THE CRAWFORD FUND

For a Food Secure World

WASTE NOT, WANT NOT

The circular economy to food security

The Crawford Fund

2016 Annual Conference

Canberra ACT, Australia

29–30 August 2016

Editor: A. Milligan

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The Australian Academy of Technological Sciences and Engineering established the Crawford Fund in June 1987. Named in honour of the late Sir John Crawford, the Fund commemorates his outstanding services to international agricultural research. The Crawford Fund is a non-profit, non-government organisation, dedicated to raising awareness of the benefits to developing countries and to Australia of international agricultural research. The Fund depends on grants and donations from governments, private companies, corporations, charitable trusts and individual Australians. It also welcomes partnerships with agencies and organisations in Australia and overseas.

The Fund promotes and supports international R&D activities in which Australian research organisations and companies are active participants. It supports the work of the Australian Government's aid program, particularly with the Australian Centre for International Agricultural Research (ACIAR), CGIAR and other international research centres.

The annual conference is a key part of the Fund's public awareness campaign, which increases understanding of the importance and potential of international agricultural research, its achievements and needs.

The Fund also runs training programs that fill a niche by offering practical, highly focused non-degree instruction to women and men engaged in agricultural research and management in developing countries.

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Contents

Acknowledgements

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Member Grains Research & Development Corp. Board and Crawford Fund Board

The Hon. Margaret Reid AO (Lunchtime discussion session)
Chair, Crawford Fund ACT Committee

Ms Jo Evans (Sessions 4 & 5)
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Foreword

As the first Chair of its Board, Sir John Crawford asked the International Food Policy Research Institute (IFPRI) to translate complex scientific and economic findings into language comprehensible to policy makers and the broader community. He directed his request to an elite group of scientists and policy makers, and I am pleased to see that Dr Karen Brooks of IFPRI, Director of the CGIAR Research Program on Policies, Institutions and Markets, is delivering the first keynote of this year's conference.

Sir John was also aware that policy is formulated in a political context. He keenly tested the practicality of new approaches more broadly, including among illiterate farming communities in India whom he encountered in his landmark work as part of a World Bank Mission there in 1966. His contribution to the 1966 mission was pivotal to India's progress to the Green Revolution.

Informing policy makers and the broader community on the contributions that international agricultural research, training and development can make to a food secure world is the central aim of the Crawford Fund's public awareness program and the key purpose of its annual conference. Our topics are selected accordingly.

There is, of course, no single pathway to global food security, but instead an array of opportunities: new higher yielding and more resilient technologies and farming practices; enhanced trade through better biosecurity; reduction in food losses and waste; and more. For food loss and waste, our topic this year, we have again assembled a panel of world's best speakers, from Australia and internationally, addressing issues along the food supply chain. I take this opportunity to thank them all for their energy and interest in this important food security issue and for taking the time to be with us today.

Australia continues the tradition set by Sir John of taking a lead in pathways to global food security – through the Australian Centre for International Agricultural Research and the many Australians engaged in agricultural research and training for development. We have a number of them here at this conference, to highlight Australian innovation in food loss and waste.

A recent OECD meeting records that 'Australia was out in front on open market approaches along with the US [and that] the proposed Australian National Food Waste 2025 Strategy was also introduced, along with the concept of tying food waste to the Emissions Reduction Fund to encourage food waste recovery'. Other issues taken forward by the OECD, and at this year's conference, include the concept of a circular food economy; measuring loss and waste – recognised by the G20 technical platform on food loss and waste as the next goal to be achieved so that further progress can be made; and how costs might be offset by benefits to managing food loss and waste to farmers, retailers and consumers: another way of expressing 'doing well by doing good'.

All of this is a difficult task to harmonise globally. We invite you to join the effort.

We and our collaborators have supported 48 young Australians to attend this year's conference. They have shown their interest and passion around food loss and waste, or food security more generally, and hope to engage with delegates today. We need young people to take up the mantle to address food security through research, training, volunteering and advanced careers.

The Crawford Fund wishes to thank the sponsors and supporters of this year's conference. They are many, and are much appreciated for supporting the conference and our burgeoning young scholars program. All are listed in this proceedings.

Hon. John Kerin AM
Chairman, The Crawford Fund

Letter from the Minister for Foreign Affairs

THE HON JULIE BISHOP MP

Minister for Foreign Affairs

The Hon Margaret Reid AO
Crawford Fund Board of Directors
Wetlands House
1 Dairy Road
FYSHWICK ACT 2609

Dear Margaret

The Crawford Conference is an important event on the international development calendar and this year's Conference focuses on one of the critical food challenges for the global community – food loss and waste.

The importance of this challenge is recognised in the new Sustainable Development Goals. These include broad goals on poverty and hunger and also a specific target to significantly reduce food loss and waste. Achieving this ambitious target would boost food security and improve livelihoods, as well as lead to more sustainable resource use and reduced greenhouse gas emissions.

The Food and Agriculture Organisation estimates that US$750 billion worth of food is lost or wasted every year. This is more than five times the US$132 billion worth of Official Development Assistance provided by OECD donor countries annually.

Development assistance is dwarfed by the size of this challenge, but well targeted aid programs in agriculture have a vital role to play in finding and enabling solutions. Seventy per cent of the world's extreme poor are engaged in the agriculture sector and it is a key source of jobs, incomes and exports for many developing countries. It is also a key driver of economic growth, poverty reduction and enhanced stability. This is why I included 'Agriculture, fisheries and water' as one of the six priority areas of Australia's development policy.

Australian aid investments in agriculture are designed to be innovative and to play a catalytic role, particularly through leveraging private sector partnerships, investment and know-how. Our aid helps to strengthen markets and reduce food loss and waste at various points along the value chain – including addressing constraints and inefficiencies related to harvesting techniques, storage, transportation, infrastructure, packaging and marketing. For example, Australia has been a key driver and funder behind the innovative AgResults program (which we currently chair). Later today, you will hear more about one of

the AgResults pilots, which is finding cost-effective private sector solutions to improve post-harvest grain storage for poor farmers in Kenya.

Australia's tough farming environment and long-standing tradition of research and innovation have forged world-class agricultural expertise, which is well-represented at this Crawford Fund conference. Australia has also built partnerships with experts across the globe and I trust many of them are also in attendance.

I would like to acknowledge the important role ACIAR plays in harnessing innovation through agricultural research partnerships. ACIAR is recognised as a global leader in developing and delivering effective agricultural research partnerships in developing countries. It extensively uses Australian research capability to target important development challenges, including food loss and waste. For example, ACIAR is working with a producers' cooperative in Pakistan to improve the quality and shelf-life of locally-grown mangoes through better post-harvest management. This reduces food losses and boosts incomes for poor farmers.

The Government also recognises the vital importance of attracting and nurturing future generations of agricultural development practitioners. I know there are many students in the audience today, including New Colombo Plan students. The New Colombo Plan (which I launched in late 2013) provides a great opportunity for them to benefit from in-country experience as part of their studies. I am delighted these scholars have recognised the value of focusing on the agriculture sector and are in attendance.

Finally, I express my appreciation to the Crawford Fund for your continuing role in raising awareness of research and policy challenges in agriculture and for creating platforms such as this annual conference to bring together experts and practitioners from around the globe to find solutions.

I wish you well with the conference and look forward to its ongoing impacts.

Yours sincerely

Julie Bishop

30 AUG 2016

Waste not, warm not: poverty, hunger and climate change in a circular food system

Dr Karen Brooks

CGIAR Research Program on Policies, Institutions and Markets,
International Food Policy Research Institute (IFPRI)

ABSTRACT: Reduction of food loss and waste has received increased attention in recent years. Several spikes in food prices since 2008 have highlighted the hardship that poor people, and especially poor children, face when food is priced out of their reach. With as many as 800 million people still undernourished, of whom about 160 million are stunted young children, the fact that as much as 30% of food is lost or wasted appears unconscionable. Surely the loss could be recovered and channelled towards the hungry! Much of the discussion of food loss and waste has been predicated on this assumption, with the related conclusion that better management and distribution of existing supplies could substitute for investment in increased productive capacity. The assumption is in part borne out by empirical evidence but, as is often the case, the full picture is more complex. Moreover, discussion of food loss and waste in terms of feeding the hungry misses the environmental benefits associated with better management of existing production. Food systems that lose and waste less will generate fewer greenhouse gases and contribute less to global warming. The economics of reduced loss and waste creates both winners and losers, but the environmental calculus has only winners. The policy and institutional arrangements of food systems that generate less loss and waste would look quite different from our present systems.

Keywords: food loss and waste, feed the hungry, waste and gas emissions

Thank you to the Crawford Fund for defining this year's conference topic as food loss and waste, and for giving me a chance to talk with you about it.

One of my main messages is that addressing food loss and waste should be an integral part of any strategy for green growth. It is very important for food security: it increases the amount of food available for consumptive use. It is very important for consumer welfare: having less loss and waste reduces consumer prices, makes food more affordable and improves consumer incomes. It is also very important for reducing the environmental footprint of agriculture – a key factor in tackling climate change and promoting sustainable use of resources. For all those reasons, it is very important to address the very large levels of food loss and waste.

We often think about these issues in the context of global hunger, either with regard to Sustainable Development Goals or with regard to the question of how we feed the population that we expect to have in 2050. Often it is argued that if

This is an edited transcript of the presentation, with some of the powerpoint slides shown.

we could reduce loss and waste we would not need to produce all this extra food. We would be able to solve global hunger and we would be able to feed the growing population.

Instead, I would argue that while reducing loss and waste is definitely part of the solution, it is not the *whole* solution because, whether the hunger is local or global, there need to be companion measures to ensure that hungry people have access to food. It is not just a question of the quantity and the availability of food, but also a question of access.

There may be too much food in this refrigerator for a small household to eat before some must be thrown out.

A separate factor is individuals' management of food waste. The photo here of my own refrigerator shows that my household is definitely part of the problem, not yet part of the solution. Other people I know, however, regularly eat all the food in their refrigerators rather than leaving it there too long and then carrying it out as trash. Clearly we have differing levels of optimal food waste – and that is part of the issue we are addressing here.

In fact, the generation of food loss and waste is the result of millions of optimisation decisions that economic agents take. Our challenge is to figure out how we can shift their incentives. How do we shift that decision calculus so that people will make different choices?

Food prices

Attention to food loss and waste tends to track closely the movement of global food prices. Professor Louise Fresco in her Sir John Crawford Memorial Address last evening* told us that Sir John was interested in this topic in the 1940s. Those years were not a period of high food prices, so he was ahead of his time.

As an example, look at the price of rice in Thailand through the years 1900–2012 (Figure 1). We know that there was a spike in food prices and interest in loss and waste at the time when the prices went up in the early 1970s. After that, there was a period where people did not really pay much attention to loss and waste. Concern rose again in the 2008–09 price spikes and then again in 2011 and 2012.

During periods when prices are relatively low we should be very concerned about food loss and waste, because it is then that waste actually goes up. In fact, we should be concerned at all times – whether prices are high or whether prices are low. It is an important topic.

Measuring food waste

We should know how much food is being wasted. We can expect to hear a range of numbers in the course of this conference – and that is correct. We cannot know exactly what the amounts are, and in fact there are no exact

*not included in these Proceedings.

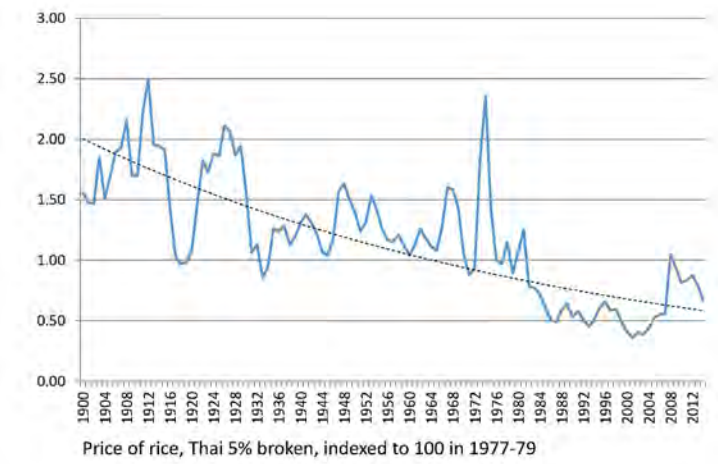


Figure 1. Attention to food loss and waste tracks spikes in prices.

amounts. Food waste depends on context and on measurement approaches and methodologies. It depends on the type of food and the commodity that is being looked at.

