and create partnerships, so that you also feel that it is useful to have somebody you have trained in Australia to cooperate in the agricultural research and development?

Moderator: John Anderson

Thank you. It's a good question. How do people who want to build careers make contact with the right people in the right organisations? I'd imagine some are more accessible than others. Wendy, do you have a view?

Wendy Umberger

ACIAR's alumni network, whether it's via Australian awards or a John Allwright Fellowship, is actually I think one of our best assets. We put funds into development working with our friends in the countries you go back to. We are improving that alumni network and doing more regular communication. For Nepal, I think we have communication with someone in your country with whom we can keep the alumni network going. For ACIAR, staying involved with our alumni is very important. We will continue to bring you into events, as also will the Australian embassy. You are a huge asset and a friend for the future, and communicating with you will be a good way for our countries to continue work together.

Moderator: John Anderson

Many of you should have been able to build a relationship with your mentors as well, and those mentors will have their own networks that will be useful for you in the future. If not, come to me and tell me your mentor was no good!

Q: Maria Ortiz, Tasmanian Farm Innovation Hub, and a Crawford Fund scholar

With the increased amounts of animal protein and changes in human movements driven by climate change, what is the role of policy in ensuring disease control, surveillance and monitoring while maintaining global trade and food security?

Kym Anderson

You are asking how do we control disease spread globally. Globalisation of course increases that risk. We have seen that happen with avian flu and swine flu, as well as the Hendra virus in horses. This is a reality of globalisation: ships moving around, aeroplanes fly us around, and they and we can carry diseases from one country to another. We need to have good biosecurity. Every country needs that. Australia puts a lot of effort into biosecurity elsewhere through training people in neighbouring countries, because we have an interest in them excluding foreign diseases too.
I think this is something that's done globally; for instance, the Americans, New Zealanders and others also train biosecurity staff in developing countries. Those policies are very important, so we need good bureaucrats in that area of work to make sure that we do the best we can to minimise that negative effect of globalisation.

If you think a long way back, Aboriginal people suffered in Australia from Europeans arriving here a couple of hundred years ago, and similar human diseases spread across the North Atlantic. But globalisation brings other good things: it introduced potatoes and tomatoes to the world from their original sources, and in the other direction there has been poverty reduction and increased food and nutrition security. We have to trade off the positives and negatives. There are negatives, but they're tiny compared with the positives.

Moderator: John Anderson

Thank you very much to our four panellists. We have gained real value from them, and please all show our appreciation in the usual Aussie way.

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Bios of the four panellists

Éliane Ubalijoro, PhD, is Chief Executive Officer of the Center for International Forestry Research and World Agroforestry (CIFOR-ICRAF) and Director General of ICRAF. An accomplished leader with a background in agriculture and molecular genetics, she serves on several boards and has been recognised for outstanding contributions in the areas of innovation, gender equity, and sustainable prosperity creation.
Dr Ubalijoro has been a professor of practice for public–private sector partnerships at McGill University since 2008, with research interests focusing on innovation, gender and sustainable development for prosperity creation. From 2021 to March 2023, she was the Executive Director of Sustainability in the Digital Age and the Canada Hub Director for Future Earth. She is a member of Rwanda's National Science and Technology Council and Presidential Advisory Council, the Impact Advisory Board of the Global Alliance for a Sustainable Planet, the Science for Africa Foundation, and the Capitals Coalition Supervisory Board, among others. She is a fellow of the International Science Council. Recognised for her work in leadership and gender equity, Dr Ubalijoro is a recipient of the International Leadership Association's 2022 awards in women and leadership for outstanding practice with broad impact, and is part of a cohort of appointed International Science Council fellows in recognition for outstanding contributions to promoting science as a global public good. She has facilitated the UNAIDS Leadership Programme for Women at the United Nation System Staff College. Dr Ubalijoro was a member of FemStep, a research network highlighting rural girls' and women's perspectives for engendering poverty reduction strategies in Rwanda, South Africa, Tanzania, DR Congo and Ethiopia using arts-based methodologies. Her career path was featured in Forbes in celebration of International Women's Day 2019.