Through a very comprehensive literature search, a colleague of mine, Mark Rosegrant, found a wide range of measurements across the many references to food loss and waste, as shown in Figure 2. Amounts tended to be relatively large and narrowly ranging for animal products. For grains and for fruit and vegetables the measurements were also high but ranged much more widely.

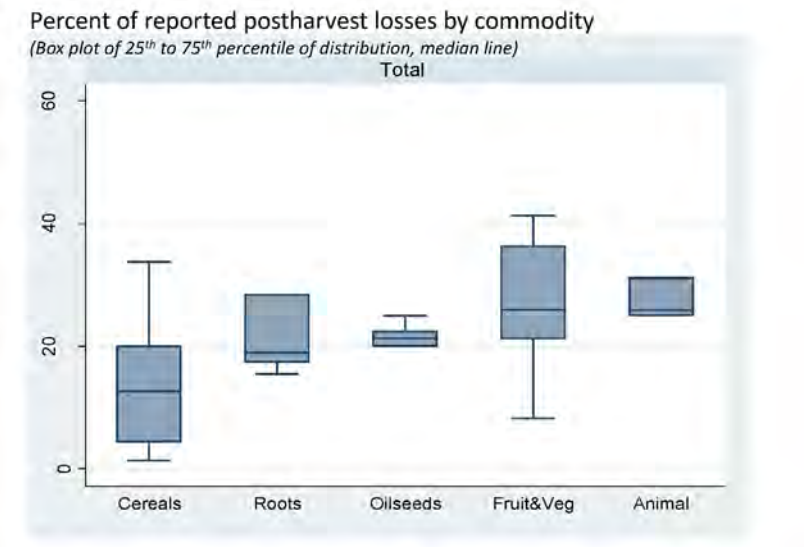


Figure 2. Measures of postharvest losses vary widely. *Source*: Rosegrant *et al.* (2015).

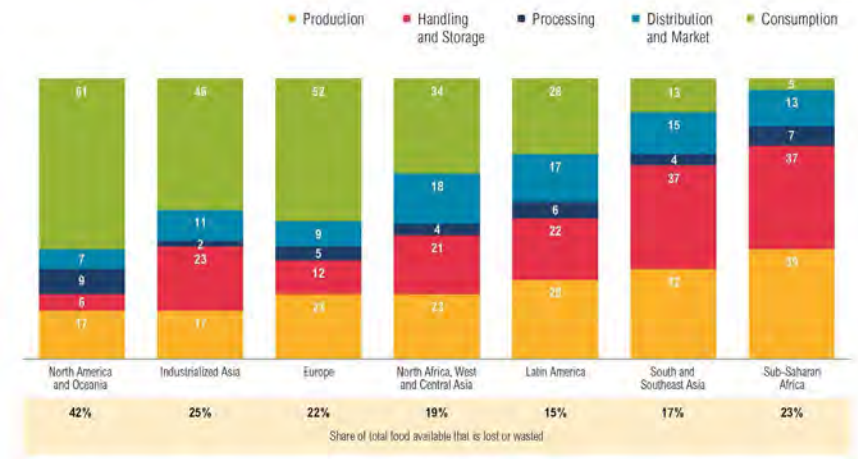


Figure 3. Food loss and waste occurs more 'near the fork' in developed regions and more 'near the farm' in developing regions (as a percentage of kcal lost and wasted). *Source*: World Resources Institute (based on FAO 2011). Numbers may not sum to 100 because of rounding.

We could think about the measurements in another way: by region. The bar chart (Figure 3) shows that North America and Oceania – where I and many of you live – are big losers and wasters, and that much of that loss and waste takes place at the consumer level, close to the fork. By comparison, in South Asia and Latin America, percentage loss and waste is relatively smaller but still significant (values in the pink horizontal bar). Percentage loss and waste in Africa south of the Sahara is intermediate and occurs mostly close to the farm. This gives us an understanding of the global distribution of loss and waste, and a little bit of understanding of the distribution along the value chain.

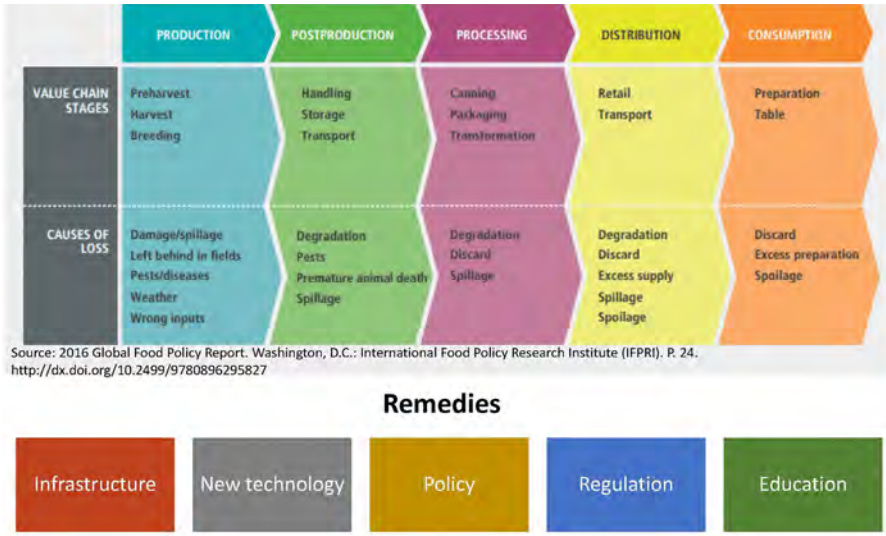


Figure 4. Diagnosing why loss and waste happen, and where along the value chain, can help in choosing appropriate remedies. *Source*: IFPRI (2016) page 24.

When we look at food loss and waste across the value chain itself (Figure 4), we see that at different stages of the value chain there are different mechanisms causing loss. Once we understand those, we can see that there are different remedies for addressing loss and waste. We need to know the quantities, and where the loss and waste are happening, before we can calibrate interventions and remedies appropriately to address the issues.

Can reducing loss and waste address global hunger?

The global map (Figure 5) shows the Global Hunger Index that IFPRI and other colleagues produce on an annual basis. It shows areas where many people experience severe hunger (the pale and deep orange on the map). Yet in the places where loss and waste are high, that is North America and Oceania, few people have deep hunger. In areas where loss and waste are moderate or relatively low, there are low-income populations and high levels of hunger. It is clear, from this very simple geographic distribution, that there is not a good correlation between where loss and waste of food are greatest and the hunger is greatest. That is something to consider as we ponder how to reduce loss and waste to address hunger.

Productivity shock. Who benefits?

Productivity shock is a sudden boost in food production. My very esteemed agricultural economist colleague from Australia, Will Martin, now at IFPRI, has been considering what would happen if we suddenly had more food for a given bundle of inputs. Focusing particularly on the implications for poverty, he asked 'What would be the distributional impact of that? Who would gain and who would lose and by how much?' (Figure 6).

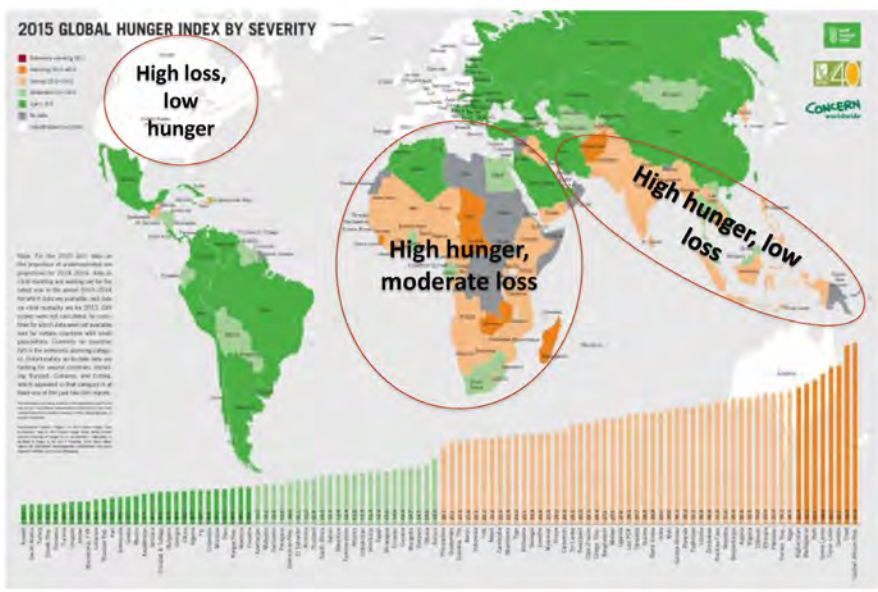
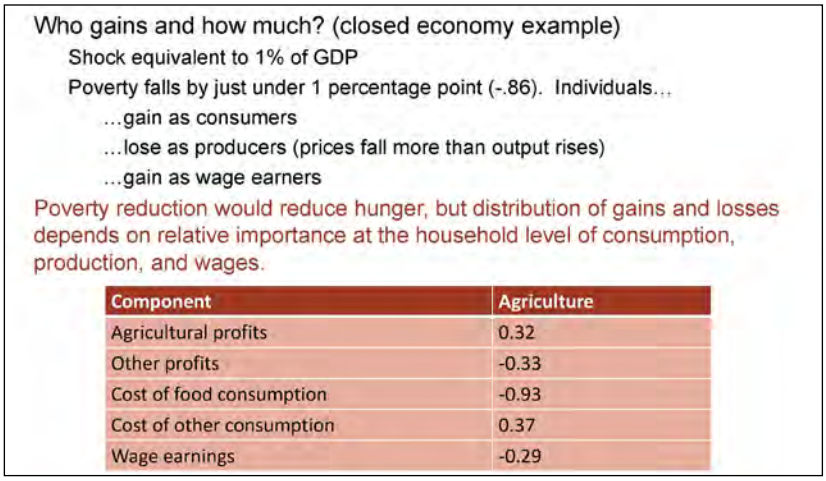


Figure 5. Global hunger mapped against areas of the world where food losses are large.



Component	Agriculture
Agricultural profits	0.32
Other profits	-0.33
Cost of food consumption	-0.93
Cost of other consumption	0.37
Wage earnings	-0.29

Figure 6. Considering reduction of loss and waste as equivalent to productivity shock, a one-time boost to agricultural productivity. *Source*: Ivanic & Martin (2014).

If we were able to substantially reduce loss and waste, the effect would be the same as a productivity shock. We would get an additional amount of food for the same agricultural input. If we then go through a global general-equilibrium assessment of who gains, who loses and by how much, we can see that there are very substantial gains. On balance, the gains are positive.

The main people who gain are consumers and wage earners, because when the food available is more affordable these people are able to buy other things in addition to food. Jobs are created. Demand for waged work goes up and so they benefit. The ones who have a more ambiguous benefit are the actual agricultural producers, the farmers. More food means that prices are going to go down, all things being equal, so farmers will not necessarily benefit from a reduction of loss and waste. This depends a bit on where the reduction takes place in the food chain.

In any case, we see that there are net gains and they are very significant and we should keep that in mind. It is a reason to aim for reductions in food loss and waste, but there are distributional issues there and some people gain more than others.

Mark Rosegrant has worked through a different exercise. Thinking about the Sustainable Development Goals and feeding the world in 2050, he asked: 'If we reduce loss and waste, *how much* does that reduce hunger?'. He recognised that of course it is not free to reduce loss and waste. We have to make investments in order to do that, mainly in infrastructure – in roads, in power and in storage capacity within the developing world. In this exercise he examined the costs of those and how much loss and waste might be reduced by making those investments in infrastructure. Is that a good investment? Does it help reduce hunger? Does it yield a good return, and how does that compare to an alternative investment in agricultural research where the amount of food is increased by enhancing agricultural productivity?

Population at Risk of Hunger in 2050

Region	Million People				% Change from baseline		
	Baseline	Reduced losses, developing world (6% by 2025)	Reduced losses, global (10% by 2030)	Faster productivity growth, no change in losses (.4% crops, .2% livestock)	Reduced losses, developing world	Reduced losses, global	Faster productivity growth, no change in losses
East Asia and Pacific	126	118	116	115	-6.3	-7.5	-8.6
Europe and Central Asia	38	37	37	37	-2.9	-3.7	-4.1
LAC	48	45	44	44	-6.0	-7.7	-8.6
MENA	38	37	36	36	-3.9	-4.9	-5.8
South Asia	162	138	134	131	-15.3	-17.6	-19.2
SS Africa	137	116	112	108	-15.8	-18.6	-21.2
Developing	509	452	442	434	-11.2	-13.1	-14.7
Developed	59	56	55	55	-4.7	-6.1	-6.9
World	568	508	497	489	-10.5	-12.4	-13.9

Figure 7. Can we feed the hungry in 2015 by reducing loss and waste? Calculations from IFPRI IMPACT Model version 3. *Source*: Rosegrant *et al.* (2015).

The results of his estimates (Figure 7) are very interesting because they show that if we simply continue doing what we are doing now – with reasonable economic growth – we will have growth in agricultural productivity. By 2050 there will be fewer people at risk of hunger in the world: about 568 million will remain at risk. That is fewer than today, but still a very large number. If we invest in infrastructure to reduce loss and waste, or invest in agricultural growth to increase the rate of productivity growth, by how much do those alternatives reduce the population at risk of hunger? For both approaches, the answer is something significant, but not actually all that big. On the bottom line of the table, the numbers go down from 568 million to a little bit over or under 500 million – roughly comparable. These approaches yield good rates of return and they tell us that it is important to do each of these things ... but that those are not enough.

To really reduce global hunger, we will have to do something more than simply reduce loss and waste, simply invest in infrastructure or simply invest in agricultural research. We have to do all those, and some other things as well.

Reducing food loss and waste also costs money. It is not free. It is not achieved simply by me opening my refrigerator and deciding I will not let all that food go to waste, and changing my consumer behaviour. Most of the investments that are required to reduce food loss and waste are rather expensive, and we have to recognise that this approach is going to cost money. Even if food prices are lower, many poorer people will still be hungry and so there need to be additional companion measures to specifically address the needs of the hungry.

What can the first world do?

Now, let us consider North America and Oceania, places where there are relatively high incomes but still there is hunger. In my own country, the United

States, we understand that approximately one in five children is at risk of hunger. It is a very high number for a very rich country. If we reduce food loss and waste in an area where we know hunger is very high in the US, what does that do for this specific population which is hungry?

The answer is: it helps. Reducing loss and waste makes a modest contribution by reducing prices and making the food stamps go further, making food more affordable. However, that approach does not solve the issue – which is, fundamentally, one of access to food supply by these hungry people. We need additional measures that take that avoided loss or waste and make it available to the populations at risk. Examples might include school feeding programs, soup kitchens, pantries. It takes special instruments and special measures to address the needs of special groups.

Summarising so far

- Although it is not part of the agenda addressed in this conference, we know now that an increase in the supply of food definitely helps consumers but does not necessarily reach hungry people. Solving the issue of hunger involves solving access to food and not just overall adequacy of food supply.
- Producers also do not necessarily gain if prices fall when food loss and waste are reduced. Producers may gain as consumers, but they do not necessarily gain as producers. This means we need to look at the distributional impact of addressing loss and waste.
- Ownership matters. The economic agent who owns the food that is not lost or wasted, the food that is saved, is the person (along with consumers) who reaps significant benefit. Therefore it is very important to understand where losses occur and where the savings can take place along the value chain.
- Investment in agricultural research remains important. Together with increased trade it should complement reduction of loss. Innovative technologies can reduce food loss and improve the storage of commodities.
- Special measures – such as safety nets, special stores or distribution centres, and food distribution channels – may be necessary for specific populations in hunger. General market measures will not be sufficient.

Warm not

This conference is not just looking at the want-not side. The conference title also mentions the circular economy – and that brings in sustainability and environmental aspects.

If we think of reducing food loss and waste as part of a strategy of green growth, then we should think of the environmental dimensions as well. These include resources that are used in agricultural production but are underpriced and not necessarily accounted for as they should be, especially water.

In a green growth strategy, we are thinking of the environmental footprint. That includes the footprint of the disposal of spoiled food, and also the greenhouse gas emissions generated both in the production of food that ultimately no-one is able to eat, and in the transportation and the marketing of those items. These are very important other dimensions of food loss and waste, quite apart from

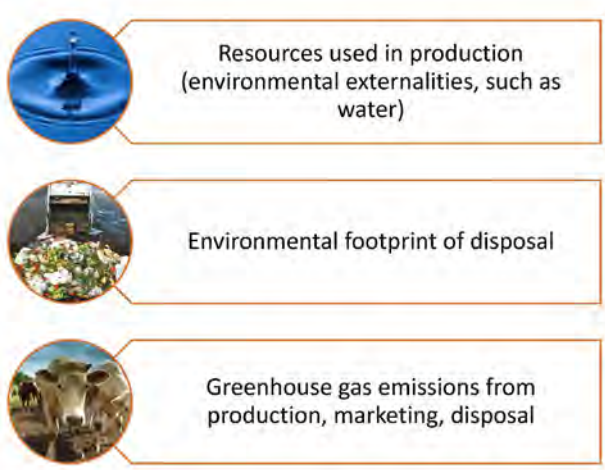


Figure 8. The circular economy focuses attention on environmental aspects of waste and loss.

hunger. I want to spend just a few minutes talking about one of those: namely, the greenhouse gas emissions.

Generation of greenhouse gases from lost and wasted foods takes place across the value chain (Figure 8). Most of the greenhouse gases associated with loss and waste result from the fact that we are not able to use all the food we produce, although there is supplementary generation of gases from landfills and from transportation.

All those resources used in the production side are generating greenhouse gases. Looking at the commodity composition where these losses are generated, we see that a lot of the generation is in the livestock sector, producing meat and dairy products. Quite a substantial proportion also comes from the fruit and vegetables sector, but, although we know that spoilage in that sector is very high, the greenhouse gases generated in the livestock sector are still greater.

We know that these amounts add up to very large quantities in the United States. One particular study (Figure 9) assessed the quantity at approximately 2% of the total generation of greenhouse gases within the United States. If we think about the overall contribution of agriculture to greenhouse gas production and then we think about the – even imperfectly – measured amounts of food that are lost and wasted, those numbers are roughly consistent. Therefore, we could say that about 2% or 3% of greenhouse gas emissions globally are associated with lost and wasted food. It is not 100% but it is a significant amount, and in considering overall strategies for green growth and for climate management we should keep this in mind. It is a relevant element in the agenda.

Summary

To be effective in our thinking about managing agricultural loss and waste, we have to think of both sides – the hunger and food security side, and the environmental side.

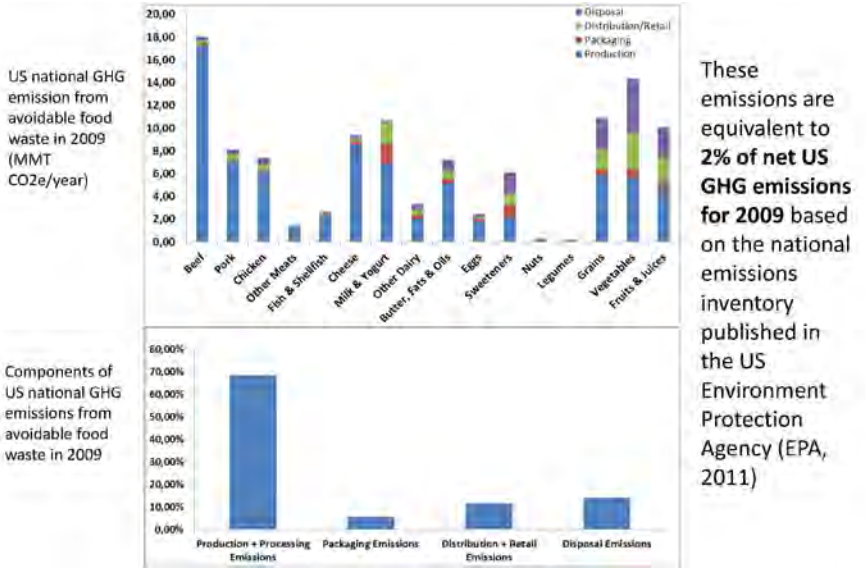


Figure 9. Greenhouse gas production in the United States. *Source*: Venkat (2011).

We need to pay sustained attention to food loss and waste, both when prices are high and when they are low. I am very pleased this conference is taking place now, when there is no price spike. We are paying attention to the issue, and that is very important.

Accepting that the want-not and the warm-not agendas really complement each other, these are the kinds of actions we should keep in mind (see also Figure 10):

- We need good measures of how much is lost, in what context, and where. That allows us to calibrate our remedial measures.
- We need to recognise that remedial measures take money. There is going to be a requirement for investment in infrastructure, and we should think of multi-purpose infrastructure – not only to reduce loss and waste, but also to add it into the calculations of where we build roads and where power goes.
- We also need increased investment in agricultural research. That is not a substitute for infrastructure investment. Managing food loss and waste and managing food productivity, particularly in climate-smart technologies, are complementary to each other.
- We need targeted assistance for the hungry, and we need recognition that not only the overall quantity of food is important for managing hunger, but also providing access to food for those who need it.
- Finally, we need innovation in the hospitality and retail sectors, as well as in consumer behaviour, so that each of us becomes part of the solution, not part of the problem. Some changes are already under way, and we will hear about them throughout the day. Much more can be done.

I look forward to our discussions today.

Figure 10. Attention to hunger and environment warrants sustained attention to loss and waste, not episodic preoccupation and then neglect.

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Dr Karen Brooks joined IFPRI in 2012 as Director, CGIAR Research Program on Policies, Institutions and Markets. Prior to that she worked for the World Bank for more than twenty years in various capacities, including ten years as Sector Manager, Agricultural Operations, Africa Region, and during the 1990s as Lead Economist on agricultural issues of the transition from central planning in Eastern Europe and Central Asia. Prior to joining the World Bank, she was Associate Professor in the Department of Applied Economics at the University of Minnesota. Karen holds an undergraduate degree in Political Science from Stanford University, and a PhD in economics from The University of Chicago. She has published on issues related to agricultural policy in centrally planned economies, price and land policy in countries transitioning from planned to market economies, and the challenges of youth employment in Africa south of the Sahara.

Session 1 Q&A

with Dr Karen Brooks

Chair: Andrew Campbell

Q – Tony Fischer, *Crawford Fund and CSIRO*
You mentioned insects, pests and weather as factors in food loss. A very simple question: where do we draw the line with this discussion?

A – Karen Brooks
Most of our calculations would be at the harvest or the post-harvest stage. Prior to that, we would be looking probably at issues of productivity and yield, rather than at loss after the harvest. Clearly, if we can avoid pests in the process of harvesting, if we can harvest more, then that's a positive and it gives us more food, so we're reducing loss, but I think that's one of the issues of measurement that people are grappling with and we need clear definitions. Whether you call the calculations as starting at the point of harvest or starting before harvest, you can think of remedies, and if you diagnose your problem you can think of different solutions, according to what the problem is that you're trying to solve.

Q – Peter Wynn, *Charles Sturt University*
Thanks for the talk. Look, in many parts of the world, farmers do not receive appropriate prices for their commodities, for reasons that may include manipulation and corruption along marketing chains. I could instance examples from smallholder dairy farmers in Pakistan and dairy farmers in Australia. How much does this situation of inappropriate payment help limit the amount of food produced throughout the world?

A – Karen Brooks
The how-much issue is one that I really can't answer, but I think there's a lot of interest in investigating and learning more about that. In relation to the qualitative problem that you've highlighted, my colleague Maximo Torero at IFPRI, who does a lot of our value chain work, has been looking specifically at the milk marketing issue. It's a question of how you manage quality. Quality is related to loss, because if producers are able to deliver higher quality milk and know they're going to be paid for it, then that milk is more likely to get constructively embedded in the processing chain and result in something that a consumer can drink or eat. The problem that was being addressed there was that producers would take their milk to the processor and the processor would say, "Oh, this doesn't look like very good quality. We'll give you this much for it so we'll only pay you for low quality", no matter what the quality was. They didn't really trust the testing that the processor was undertaking, in order to calibrate the payment, so they turned to a third party tester who was trusted by both the processor and the producers to go through that testing process and to

This is an edited transcript of this Q&A session at the conference.

provide a verdict to the quality that both sides were willing to accept and that resulted in processors being forced to pay for higher quality and for producers being willing to deliver higher quality. In other words, institutional solutions can sometimes address some of these issues of quality. Not all of course. There can be other instances of lack of competition along the value chain which impede payment for quality. This is just one example.