Dr Cary Fowler is perhaps best known as the 'father' of the Svalbard Global Seed Vault, which UN Secretary General Ban Ki-Moon described as an "inspirational symbol of peace and food security for the entire humanity". This facility provides ultimate security for more than 1 million unique crop varieties, the biological foundation of agriculture and the raw material for all future plant breeding and crop improvement efforts. Dr Fowler is the former Executive Director of the Global Crop Diversity Trust, an international organisation co-sponsored by the Food and Agriculture Organization of the UN (FAO) and the Consultative Group on International Agricultural Research (CGIAR). Prior to leading the Crop Trust, he was a Professor at the Norwegian University of Life Sciences, and a senior staff member of Bioversity International. Earlier, he oversaw the UN's first global assessment of the State of the World's

Plant Genetic Resources. He was responsible for drafting and negotiating the first FAO Global Plan of Action on the Conservation and Sustainable Utilization of Plant Genetic Resources, formally adopted by 150 countries in 1996. Following this, Dr Fowler twice served as Special Assistant to the Secretary General of the World Food Summit and represented the CGIAR in the multi-year negotiations on the International Treaty on Plant Genetic Resources.
In 2015, Dr Fowler was appointed to the Board for International Food and Agricultural Development by President Obama. He is a former board member of the International Maize and Wheat Improvement Center, and former Chair of the Livestock Conservancy.
Dr Fowler has been recognised with several honorary doctorates and many awards including the Thomas Jefferson Award for Citizen Leadership, the Heinz Award, the Meyer Medal from the Crop Science Society of America, the Wm. Brown Award from the Missouri Botanical Garden, and the Proctor Medal from the Garden Clubs of America.

Professor Wendy Umberger is the new CEO of ACIAR. Previously, she was the President of Australia's Policy Advisory Council (for International Agricultural Research and Development) and an Honorary Professorial Fellow in the School of Agriculture and Food at the University of Melbourne. She is an expert in agricultural economics and development and food policy. She has worked on food system issues across the Indo-Pacific region and led interdisciplinary value chain research projects in Asia, Australia, North America, the Pacific Islands and South Africa. Her research has explored opportunities for agricultural smallholder households in producing high value (horticulture, dairy, beef) food products and adopting new technology to gain access to modern food value chains.
From 2013 to 2022 she was the Foundation Executive Director at the Centre for Global Food and Resources at the University of Adelaide and a Professor in the School of Economics and Public Policy. She served on the Board of Trustees of the International Crops Research Institute for Semi-Arid Tropics (ICRISAT) from 2015 to 2021. She is also an Independent Director of Grain Producers South Australia (GPSA), a Director of the International Association of Agricultural Economists, a board member of Food Bank SA, an Honorary Fellow of Food Standards Australia New Zealand, and a Distinguished Fellow of the Australasian Agricultural and Resource Economics Society. Wendy has a B.S. in Animal Science (1996) and M.S. in Economics (1998) from South Dakota State University and PhD in Agricultural Economics (2001) from the University of Nebraska-Lincoln.

Emeritus Professor Kym Anderson AC FAAEA FASSA DFAARES DFESA has contributed to economic development in the overlapping fields of international trade and political economy, with a strong focus on agriculture and products of importance to developing economies. His work and outputs, prodigious and varied, have been widely recognised for their quality and significance, in Australia and abroad, including by leading international agencies. Kym is the George Gollin Professor Emeritus in the School of Economics and Public Policy and formerly foundation Executive Director of the Centre for International Economic Studies at the University of Adelaide, where he has been affiliated since 1984; and he is an Honorary Professor at the Australian National University's Arndt-Corden Department of Economics where he was a Research Fellow during 1977–1983 and a part-time Professor of Economics during 2012–2018. He has held senior research leadership positions at the World Trade Organization and the World Bank; and a large number of significant research advisory positions, including in Australia. He is highly respected internationally for his knowledge, understanding and leadership, with an excellent citation rate that indicates his international leadership in agricultural economics. Kym has also played major roles on the ACIAR Commission and Policy Advisory Council and has chaired the Boards of the International Food Policy Research Institute (IFPRI) and the International Centre of Insect Physiology and Ecology (ICIPE).