Q – Addisalem Benyam, *Central Queensland University*
You cited the problem that increased supply helps some consumers but does not necessarily reach the hungry in developing countries. Increase in food production requires commitments of resources. We're talking about reducing greenhouse gas emissions, but vegetable production and transportation all contribute to greenhouse gas emissions, and there is no guarantee that the food that has been produced will reach the consumers or the target hungry people. How is it possible to narrow the divide between the problems and solutions in terms of greenhouse gas?

A – Karen Brooks
Thank you for raising that, because it gives us a chance to go over one other very important message. Let's say we start with a situation of food production where there's a certain amount of loss, a relatively high level of loss, relatively early in the value chain. That food is going along the value chain and it doesn't necessarily reach the consumer. If we can address the loss, close to the production stage, through building a better road or helping with investment in storage, or perhaps through providing water supply or power for a local market, those interventions will reduce the loss and make more food available in that market to reach consumers. More food available makes that food more affordable because the price comes down. That's all positive and it helps all consumers buying that food.

The point I wanted to make is that many consumers buying that food will benefit, but people who are very poor and hungry need more than a modest reduction in the price of food. They need something designed specially for them. Programs often used in developing countries to address this situation are 'safety net' programs, 'targeted food assistance', 'school feeding' programs – which are specifically targeted for the population that is at highest risk of hunger. They aim to supplement the reduction in food loss and waste, and can take place anywhere along the value chain, and bring down prices for everybody.

Q – Heather Smillie, *the University of Melbourne*
You discussed that when there's an abundance of food, there's an abundance of waste. Clearly when prices rise, people tend to value food a lot more and there's more concern about waste. Other than hiking up the price of food in the developed world, how else can we make people value food and therefore want to waste it less?

A – Karen Brooks
In high-income environments where we have a lot of media, a lot of communication, there's quite a lot that can be done through consumer awareness and behaviour change, and I think that's happening. I think people now feel less comfortable buying things and just letting them sit in the refrigerator. I think we shouldn't underestimate the willingness of consumers to take voluntary actions that they understand to be important. In addition, we can have innovations in the retail system. In car-based cultures such as North America and Australia, it is possible to shop less frequently and buy more. That can lead to increased waste and loss. In a retail system that has fewer smaller outlets as opposed to a few large ones, it's easier for people to shop more regularly and to manage their inventory at home. In the US, we're seeing the big grocery stores opening smaller stores with what they call 'a curated collection' of products, a selection of things you ordinarily need. People can stop in there and shop more frequently. This is an example of changes in the retail system. If we really want to, we can put fines on people. We can say you can only have one garbage bin, and if you have more garbage bins we're going to tax you via your property taxes. There are a lot of things that could be done. We've not quite achieved them yet in municipal management, but instruments are available.

Q – Shiwangni Rao, *Charles Sturt University*
I'm originally from Fiji, and coming from a small country into Australia and seeing the consumer market in these big countries, I noticed that there is a push towards plus sizes, bigger sizes. People get food in bigger quantities, often opting for a bigger size instead of a smaller one. They buy more and they may not end up using it. I believe that may be one of the bigger contributors to creating so much waste. What is your perspective on this issue? Can we effectively reduce food waste if we reduce the sizes of our products?

A – Karen Brooks
I think that is a very important part of the solution. I think it comes into the general category of changes in consumer behaviour. I think consumers are sending the message to the hospitality industry, to restaurants, saying "We want a choice". There may be a few of us who really want that half pound steak on the plate and we should be able to order it, but many of us, particularly as the population ages, want smaller portions. The restaurants are finding it helps their business to make that available, to offer that greater choice. I think the same is happening, perhaps not as rapidly as it should, in the packaging within the grocery business where one has a choice of either getting the enormous amount if you have a huge family or getting a very small amount if that is what you need.

I think this way of empowering consumers to understand the issue, to recognise that they can do something and to feed that information back into the retail and the hospitality industry, can be rather powerful. It doesn't work instantaneously, but I think we already see it at work.

The complex picture of on-farm loss

Brian Lipinski
World Resources Institute

ABSTRACT: Losses at the farm level are among the least understood aspects of food loss and waste throughout the value chain. Estimates differ greatly. Depending on the crop, geographic region and infrastructure available, drivers behind on-farm losses differ greatly as well, as do the solutions necessary to address these losses. This complexity makes it difficult to identify just where to apply interventions to reduce food loss at the farm level. This presentation seeks to examine what is known about on-farm losses, identify major gaps in knowledge, and propose steps forward to help demystify the nature of food loss at the production level. A special emphasis is placed on quantification and measurement of food loss, since the lack of data available around this issue is a major barrier to understanding the best approaches for reducing food loss. The focus then shifts to solutions to food loss, which will be further highlighted through case studies being offered by the next speakers in this session.

Keywords: on-farm losses, on-farm storage, market access, food-loss data

The World Resources Institute, where I work, is a global research organisation whose mission is to move society to live in ways that protect Earth's environment and its capacity to provide for current and future generations. We work on a number of topics as part of our food program. One of these is the complex picture of on-farm loss. In that program we examine how people currently 'segment' the food supply chain when talking about food loss and waste, and how people define harvest – 'the production stage' – the theme of this first session of today's conference. Our group looks at what happens during and immediately after harvesting on the farm. 'Harvesting' is most commonly defined as the time when the crop is ready for harvest, or when the animal is ready for slaughter.

There are ambiguities around definitions and I shall touch on those a little later. However, I think it is excellent that this entire session is focusing on on-farm loss. In my experience in the food loss and waste 'world', the farm itself is often neglected as a research priority or research area, especially in places like the United States, Australia and Europe. In these developed regions the research tends to focus more on the distribution and marketing and consumption aspects.

Dr Brooks has already shown you Figure 1, which comes from a paper about reducing food loss and waste which my group published a few years ago. As Dr Brooks mentioned, its broad message is that in places like North America, Oceania and Europe much more food waste occurs at the consumption end of the chain, while in places like sub-Saharan Africa much more loss and waste happen at the production and storage end.

This is an edited transcript of the presentation, with some of the powerpoint slides shown.

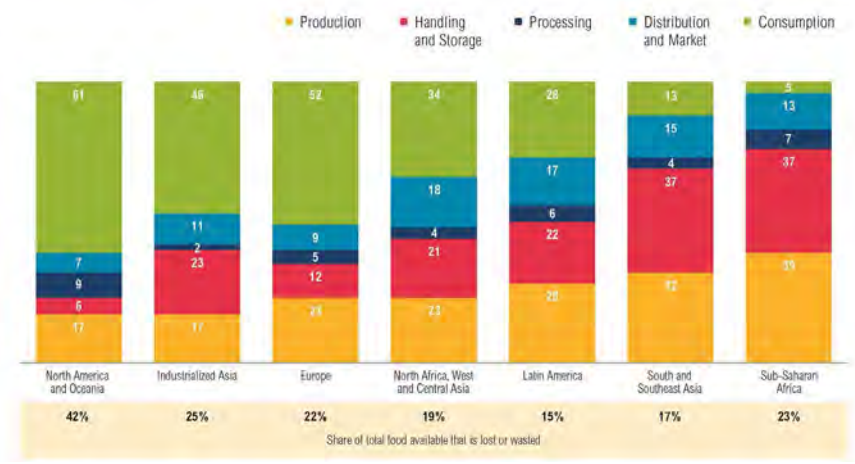

Figure 1. Losses at production are more prevalent in developing regions, while food waste at consumption is more prevalent in developed regions (% of kcal lost and wasted).
Source: World Resources Institute (based on FAO 2011).
Numbers may not sum to 100 because of rounding

You will notice that the losses at production, which are shown as yellow bars, are still quite significant even in places like North America and Oceania. Loss at that stage is still about 20% of the total food loss and waste that is occurring. You can see that losses in storage also vary quite a bit. Nevertheless, the production losses are significant wherever you are in the world, and that is why it is important to address this topic today in its own session.

Another reason is that the farm level is where you can most affect the lives of smallholders and their livelihoods by addressing on-farm solutions at that point. And finally, what happens at the farm can affect what happens 'downstream', further on along the food system.

When we talk about food loss and waste, we segment our discussions into five categories (Figure 2). If a tomato goes bad in your fridge, that is a consumption waste. However, things that happened at the farm level could have affected the shelf life of that tomato. There are many interconnections in the system which can be lost when we just discuss the issues in rigid categories.

Challenges in addressing on-farm losses of food

I shall now give a quick overview of the challenges that are unique to addressing on-farm loss, and they are all inter-related.

There is the extremely context-dependent nature of on-farm loss. Farming looks very different from region to region, country to country, town to town, climate to climate, even from individual farm to individual farm. Therefore, when you are trying to come up with solutions that will tackle on-farm loss in a big way, it is difficult to find the one-size-fits-all no-regrets solutions that will be applicable in a wide variety of contexts.

Figure 2. Five categories used in discussing food loss and waste along the entire value chain. *Source*: World Resources Institute (based on FAO 2011).

As well, there is the difficulty of adapting new technologies and practices, and this is not unique to the food loss and waste world. It is difficult to propagate new technologies and new techniques out amongst farmers, maybe because of cost, maybe because it difficulties reaching them, or maybe because materials involved in the technologies are unavailable in certain parts of the world.

Another challenge is the dispersed nature of farms and farm loss. It is happening at the smallholder level, and that means you have to reach all these individual farmers. That is more difficult than working on, say, supermarket waste where you can interact with large retailers who often will then be able to institute policies that are much more wide-ranging. That is quite a contrast to trying to institute changes at the farm level.

And finally, we lack really good data around on-farm loss and around food loss and waste in general. Although the chart in Figure 1 looks very official and as if the numbers are solid, actually those are only extremely broad estimates based on the best numbers that we have available at the moment. Knowing that a lot of production is lost in sub-Saharan Africa does not help in establishing a program specifically around the types of crops and types of livestock that need to be addressed. You need to know what those more specific hotspots are.

Possible interventions

Figure 3 lists six possible high-level interventions. These are just some ways in which we can address on-farm loss, and certainly not exhaustive. The next three speakers will present specific case studies.

Facilitating new markets for 'unmarketable crops'. You have probably heard about 'ugly' fruit and vegetables, where food items that do not meet certain standards of cosmetic quality end up being rejected for the market. Although it is perfectly good food, perfectly nutritious, healthy and available for

Figure 3. Possible high-level interventions to help reduce on-farm loss.

consumption, it does not get to market because it does not meet a particular standard. However, you can facilitate donation of that food, for example, and that is a fairly common practice in the United States. There is a practice called 'gleaning', where volunteers go to a farm and retrieve all the food that was not harvested. Maybe the apples in the orchard were too small. Then that food gets donated to people who need it.

Here is another innovative example. Where I live, in Washington, D.C., there is a service available now where I can buy a box of 'ugly' fruit and vegetables delivered to my door. They are items that farmers were not able to sell to the market. Now 'start-up' businesses are working directly with farmers to get that food to people who want it. To be a consumer of a service like this I still need to be aware of these programs and motivated enough to take them on.

Some supermarkets, such as Walmart, have started selling 'ugly' fruit and vegetables at lower cost than other fruit and vegetables, and they are finding that these fruits and vegetables are selling faster than so-called 'normal' food.

Adjusting quality standards for crops. While similar to the previous examples this intervention is more at government policy level. For example, the European Union might have a policy that 'a banana must have a specific curvature to it, and be of this length, or you cannot sell it'. It is true that this is something that happens. A policy like that means perfectly good food does not get into the market because it does not meet a very specific standard.

Improving market access. This intervention includes actions such as building roads that allow farmers to take their crop to market. You can reduce losses on the farm but if your storage facilities are inadequate, or if the crop must be immediately used or sold quickly after harvest, it will still end up as food waste – just at a different stage in the value chain.

Figure 4. (left) Organisations involved in the Food Loss & Waste Protocol; (right) the *Food Loss and Waste Accounting and Reporting Standard*.

We can also add 'market fairness' as a part of market access, recalling the question after Dr Brooks's talk which pointed out that if farmers are not getting the price they deserve for their produce, that situation can also lead to increased levels of food loss.

Increasing agricultural extension services. Many people at this conference are familiar with the concept of increasing agricultural extension, and you are probably quite passionate about it. This is how farmers can become educated on new technologies, on best practices that can reduce losses at the farm level, and on harvesting and storage techniques.

For **improving harvesting and on-farm storage**, establishing a cold chain is an important intervention. There are regions that currently do not have access to a cold chain, throughout the food supply chain. It is not clear to what extent this is the situation, nor who pays for putting in a cold chain and for the sorts of investment required for that infrastructure. And then what is the trade-off between the reductions in food loss that we get from that investment and the additional resource cost that comes as a result of making those investments in greenhouse gases and energy?

Improved data – an area that I work on quite closely. Once you know what is happening in a specific farm or in a country, in terms of the crops that are being wasted, and the reasons for that, and what happens to that material, then you can really start to target interventions towards those hotspots. That effort is called 'The Food Loss & Waste Protocol'.

At the World Resources Institute we have worked with a number of organisations on developing the Food Loss &Waste Protocol (Figure 4), and many people at this conference have contributed to the protocol's development.

The protocol is an effort to develop a global standard for how we define, measure and report on food loss and waste. We need it because, in so many cases, food waste might mean to me something entirely different from what you mean when you talk about food waste. You might be referring to landfill. I might mean anything that was intended for human consumption but ended up being fodder for livestock or an anaerobic digester. That is food waste, to my mind, but for you it might be just landfill. I might say I waste 30% of my food, and you might say you waste 10% of your food: I am thinking you are doing so much better than me – and actually, we may not even be talking about the same thing!

The Food Loss & Waste Protocol is a set of common definitions and practices for how to define, measure and report on food loss and waste. It was released in June 2016, and is being widely taken up. It can be used by corporations and by countries and by anyone who is undertaking a study where they are interested in reducing their food loss and their food waste.

There is also a *Food Loss and Waste Accounting and Reporting Standard* (FLW Protocol 2016) (Figure 4).

Do contact me. My email address is at the World Resources Institute (WRI) website, www.flwprotocol.org/. The WRI is on Twitter (@WRIFood).

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Brian Lipinski is a research associate with the Food Program at the World Resources Institute (WRI). During his time at WRI he has worked extensively on the topic of food loss and waste, having served as the lead author on the paper 'Reducing Food Loss and Waste' (reference above). That paper then led to the development of the Food Loss & Waste Protocol, a multi-stakeholder effort to develop the global accounting and reporting standard for quantifying food and associated inedible parts removed from the food supply chain. This work will enable a wide range of entities – countries, companies and other organisations – to account for and report in a credible, practical and internationally consistent manner how much food loss and waste is created, and identify where it occurs, enabling the targeting of efforts to reduce it. Brian also serves as part of the secretariat for Champions 12.3, a unique coalition of executives from governments, businesses, international organisations, research institutions, and civil society dedicated to inspiring ambition, mobilising action, and accelerating progress toward reducing food loss and waste. He holds a Master of Science degree from the University of Michigan, School of Natural Resources, and resides in Washington, D.C.

Increasing on-farm storage: innovation, prizes and public mechanisms that benefit small farmers

Rodrigo Ortiz

AgResults

ABSTRACT: Post-harvest losses of grain in the developing world lead to lower incomes among smallholder farmers and reduced farm-level food security. This problem is particularly acute in sub-Saharan Africa where post-harvest losses are estimated at US$1.6 billion per year. Moreover, insufficient on-farm storage solutions often lead farmers to sell soon after harvest and receive lower prices when the market is flooded or, even worse, to buy back grain later in the season at a higher price. Private-sector solutions to post-harvest losses exist, but companies often see low-income farmers as a risky and unattractive market. Smallholders do not understand the benefits, nor feel they can afford the solutions. AgResults' Kenya On-Farm Storage Project uses prize competitions to incentivise the private sector to bridge this gap and enter into the market. This project is one of six innovative prize competitions of the AgResults Initiative, a partnership between the governments of Australia, Canada, the United Kingdom and the United States, and the Bill & Melinda Gates Foundation. Prize competitions offer an innovative method for the public sector to use funds effectively and efficiently to engage the private sector. In the case of Kenya, the prize encourages companies to design, develop, market and sell new (or redesigned) on-farm storage devices to smallholder farmers. This presentation describes AgResults' prize competitions, the Kenya On-Farm Storage Project, its impact and its sustainability. It discusses how prize competitions offer the development community an efficient and affordable mechanism to finance development programs in the future.

Keywords: pull mechanisms, private sector, grain storage, smallholders

I am very excited to be here to tell you about a project I am working in which is really my passion – the AgResults Initiative. This is a unique and new initiative which brings together UKaid (part of the UK Department for International Development, DFID) and the Australian Department for Foreign Affairs and Trade (DFAT) and Global Affairs Canada, USAID, the Bill & Melinda Gates Foundation and the World Bank to promote 'pull' mechanisms and innovation in agriculture (Figure 1).

Pull mechanisms vs traditional approaches

Pull mechanisms are incentives to the private sector. They aim to break through barriers that hold back private-sector success. There are situations where private-sector entities 'see' barriers to productivity or trade which they would not be comfortable overcoming. Therefore, 'pull' mechanisms are designed

This is an edited transcript of the presentation, with some of the powerpoint slides shown.

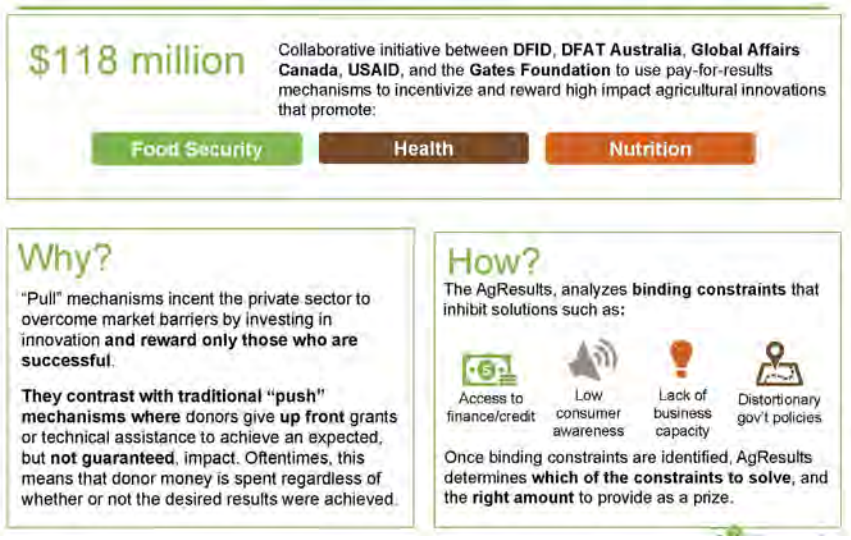

Figure 1. An overview of AgResults and its philosophy and theory of change. AgResults works for innovation in research and delivery.

to motivate these groups to go into new, unexplored markets. This approach, offering incentives, is very different from traditional approaches that I, for instance, have seen during 35 years of my career so far, which use 'push' mechanisms.

Push mechanisms include, for example, technical assistance, grants and study tours. They aim to motivate the target audience to adopt a certain behaviour, and under this mechanism the funding body pays upfront, hoping for results. Whether the target audience achieves the results that the funder is looking for, or not, the funds are disbursed anyway. There is no guarantee of a good outcome from the donor's perspective.

Our approach is different. Sometimes we help the target audience access credit. In other cases, we increase consumer awareness. If there is a lack of business capacity in an area in a developing country, our 'pull' mechanisms can promote that capacity. Frequently we encounter distortionary government policies, and by using a pull mechanism we aim to circumvent or overcome some of those distortionary policies.

The X-prize

Prizes can stimulate private-sector interest. Prizes can add attractiveness to a market that would normally not be attractive. Suitable prizes can create a platform for innovation, which is one of our aims, and also bring in a crowd of potential problem-solvers. Instead of addressing one particular group of innovators, we use prizes to attract and welcome as many problem-solvers as possible. We are technologically agnostic. We really do not care what solutions problem-solvers produce so long as they can meet the objectives of the project.

Probably the best example of pull mechanisms that I can cite is the 'X-prize'. The X-prize launched a US$10 million competition for the private sector to go

into space. Prior to the X-prize, space exploration was all government owned and run. After the X-prize, as a result of this US$10 million prize, there was over US$100 million in private-sector investment in space, and now there is a flourishing private sector in space exploration (Figure 2).

Pilot projects around the world

AgResults is running pilot projects around the world. We are addressing different issues in different countries. In Nigeria, our aim is to eliminate aflatoxins in maize. In Uganda the pilot project is intended to promote diversification in legume seeds and away from maize seed. In Kenya, our pilot is about on-farm storage solutions, as I describe below. In Zambia, our project is attacking deficiencies in vitamin A through bio-fortified orange-coloured maize. In Vietnam, we are launching a greenhouse gases pilot project, aiming to reduce production of greenhouse gases while increasing yields, and this is to be done through using less fertiliser and better management of paddy rice. And for the whole world, about a month ago, we launched a US$30 million prize for the pharmaceutical, biotech and/or animal health industry to produce a brucellosis vaccine that is appropriate for developing country environments and requirements.

These are all very exciting pilot projects, and we are finding they are pulling in substantial innovative thinking.

On-farm storage solutions in Kenya

In sub-Saharan Africa, on-farm post-harvest losses cost about US$1.6 million per year. In Kenya, smallholder farmers will normally crop in two seasons. They will harvest their maize and try to store it till the next season, for their own consumption and also to eventually sell it.

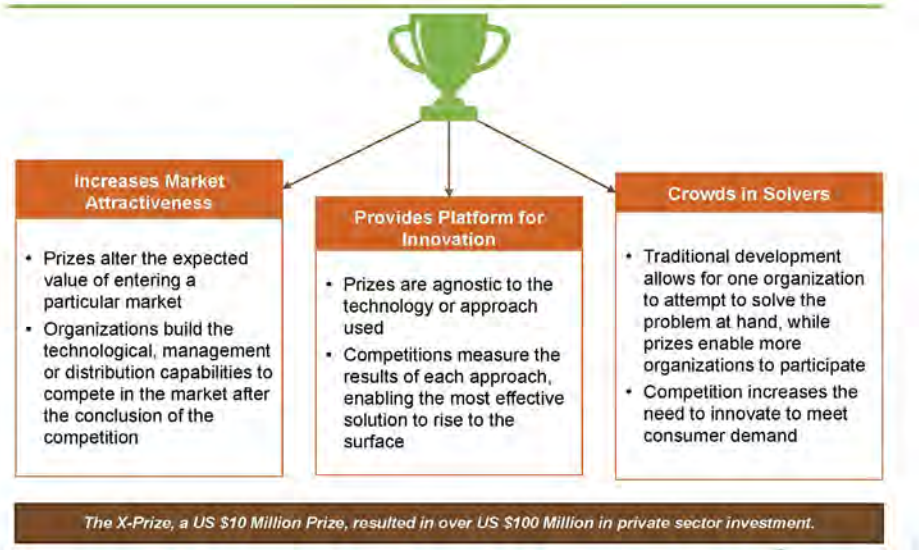

Figure 2. Prizes stimulate private-sector investment by altering the expected return.

If they do not have appropriate storage devices, the Larger Grain Borer and other insects can completely decimate that store of harvested grain. Farmers and their families can be subject to severe food security issues as a result. We find that farmers often sell immediately after harvest, flooding the market and getting a very low price for their grain. Later, when they need that maize for their own use, several months after harvest, they have to buy it, sometimes at a substantial premium.

An on-farm storage solution, instead, allows smallholder farmers to keep their harvested maize at harvest time, and sell it later when the price goes up. They can use their stored grain as a bank as well. When they need money after harvest for school fees and other things, they find that when they open these hermetically sealed storage containers, several months after harvest, the maize is in perfect condition and can command a premium price in the market.

Unfortunately, because of lack of awareness from smallholder farmers, as well as other market barriers, private-sector on-farm storage-solution producers often focus their attention on large to medium farms, and have not produced devices that would be accessible and affordable to smallholders.

For the AgResults contest in Kenya, we are working in two very different regions of the country. The Rift Valley traditionally has not had Larger Grain Borer. Here, essentially, it is good farming practice to store maize from one season to the next. Therefore, we are offering the prize to private-sector participants who can reach a threshold of 21,000 metric tonnes of storage capacity sold. The winning participant will get US$750,000 as a prize, and all the companies that reach that threshold by the end of the contest period will share proportionately in a US$1 million additional prize. This is a great incentive to the private sector there, and they are moving quickly in response.

In the Eastern region of Kenya, which is where there is a prevalence of Larger Grain Borer, it is different. Innovators there will be competing for a US$3 million prize at the end of the period, which will be distributed in proportion to their sales during that period.