SUMMING UP AND THE WAY FORWARD

Dr Colin Chartres

Chief Executive Officer, The Crawford Fund

Thank you to all the speakers, and the panellists in that last session and to John Anderson. The conversation was a great discussion, and I have also enjoyed every single talk we have heard today. They have been highly educational and really informative, and I think all of us have been kept very interested.

All the way through, this conference has been about managing risks in a very confronting world.

At the Crawford Fund we give a lot of thought to how we want to steer the ship through the sort of seas that we are negotiating. We highlighted the three Cs to the speakers (**c**limate change, **c**onflict and **C**OVID-19); John mentioned them in his introduction, and other speakers have discussed climate change and conflict.

Our speakers have demonstrated that risk comes in all forms: some biophysical, but many others being off-farm issues associated with trade and markets, geopolitics and national policies.

There is a complex spectrum of issues and risks often confronting poor smallholder farmers as well as the larger farmers and farming enterprises. Our speakers today have comprehensively identified a wide range of these risks and a number of really good potential responses to them.

One additional thing that I particularly want to highlight is something that was brought home to me in what we called our Fiji Pacific Dialogue in Fiji three months ago.

Right at the beginning of that meeting, several speakers from Pacific countries pointed out to us that they were having to deal with one risk after another, with increasing frequency. They were particularly talking about cyclones. Cyclone Winston wasn't very long ago, and there have been other cyclones subsequently, and there was the very large volcanic eruption near Tonga. They spoke quite emotionally about the impacts that these repeated and increasingly frequent risks have on communities and their psyche.

There is an overwhelming economic, social and mental burden in dealing with one disaster after another. That is something that we, elsewhere, don't always appreciate, and it's very hard to deal with when you're in that kind of situation. It grinds the community down and saps their resilience, because no sooner have you clawed your way out of trouble from one issue, something else bad happens.

My fear is that as the impacts of climate change deepen and become more pervasive and frequent, many more agricultural communities will be faced with situations our Pacific cousins are

already dealing with. We saw a slide today showing the whole southern part of the Mekong Delta going a metre underwater. If that comes to pass, it is going to be a tremendously difficult thing to deal with because there are millions of people living in that that region.

Farmers in all countries and of all sizes, from smallholders to large commercial operations, are coming increasingly 'under the hammer' having to deal with these risks, while at the same time agriculture is being identified as a significant contributor to one of the most critical risks: namely, climate change. We can argue about the figure, but approximately 20–25% of global greenhouse gas emissions come from agriculture, in terms of fossil fuel use, fertiliser use and a range of in-field chemical processes that contribute to greenhouse gas emissions, including nitrification and also methane from cows. That does not include the loss of natural habitats and rainforests from ongoing land-clearing to feed our insatiable appetite for food.

While the latter requires strong action to limit and prevent further damage, I fear that in this day and age we all too easily fall into a 'them and us' blame-game over greenhouse gas emissions from agriculture.

The emissions occur because we, the consumers, want the food that is produced by the farmers; and so we are as much a part of the problem as are the farmers who do the production. We need to work very closely with farmers to encourage and incentivise production practices that maximise production of healthy food and that minimise climate change impacts.

We must also include the consumers, retailers and the entire market chain and businesses providing inputs to agriculture, when looking for solutions that mitigate or lead to adaptation to risk. To achieve this harmonisation, we need appropriate policies, trade practices and better educated consumers, not to mention institutions that support and encourage change. I am heartened, therefore, to see organisations like Farmers for Climate Action and the National Farmers Federation support for zero emissions by 2050. But we need more, and we need to totally de-politicise this debate if we are going to have success.

Today's key points

I now want to come to some of the key points made today. It is quite difficult when you are trying to summarise a conference, because everyone goes away with a different 'take' on what they have heard. I have tried to come up with very short phrases that illustrate what I got out of the various talks, and I'll mention these as I go through this summary.

From Cary Fowler's talk I've got two words: 'moon shots'. He used that phrase during his talk, and it was a really salient point, I thought, in that we need to be spending big if we are going to tackle some of these big problems, and we need politicians to lead these challenges. Just as John Anderson said earlier, we need to be investing significantly in agriculture in Australia because that's what we do well.