The end result of this approach in Kenya is that we can expect minimum crop losses from smallholder farmers in future. The prize is helping to capitalise and develop a sustainable market for farming solutions specifically tailored to the smallholder farmer context, which was not the case in the past. By offering these prizes, we are creating strong incentives to develop new technologies. There are now several different types of storage solutions in use in Kenya: metal silos, plastic tanks and storage bags, among others (Figure 3).

We have also collaborated with a research institution, the International Center of Insect Physiology and Ecology, and developed a ‘penetration protocol’ for testing these devices, to ensure efficiency. The protocol comprises three stages:

- *Insect damage test*: to assess the efficacy of storage devices in protecting the grain from insects that enter during the storing process.
- *Penetration 1 test*: to determine if Larger Grain Borer can breach storage device materials.
- *Penetration 2 test*: to assess whether insects released outside a full-size storage container can penetrate the device within a four-week period.

Figure 3. The Kenya Pilot Implementers are marketing and testing the use of plastic tanks, metal silos and hermetically sealed bags as storage devices.

The protocol has been a substantial contribution because up till now there really was no testing protocol to determine the efficacy of either resistance to the pest or proof of protection against the pest. If you are interested in the details of this protocol, we would be willing to share them with you.

To date, the pilot has attracted six local and international sellers, and two more are applying (Figure 4). There has been a tremendous amount of interest. The

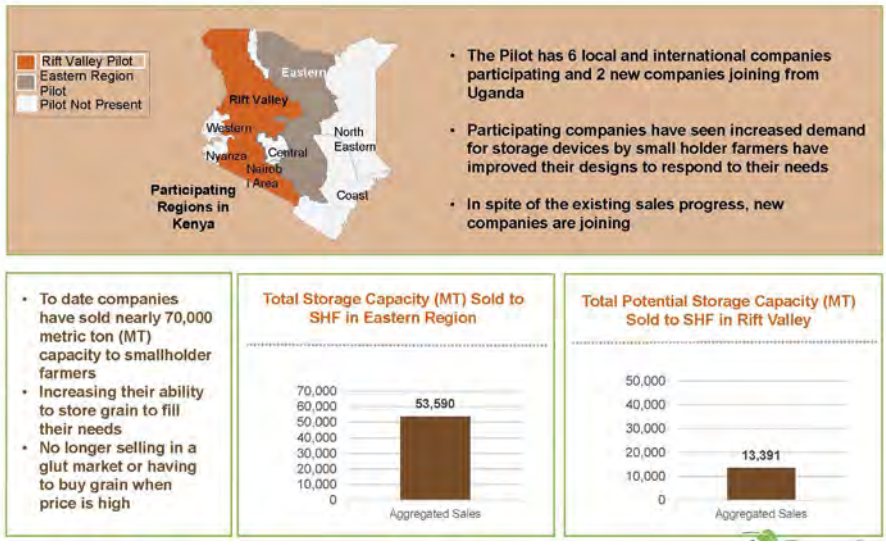

Figure 4. Increased market participation by various on-farm storage providers leading to increased sales to smallholder farmers (SHF).

smallholder market was a completely undeveloped market, and as a result of this initiative more and more farmers are realising that they can afford these devices, and that the devices can make a significant difference to their livelihoods and food security. They are no longer selling in a market where they are at the mercy of highs and lows of prices.

We expect the impact of this pilot will be (Figure 5):

- benefits to about 480,000 smallholder farmers;
- about 172,000 metric tonnes of storage capacity;
- a gain of about US$14 million to the smallholders.

In addition to the impact on smallholder farmers' ability to store and sell their crop at better times, the Kenya pilot has also found that airtight storage significantly reduces aflatoxin contamination of the maize.

Summary

In summary, we have created a virtuous circle with the private sector (Figure 6). The makers of storage solutions are innovating and adapting to a new and developing market. Agro-dealers are being set up and they are helping in the distribution network. Smallholder farmers have already identified and bought into this idea, and we at AgResults feel that there will be a viable and sustainable market once our pilot finishes, three years from now.

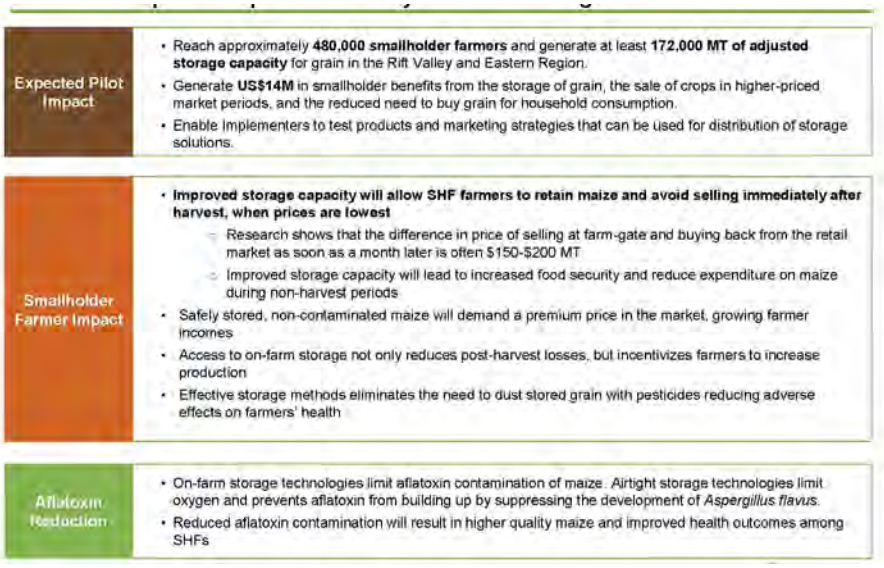

Figure 5. Expected impacts of the Kenya On-farm Storage pilot to smallholder farmers (SHF) and others.

Figure 6. By offering an incentive, this project run by the private sector has created a sustainable new market for devices that fit the needs of smallholder farmers.

Rodrigo Ortiz is the Secretariat Lead for the AgResults Program that implements the Kenya On-Farm-Storage Pilot. He is a senior economic development adviser who specialises in private-sector development in emerging markets, with experience in 74 countries, spanning 40 years. With a proven track record of developing organisations and leading and implementing large and complex technical assistance programs, he has advised economic development agencies, provincial and state governments, and international donor organisations including USAID and the World Bank as well as other public and private-sector organisations. Throughout his career, Mr Ortiz has created and managed world-class economic development, investment and export promotion agencies. These agencies focus on export, trade and investment services, logistics and special economic zones, and industrial, agricultural and service sector projects in Africa, the Middle East, North Africa, Latin American, the Caribbean, and East, Central and South East Asia. Prior to AgResults, Mr Ortiz was with the World Bank, where he headed a technical assistance unit that develop investment promotion capacity for member countries. He was the resident Program Manager for large projects in Jordan, South Africa, Bolivia, Cyprus, and Pakistan and he held strategic roles in technical engagements throughout the globe.

Crop health capacity-building in least developed countries: a unique approach

Madaline Healey

University of the Sunshine Coast

ABSTRACT: Agriculture employs over 70% of the workforce in Laos, one of the least developed countries in the world, and provides approximately 27% of total GDP. Intensifying vegetable production will increase plant pest and disease pressure and significant on-farm losses for the majority of subsistence and smallholder cooperative farmers. Intensification is likely to happen if Laos is to meet the World Trade Organization Agreement on Sanitary and Phytosanitary Measures (the 'SPS Agreement') requirements for exports to the ASEAN economic community and international markets. This will be a major challenge in the horticultural production areas of Savannakhet and the Bolaven Plateau because there is little capacity in crop health there to support farmers. In collaboration with Provincial Government authorities and the Australian Government volunteer program (AVID) managed by Scope Global, the Crawford Fund has committed to a long-term program to build capacity in crop health, biosecurity and food safety in Laos since 2009. Engaging volunteer early-career scientists to deliver insect and disease diagnostics training has increased the capacity of local counterparts to provide crop protection advice. Placements provide context-specific training and longer-term sustainability through gradual training, while also giving volunteers an opportunity to engage in a career in international agricultural development. Crawford e-mentors support volunteers in five countries with advice and pro-bono laboratory services – a unique feature of the program. Crop management strategies have already been implemented on key farms with the help of local staff, leading to reduced crop loss and increased yields. This long-term commitment will contribute to rural economic development of the smallholder farm sector in Laos, and facilitate trade in rural commodities.

Keywords: crop health, early career scientists, pest and disease diagnosis

I have been involved in the Crawford Fund's Capacity-building Program in the Lao People's Democratic Republic (Laos) for over three years: first as an Australian volunteer for international development, based in Savannakhet in southern Laos, working as an entomologist and Integrated Pest Management (IPM) Officer; now in a research role, providing support to our Lao colleagues and volunteers in country.

With a population of 7,000,000 people, Laos relies heavily on agriculture for domestic use, export and trade and subsistence living: 4% of the total area of Laos is under vegetable production. Many people in rural areas live below the poverty line. However, in recent years, Laos has made large strides toward lifting people out of this situation, largely through improved agricultural production.

This is an edited transcript of the presentation, with some of the powerpoint slides shown.

Laos is a full member of the World Trade Organization, and aims to be an equal ASEAN economic partner. To achieve that, the Lao Government recognises the need to increase agricultural trade and productivity. The Government will push for more intensive vegetable production to meet export demand, putting enormous pressure on growers, the majority of whom are subsistence farmers and smallholders. Routinely there is 20–50% loss of yield through pests and diseases, and increased production is expected to add to this burden. However, there are very few crop protectionists available in Laos to deal with these issues, and many of those are based in the capital city Vientiane, which is far away from the major agricultural production areas of Savannakhet and Champasak in the south of the country.

Since 2009, the Crawford Fund has been committed to a long-term capacity-building program in Laos. In a collaborative approach, a low-cost program was designed to deliver training in integrated pest and disease management strategies in horticulture. The program engages with national and provisional governments in Laos including the Provincial Agriculture and Forestry Office (PAFO), and with Australian Volunteers for International Development (AVID) managed by Scope Global.

A key feature of this program is its unique approach to volunteer placements. Rather than placing individual plant pathologists or entomologists in the provisional offices of Savannakhet and Champasak, the program builds clusters of placements, and this means that the volunteers' skills complement each other. The arrangement also encourages collaboration and networking between the provincial offices. Throughout the placement, the volunteers are provided with professional and personal support by Crawford e-mentors.

The program's main aim is to increase knowledge and understanding of pests and diseases by local colleagues in the provisional offices. It provides hands-on participatory learning in laboratory, classroom and field, and allows for context-specific training through field surveys for pests and diseases and by curating collections and conducting field and laboratory diagnostics.

During the learning process, information is used to develop and apply integrated disease and pest management strategies. Key problems are identified in the field and regular visits with growers ensure that the channel of communication is kept open and we can target major on-farm issues.

There is also an emphasis on conducting small-scale local research. Everyone involved gains experience in facilitating and implementing research, including publishing their findings in peer-reviewed journals, which increases the scientific validity of the work that we do in Laos. Good examples are our research into improved seedling production techniques (Turner *et al*. 2013), and into *Fusarium* wilt of watermelon (Callaghan *et al*. 2016). There are permanent research sites and on-going monitoring.

Growers are always involved, so research is targeted at issues identified by them, directly targeting their needs.

Through local growers' attendance at our trainer workshops, farmer field days and regular on-farm visits, our work is reaching the people who need the information, and improved integrated pest and disease management strategies have been observed on-farm.

Many growers are practising crop rotations and including fallow periods into their regimes. Some are producing disease-free seedlings, raised in home nurseries, and practising on-farm hygiene by removing weeds and crop residues, all of which is resulting in reduced on-farm crop losses through fewer disease and pest incidents. We also now have farmers contacting our staff, seeking advice and help.

With the increase in trade and export, the Government recognises the need for better plant health and quarantine resources, so our work has progressed to encompass these needs. In the provincial offices, quarantine border staff are being trained in technical inspections to oversee import and export activities. We currently have an AVID working with the Plant Quarantine Division as a bio-security adviser in Vientiane, and he is working directly with colleagues on developing risk analysis and policy aid, to meet international food safety and quality export standards.

The work that we are doing is unique in that it integrates the enthusiasm of early career researchers with the support of highly experienced experts. While colleagues improve their capacity to diagnose pests and disease and provide management advice to growers, volunteers are provided with the opportunity to engage in a career in international agricultural development.

Delivery is low-cost, which means that the chance of long-term uptake is higher. Our colleagues are often operating with staffing limitations and budgetary constraints.

Before I conclude, I would like to acknowledge the many dedicated people that are involved in this program. A big acknowledgment goes to Scope Global and the Crawford Fund – in particular Professor Lester Burgess who has mentored and supported so many of us in the Laos and Australian teams. He has been the driving force behind this project and continues to lead and coordinate its success.

Through this program, our colleagues have gained the skills and confidence to conduct diagnostics and to deliver crop health advice to local vegetable growers in southern Laos. Alongside our Lao colleagues, we aim to see continued reduction of on-farm crop loss through better management and advice at the farm gate and we expect to see further rural economic development of the smallholder farm sector.

We aim to continue to work towards the improved scientific credibility and capacity of Laos, to engage with and meet international export standards, not only increasing national income generated through horticultural export, but also providing further food security from a local to a regional level.

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Madaline Healey is an entomologist and PhD candidate with Central Queensland University and a researcher at the University of the Sunshine Coast. Her research focus is population dynamics of agro–forestry ecosystems and development of integrated pest management (IPM) programs. Other research areas of interest include the biology and ecology of thrips, and forestry and horticulture research, particularly in South East Asia. Madaline is involved in international forestry and agricultural development research in South East Asia. She is passionate about working with local growers to enhance pest diagnostic skills and develop sustainable control programs.

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Plantwise: an innovative approach to reduce crop losses by sharing plant health knowledge

Dr Washington Otieno
Plantwise Programme,
Centre for Agriculture and Biosciences International (CABI)

ABSTRACT: Strengthening plant health systems by building capacity to manage existing and emerging pests requires innovative approaches in agricultural advisory services. 'Plantwise', a global program led by CABI, delivers improved agricultural advice through networks of plant clinics supported by a knowledge bank (an open access gateway to online and offline plant health information). Plantwise is increasingly deploying ICT tools to ensure correct pest diagnoses and appropriate recommendations to farmers. Together with partners, CABI is deploying SIM-equipped Android tablets to enable real-time capture of pest data and instant access to information that supports diagnosis and pest management advice. These tools enable 'plant doctors' to use the Factsheet Library app to access 10,000 factsheets on 4000 plants and 2500 pests. The tablets also allow 'plant doctors' to communicate via instant messaging services. At plant clinics, relevant data are logged online to enable CABI and partners to monitor the quality of recommendations, ensure that they are accurate and comply with best practice. Plant clinic data is instantly uploaded onto the Plantwise Online Management System where plant protection agencies can use it to track pest occurrences. Critical components of Plantwise include the use of ICT in training the 'plant doctors', the back-up from CABI's knowledge bases, the use of the evidence of impact of the interventions on crop losses as an indicator of potential to improve food security and farmer livelihoods, and the application of lessons learnt to improve the interventions. All of these are highly relevant to CABI's overall objectives that contribute to the UN's Sustainable Development Goals 2 and 17. This paper presents Plantwise as an innovation to reduce pre-harvest crop losses.

Keywords: ICT tools, knowledge bank, plant clinic, plant doctor, plant health systems

I am going to talk to you about a program called 'Plantwise', which is an innovative approach to reducing crop loss by sharing plant health knowledge. I work for CABI, based in Nairobi. CABI is best known to most people because of its publishing. Over time, however, CABI has had to evolve to remain relevant, and that is why we have gone into development work.

'Plantwise' is our response to the challenges of food loss and its negative impact on livelihoods. Information is important if these challenges are to be addressed, and the information provided needs to be relevant to all actors along whole value chains. Another justification for Plantwise is that it improves the capacity of small countries to deliver agricultural advice and thereby help in reducing crop losses.

This is an edited transcript of the presentation, with some of the powerpoint slides shown.

Figure 1. The three components of Plantwise.

Plantwise is implemented through government systems across three regions of the world – Africa, Asia, and Latin America and the Caribbean. Currently it has been piloted in 34 countries and is active in 32, meaning that the pilot phase did not succeed well in two.

Features and components

There are three components to Plantwise (Figure 1). First, the plant clinics. Plantwise operates through networks of plant clinics. A plant clinic is not a satellite lab; it is a simple structure in which extension officers, trained in visual diagnosis to become 'plant doctors', receive farmers who bring plant samples showing plant health problems. The plant doctors have support and relevant references to guide their work. Farmers can bring their problems to the clinic, where they are addressed, diagnosed and recommended solutions documented.

As an example, at a plant clinic the plant doctor talks with the farmer about the problem, and documents visual symptoms, the diagnosed problem and the recommendation given to solve the problem, in a prescription form. This can be paper-based or tablet computer-based.

The second component is the Plantwise Knowledge Bank, which is an online technical resource that the people serving the farmers can easily refer to for support. It provides them with fact sheets and pest-management decision guides, right on the spot. It helps them diagnose the cause of the plant health problem because they can use it as a readily accessible reference. Not all plant doctors will be able to diagnose all problems just from their own training; they often need to refer difficult or unfamiliar cases to other experts or laboratories. Here I am talking about diagnostics as opposed to identification. The latter regularly requires laboratory services.

An important feature of Plantwise is that the diagnosis is documented as part of data capture at the plant clinics; and the recommended solution for the problem is also documented. A farmer goes away with a prescription (Figure 2), and the information about the encounter remains with the plant doctor at the plant clinic and goes into the database for further validation and analyses for different uses.

The database, called Plantwise Knowledge Bank, supports the work of the plant doctors and also supports the diagnosis. The data collected from various farmers' queries

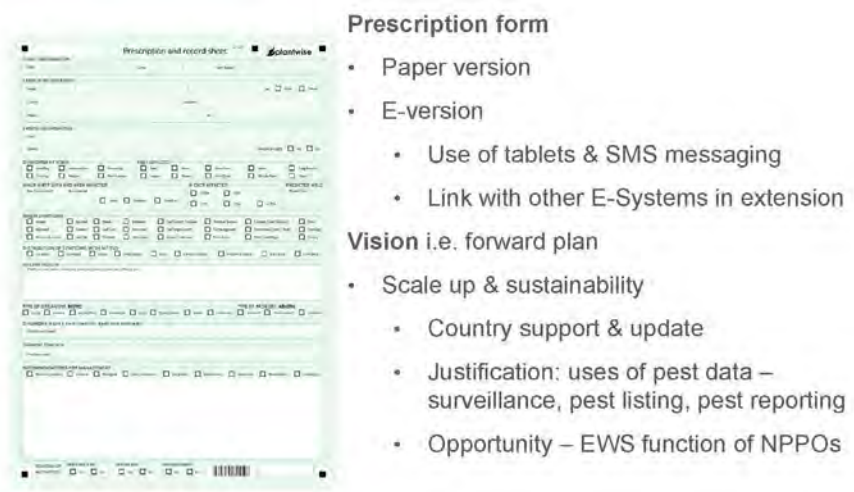

Figure 2. Data capture and use via the Plantwise prescription form

– about the farm, the crop, the pest, etcetera – is fed into the database within the Knowledge Bank, called Plantwise Online Management System (POMS), and is later validated and used to support the work of the plant doctors, besides informing decisions by stakeholders on management of plant health. Inbuilt in this is a monitoring and evaluation mechanism, because it is important always to use lessons learned to ensure there is continual improvement. This is the third component of Plantwise.

Monitoring and evaluation provide quality assurance used to give feedback to the plant doctors on their performance, and contribute to ensuring continual improvement of Plantwise activities.

Plant clinics are situated at locations easily accessed by farmers, their locations being determined by ease of accessibility but within rural locations. Plant clinics must be run on a regular basis: for instance, a particular location and a particular time at weekly, bi-weekly or monthly intervals.

Plant doctors are essentially extension officers trained in visual diagnosis and how to give good advice to farmers as pest management recommendations. The majority of them are government employees who have had basic training up to degree and diploma levels. Plantwise training gives them more focus on plant health, through short training on diagnosing common plant-health problems and their solutions. When farmers bring affected plants to the plant doctors, the latter should diagnose the problem and give satisfactory and practical advice. That advice is documented in a prescription form – an important feature. Those of you who are familiar with extension in developing countries will know that documentation and data capture are rare. Without data there is very little you can do to improve a situation or make informed decisions on plant health issues.

The Knowledge Bank is an information resource. It provides diagnostic support through factsheets and good recommendations, via what we call 'pest management decision guides' specific to crops and pests. These help the extension officers to give recommendations that are practical and do not promote any unwanted chemicals. Users of the Knowledge Bank include an array of people in the agricultural sector: extension services, farmers, plant health regulators, agricultural research organisations, academia, agro-input suppliers, and others. The Knowledge Bank is also a repository for plant clinic data, which is entered into the Plantwise Online Management System.

Plantwise e-version and benefits

Data capture using a paper form is one of the most unpopular tasks for plant doctors, so it is good that the e-version, using tablet computers, is working and moving forward. The e-version has contributed significant improvements in performance, and the information captured on tablets, including images, can be relayed very quickly – far away, such as from Kenya to Australia. Within a short time, you have a potential answer to the problem. This capability far outweighs what you can do with paper. As one plant doctor said: 'It is not even comparable with the paper one ... wherever you go, this one is in the pocket'.

ICT tools therefore present an excellent opportunity to improve what can be done to manage plant health. Trials have been done in four countries – Kenya, Rwanda, Sri Lanka and India – and from those trials we have been able to make significant improvements in how data is collected and analysed, shared and used. Also, advice can be sent to a farmer as a short message using SMS, instead of being handed to them on paper. Training is required to enable that system to work, but once that is complete we find that the plant doctors themselves use the tablets to share a lot of information, and to support each other to improve how they work.

There are a number of ICT tools in Plantwise: for collecting, sharing and delivering agricultural data, and interlinking the range of actors in plant health. SIM-equipped Android tablet computers enable real-time capture of pest data, and instant access to diagnostic support and advice. The ICT tools also give plant doctors access to the Factsheet Library app, and let them communicate via SMS, and log relevant data online. This is important when there is a need to trigger prompt mitigation actions. The tablets are more efficient than working with paper, and they enable action to be triggered quickly whenever a new problem is detected. National Plant Protection Organizations (NPPOs) actually require that type of response.

In evaluations, 79% of farmers have reported improved production if they use the advice given from the plant clinics. That is 79% of farmers, not 79% reduction in crop loss. Also, 70% of farmers have reported better income after using the plant doctors' advice.

An important final benefit is that Plantwise is combating a silent aspect of food loss. You may produce and place a visually very clean food on the market, but it is very heavily contaminated with pesticides and you eat it at your own peril. One of the things we have achieved by using integrated pest management via Plantwise is to minimise pesticide use (Figure 3).

Parameters	Pre-Plantwise: 2009 - 2012	Plantwise: 2013 - present
No. of pesticide sprays per crop	4-7x	2-3x
Total cost (in Baht) of insecticides per rai (6.25rai = 1ha) per season	฿650	฿350
Farmers using only pesticides (%)	80%	50%
Mean crop loss per crop per rai (%)	50%	10%
Income per crop per rai (Baht)	฿1,000	฿4,000

The results of a farmer survey conducted by the Thai national implementing partner undertaken in 2015 by plant doctors in 3 different regions. 6 plant doctors interviewed 90 farmers in total.

Figure 3. An important aspect of Plantwise is that it reduces reliance on pesticide sprays.

Figure 4. Acknowledgements.

Summary

In summary, Plantwise offers these opportunities: to take prompt action; to have instant access to pest-management information; to capture real-time data; and to link easily to other tools we have tried such as PestPoint and Plant Village. Through Plantwise there can be effective pest monitoring and active control to mitigate against loss.

Putting that to even better use is the next challenge we face, because most countries do not do that.

I want to finish by thanking the sponsors of Plantwise, as shown above (Figure 4).

Washington Otieno is the Plantwise Programme Executive at CABI. Prior to joining CABI, he was a consultant for phytosanitary capacity development at the International Plant Protection Convention (IPPC) (2011–2013), Agricultural Biotechnology Adviser with USAID-Kenya (2011), General Manager at Kenya Plant Health Inspectorate Service (KEPHIS) (2005–2010) and research scientist at the Tea Research Foundation of Kenya (1992–2005). At KEPHIS, he managed phytosanitary services and trade matters and was involved in sanitary and phytosanitary (SPS) capacity evaluation and development at national and regional levels. He represented Kenya at meetings of the WTO-SPS Committee and the IPPC between 2006 and 2010, and served as a developing country representative in working groups and policy committees of the STDF (2009–2011). Since March 2013, Washington has led coordination of Plantwise implementation in Africa. He holds Bachelor and Masters Degrees in Agriculture and Plant Pathology from the University of Nairobi, and a PhD from Wageningen University.