I was also terrified by the 533 consecutive months of above average temperatures. It brings that climate statistic home to roost.

I was also worried by the fact that we are still trying to deal with poor infertile soils. I remember talking to Pedro Sanchez probably 30 years ago (he was the World Food Prize Laureate in 2002) and he was talking then about the capital decline in the soil fertility base in Africa. It is something we are still facing today, and something that we need to do more about.

Adapted crops are a great idea. I just hope that they get given names that make them appealing. (As I might have said before, on a visit to the World Vegetable Center I remember being shown and talked to about a vegetable they called 'slippery cabbage'! I think we need to use much more attractive names to persuade people to widen the diversity of their diets.)

In Wendy Umberger's talk she spoke about how smallholders have less capacity to mitigate risks. That resonates with my comment above about Fiji. The key question I think Wendy raised is, how do we use all these technologies and knowledge to help smallholders overcome some of these issues?

Wendy also brought home to me the fact that in the pre-conference materials we talked about on-farm and off-farm risks, but really, I have learned today, it's one solid continuum of risk. We cannot easily differentiate between those two types of risk, although we may have to do that when we break them down to manage them.

Turning to Kym Anderson's talk, I am going to be politically 'risque' here and say that Kym put the thought into my head that multilateralism must defeat populism. By that, I mean that I think we are not going to effectively globally tackle some of the issues of food security and climate change unless we involve some of the existing multilateral institutions.

We know there is a lot of antipathy towards many of these institutions: people ask why we give money to the United Nations, etcetera, etcetera. In my experience of working with the UN and some of those organisations, they have been doing some really great work – the CGIAR in particular. (However, I have a vested interest there because I was a Director General of a CGIAR center for some years.)

Kym really stressed the importance of policy uncertainty, as well as other uncertainties, increasing. He emphasised that various markets can really help us solve some of the issues around natural capital, such as carbon, water, ecosystem services. And I tend to agree with that, although getting these concepts adopted in some overseas countries is going to be a slow process. It will need a lot of thought and a lot of discussion and a lot of education about how they can, and do, work in some cases, though not all. Kym also highlighted the need to focus on policy change.

In his short talk, Professor Jamie Pittock pointed out something very close to my heart – that we need to couple technical and social innovation. One without the other will not generally work, because we need to involve people in all these solutions.

Professor Siddique emphasised a point that Cary Fowler had made, about diversification of cropping, and developing under-utilised crops. I learned some very useful things from his talk; for instance, I didn't know that teff is part of the millet family. Professor Siddique pointed out (as later did Dr Lee) that, if used effectively, some of these under-utilised crops can increase the macro-nutrient and micronutrient content of people's food while also delivering environmental benefits.

We have heard in the past from Andrew Campbell about how impressed he was with the way soldier fly larvae in Africa use up waste. Today, that was the topic of another great talk, from Dr Fathiya Khamis.

The two talks from industry bodies pointed out how industry is trying to adapt its products. Dr Roya Khalil spoke about reducing nitrification in fertilisers, so as to reduce fertilisers' environmental effects. And Ben Fargher said there is 'common ground' – those are the two words

I took out of that talk – that is, common ground between big business and some of the issues that we are trying to solve in terms of food security. The private sector, Ben said, has vested interest in a resilient and sustainable agricultural supply chain, which is in everyone's best interests.

I think common ground is very important and something we need to be looking for, between everyone involved in finding the wide number of opportunities in agri-food systems, as Dr Warren Lee discussed, and in developing solutions.

In conclusion

That is my overview of some highlights and takeaway points for me from today. I want to conclude by offering a challenge to some of the younger people in the room.

I thought I had retired about ten years ago when I left the International Water Management Institute, but then I was drawn in by the Crawford Fund – a move I did not resist and have truly enjoyed. I will be retiring from the Fund in the next six months, so this is the last conference I will have helped organise.

Reflecting briefly about what the agricultural landscape was like around 40 to 50 years ago when I started my career, the Green Revolution was well underway; the emphasis was still on development and on producing enough calories to feed a growing global population. We did that, really well, but in some ways, in terms of greenhouse gas emissions and monocultures and loss of biodiversity, we are now dealing with the impacts of the Green Revolution.

While some people still go to bed hungry, that is mainly due to poor distribution and access to food, not to a total global scarcity. We are also now dealing with an epidemic of over-nutrition and consequent non-communicable disease burdens which were much less common 30 or 40 years ago, so the situation has changed quite dramatically. We are now looking at things like sustainable intensification to reduce the amount of land used in agriculture, to reduce water demand, reduce greenhouse gases; innovation in fertiliser production and use; crop diversification; and the criticality of nutrition as opposed to calories dominates our thinking. The challenges have changed, but in my view they are just as profound as they were 50 years ago.

As I may have mentioned in other conferences, the vice-president of the Asian Development Bank in about 2007 or 2008 told me that agriculture was a sunset industry and not of much interest to them. I was horrified. Then the global food crisis and the global financial crisis hit, accompanied by food scarcity and food riots. The bank, having got rid of a number of agronomists and engineers involved in water and food production, rapidly had to reappoint people!

That illustrates that food and water issues are not going to go away for quite some time, even if population growth rates are slowing – as John Anderson says. That will be a good thing in terms of the environment and food supply, but it may cause difficulties in terms of other social aspects and issues.

However, now that our conferences are attended by many members of the RAID network, and now that the average age of the people here has gone from perhaps 60 to 40 or even less, I'm retiring with the considerable hope that these challenges of the next 40 to 50 years will be very successfully met!

Acknowledgements

I am very happy to thank our highly valued sponsors, who are listed on the website and in these conference Proceedings (pages v–vi). Many of the sponsors have provided speakers. Many of them also collaborate with us throughout the year in other projects and enterprises.

I am indebted to our speakers, several of whom have travelled a long way to be here. I would like to thank our Chairs who have kept the day's program moving so well. I also thank our Keynote Listeners who always provide such a good report on the outcomes of the conference.

A good conference with a good flow on a good topic doesn't happen by simply picking something out of the air. Usually, a few weeks after the annual conference, we set up next year's planning committee and begin working through potential topics and speakers.

Cathy Reade then does her usual sterling job, cajoling and marshalling all the speakers and getting them here and dealing with all the facilities. Without Cathy we would be truly lost, I think, in getting such a good conference together. Thank you, Cathy!

I also thank the conference planning team. It is led by Tony Gregson and includes Dan Walker, Jessica Fearnley, Tim Reeves, Tristan Armstrong, Gabrielle Vivian-Smith and Shaun Coffey and myself.

To make the conference run smoothly we have a behind-the-scenes team and that team includes Sarah Paradice, Bronwyn Refshauge, Larissa Mullot and Sue Faulkner, and of course the Conference Solutions team who deal with registrations and organise the facilities.

Finally, I'd like to thank two more groups of people. First, all of you, for coming and being such a good audience, being so attentive and asking such good questions. And also, our Board, who have an important role helping us with policies and strategies, and all of whom do that pro-bono. They give up their time to meet and solve issues and help steer the Fund's growth and move it forward. That work complements the work of a very large number of *other* individuals who provide mentoring services and help in all sorts of other ways, pro-bono. From a back-of-envelope sum a couple of years ago I know that while our budget is relatively small, about $1.7 million a year or something like that, we often may get up to another million dollars-worth of input, pro-bono, from all that help. So, thank you to all the volunteers who help the Crawford Fund!

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

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Acronyms

ACIAR	Australian Centre for International Agricultural Research
ACT	Australian Capital Territory
CABI	Centre for Agriculture and Bioscience International
CIFOR	Center for International Forestry Research
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAFF	Australian Government Dept of Agriculture, Fisheries and Forestry
DFAT	Australian Government Dept of Foreign Affairs and Trade
GRDC	Grains Research and Development Corporation
ICRAF	International Centre for Research in Agroforestry (or World Agroforestry)
NSW	New South Wales
QAAFI	The Queensland Alliance for Agriculture and Food Innovation
RAID	Researchers in Agriculture for International Development

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