Session 2 Q&A – On-farm losses

With Brian Lipinski, Rodrigo Ortiz,
Madaline Healey & Dr Washington Otieno

Chair: Andrew Campbell

Q – Tim Fischer, *The Crop Trust (Norway)*
My question is to Madaline, and relates to Laos. Do you have any relationship with the National Gene Bank of Laos at all, through that particular project you've been working at? And secondly, as you move forward with that project, now that the seed vault in Norway has been operational for eight years and has over 120 countries involved, do you see it as a logical extension to encourage some of the more exotic, special and endangered seeds to be sent in that direction, through the national Genebank, to Svalbard in Norway?

A – Madaline Healey
No, in my experience with the program, that is not something we have been thinking about doing. I have no doubt that it is something that we will look at as the program moves on. At the moment, it's really just a fundamental on-ground project in building continuity, getting things moving. There's a lot of talk today about post-harvest loss as well, and that is probably something that will be looked at in the next stage of the project.

Q – Shumaila Arif, *Charles Sturt University*
My question is for Brian Lipinski. Do you think having a local market like a village mini mart in the developing countries would be one solution to on-farm loss? For example here in Australia we prefer to eat local food, but in the developing countries such as Pakistan where I come from, people prefer their food to come from the best place. Would it be a good thing to provide awareness regarding local food? Would having a local market in the village be one solution to these losses?

A – Brian Lipinski
I think that is definitely is something that could help address losses, by having an additional market where farmers can sell their goods. This would also reduce transportation times, and loss can occur throughout the transport stage and during storage. So I think that idea is something definitely worth exploring. It is not something I am familiar with, but I think anything that shortens the distance that food needs to travel can reduce food loss and food waste. There is less opportunity for it to go bad or be attacked by pests or get bruised in transit – that sort of thing.

Q – Steve Lapidge, *South Australian Research and Development Institute*
A question for Brian Lipinski. You mentioned that US on-farm losses are still considerable. Does the US have a good understanding of what those figures are? Your chart shows 17%. Has that number been ground-truthed at all?

A – Brian Lipinski
As far as I know, there are some estimates from the US Department of Agriculture, but I don't know the extent to which they have been ground-truthed. My guess is that they have not. As I mentioned, it is not a priority area in many of the relatively rich countries at the moment, which is a shame, because I think there really is a lot of potential for reducing those losses and generating income and making that food go somewhere where it's actually used as food, instead of being ploughed back into the soil or composted.

It's something that I'm hoping we'll see more of, because the US has announced a target for reducing food loss and waste that's consistent with Target 12.3 of the Sustainable Development Goals, for a reduction of 50% in retail and consumer waste by 2030. There's no number specifically assigned to farm losses, in either the US target or in the SDG target. That may change if we end up with a change in the US administration in 2016, but you never know. I think we should start to see more attention to on-farm loss, because the target has helped to elevate the profile of this issue.

Q – Jack Hetherington, *Australian Centre for International Agricultural Research*
My question is also for Brian Lipinski. You showed a chart showing the different losses across the process–supply chain. Say if there was a loss of funds and resources for R&D and potentially an ever reducing amount of funds, where do you think you would get the best 'bang for your buck' in directing your funds? Would they be more effective used in the developed world where a lot of the losses are at the consumer end? Or would the funds be more effective used to counter developing-world losses in the production and the value chain?

A – Brian Lipinski
That's a really good question. The best work I've seen so far on that in the developed world is by a group in the US called ReFED (see www.refed.com). Those people created a cost curve – a type of a cost–benefit analysis – of a number of different interventions: what reductions you get, based on investment. In their study, things like changing confusing date labels on packaging, and increasing consumer awareness, actually achieved quite a bit of benefit for the cost, but even if all of the activities that are cost-effective were applied, they still didn't achieve the target the US has set. There are some difficult questions about who would pay for such interventions. It is not always the person who pays for them that gets the benefit out of it.

In a developing country context, I think it is hard to say, because it is hard to lump developing countries together and say that one specific type of intervention would give you the best bang for your buck. The contexts are so different between countries, even though we tend to have this split between developing and developed countries. Someone else on the panel maybe has some thoughts on this? You have a bit more on-the-ground experience than I do on this topic.

Q – Simon Lockrey, *RMIT University*
Brian Lipinski, we are doing a lot of research with food producers on the farm, tracking their resource flows and linking their costs of business to resources they don't use. There's certainly an emergent theme along the lines of the comment you made about inter-wovenness and market inter-wovenness and the ugly food conundrum. Could you comment a little more on what supermarkets are doing in that space, the 'ugly fruit' program you mentioned? What sort of market mechanisms are they looking at, such as via pilot trials by retailers with 'the odd bunch'? How do they link to data, and have you seen Walmart using consumer data to determine what they are doing, such as whether they are targeting the organic-oriented hipsters, or the empty-nesters who are looking for real produce, or the young professional parents packing lunch boxes for their kids every day?

A – Brian Lipinski
Yes, I can comment on that to some extent, though it's not something I'm particularly involved with yet. Walmart in the US does have a zero-waste policy, and food is included in that policy of zero waste to landfill, but they do not yet have a specific food waste management policy. They are not specifically looking at food waste separately.

The program of selling different types of fruits and vegetables in their markets: I think they are doing that almost as a pilot to see what consumers are interested in, and what they are willing to accept. Walmart got a fair amount of negative press in the US when the program was announced because there was a perception that they were trying to sell poorer-quality food.

Globally, the retailer that we have seen do the most is Tesco, based in the UK. Tesco has been publishing food-waste data for the past three years for their operations, on their website, and they are now reporting in conformity with the *Food Loss and Waste Accounting and Reporting Standard* which I mentioned. They are actually leading the way as a retailer in this space.

I cannot answer some of your more specific questions, because I am not sure even Walmart is sure yet what their strategy is on that front.

Q – Margaret Hartley, *Australian Academy of Technology & Engineering (ATSE)*
This is a question for Rodrigo Ortiz. Congratulations on this great approach to innovation, looking at the end use and letting the research come through to answer and solve problems. I am interested in how much further that has gone, not only as benefit to the farmers in the immediate storage issues. Have you had any breakthroughs in technology development that can be further commercialised? Are there additional returns from new technologies that might have been found in relation to particular storage, and can they be further distributed beyond your pilots?

A – Rodrigo Ortiz
Yes, we've actually found two major streams technologically. One is the adaptation of existing solutions to the conditions and the requirements of

smallholder farmers. In other cases, there has been development of new technologies. For example, a couple of storage-solution providers from Uganda who were working with the World Food Programme are now competing in the Kenyan environment, supplying some of these new technologies. Technologies that have been developed include multiple-barrier hermetic bags and devices that have an insecticide impregnated into the plastic liner, on which we have seen a very quick evolution.

Given the very stringent requirements in the Eastern province, because of the prevalence of the Large Grain Borer, we initiated a test to ensure these devices worked. Some of the solutions didn't pass, so they cannot compete in that province any more. The others have continued and are moving forward and we are seeing the idea evolve constantly.

Q – Denis Blight, *Crawford Fund*
Thank you for a fantastic session, and I love the way it flowed from the overview paper on to each of the three speakers presenting case studies. My questions are to Rodrigo Ortiz and to Washington Otieno. Rodrigo, in a sense, isn't the market the prize? Some would argue that your intervention is a recognition of market failure, and that the prize would be the getting of a bigger market share. Why do you need a cash prize?

Washington, I have heard that Plantwise is trialling a serious games idea, the training game. I wish you would give us a sentence at least on that, because I think that had its origins in Australia.

A – Rodrigo Ortiz
Addressing the market, we could say that the traditional market was the larger for medium-size producers. They had the economic opportunity to analyse the possibilities. What was always an unknown factor was the capacity of smallholder farmers to actually buy these products. A traditional storage bag, with no mechanisms to prevent contamination, may cost one dollar, whereas one of the improved bags may cost up to three or four dollars – a substantial outlay on the part of the smallholder farmer. Yet, by creating affordable solutions for them, the smallholder market has reacted very quickly and they are adopting these storage solutions. They are finding that the cost–benefit of these solutions is large, relative to the losses they were achieving before. This is opening a completely different segment of the market that traditionally would not have been developed without providing an incentive for the private sector. This required quite a bit of marketing in production and training on the use of the products.

A – Washington Otieno
Yes Denis, that is the 'Plant Doctor Simulator'. Under Plantwise, we saw the need to have something that can be used digitally to build capacity or train on what Plant Doctors do. Working with Bondi Labs in Australia, we have been able to develop Plant Doctor Simulator 1 (PDS1) and we are developing a second serious game targeting plant doctors giving advice for managing plant health (Plant Doctor Simulator 2). Plant Doctor Simulator 1 is just focused on diagnosis

using pictorials, and Simulator 2 which is being rolled out later in 2016 is focused on recommendations. These are tools that can be used by academic institutions for training across a range of situations. They are some of the products of Plantwise.

Andrew Campbell, Chair
I note that ACIAR has a project called MAD, Mobile Acquired Data, led by Jack Hetherington. I think we shall see this kind of technology increasingly in our projects with the ubiquitous take-up of smart phone technology in many countries, including developing countries.

Q – Sara Blake, *South Australian Research and Development Institute*
Brian Lipinski, you mentioned a standard that supermarkets have. Here in Australia we have a bit of a duopoly between Coles and Woolworths and their standards are quite stringent. Who do you think should be putting pressure on the supermarkets to alter their standards so the different types of quality food can be available to the public?

A – Brian Lipinski
That is a good question. I think what happens is that retailers say they are just selling what consumers want, and that the reason they do not sell some other things is because consumers will not buy them. So there needs to be some sort of demonstration from the consumer level that there is a market for these so-called 'sub-standard products', which we know are not sub-standard.

I think we are starting to see that more, and that is why you are seeing some retailers in some countries adopting a policy of selling 'odd' fruits and vegetables. It is tricky though, because there can be a feedback loop where the supermarket only sells what the consumer wants, and the consumer becomes so used to perfect shiny apples that they then do not 'demand' the slightly bruised apples. The difficulty is in where you start with the 'odd' fruit policy: perhaps you need a brave retailer that is willing to pilot something like that. Maybe they find out that it has been profitable for another retailer, so they try it in a few stores and see if it becomes a larger program. I think there also is some opportunity for consumer campaigns and advocacy, but it is easy for those campaigns to get painted into the corner as being 'left-wing', 'green', and not representing the average consumer. It is a tricky sort of chicken or egg question.

Q – Ali Roush, *Flinders University*
This is a general question for the panel. In monocultures, what role do you think there is for the older varieties of grains and other crops, from the viewpoints both of dealing with pests and diseases and also for production? We have moved away from them these days, but do you think there is room for shifting back to some of the more diverse older varieties for use in production and cropping?

A – Washington Otieno
I can give you examples of what we call African indigenous vegetables. These are plants that in certain parts of the world, even in my days in secondary school,

were classified as weeds. For a long time, people who were getting better educated stopped consuming them. But over time, people have realised that those plants are not easily damaged by the most common pests, and so people are going back to them.

Based on that example, I foresee a situation where people will go back to some old varieties and landraces and find ways of improving them, while retaining some of the traits that have made them very stable and adaptable. The best example I can give you is with sorghum and millet. The very red type is not very popular, but if you are in areas where killer bugs are crawling around, eating all the popular grains, you do not want to compete with them; you go back to what the pests will not take from you.

Q – Xixi Li, *CSIRO*
These have been very interesting presentations, and I see that most of the food loss initiative is directed towards reducing the losses of foods that reach the consumer. What about the losses that are not avoidable, like the parts of fruits or vegetables that are left on the farm, that are edible and rich in nutrients? Do you see our food processing and food engineering bridging those gaps and food losses, and bringing this biodegradable material – which could stand transport and storage conditions – into different parts of the world? Where could that play, and how important do you think it is?

A – Brian Lipinski
It is true, especially in places like the US and Australia, that attention so far has been on the 'food waste' side of things, close to the consumer. I think that is why it is so important that we start paying more attention to the on-farm side of things. As we start to see food loss and waste being on the agenda more and more, as a topic, we are going to see opportunities for 'entrepreneurship' – really innovative methods of processing, and innovative uses for products. We are starting to see novel uses for various parts of foods which might be considered inedible in some parts of the world, yet in other parts of the world the people eat them all the time.

The trouble with those innovative uses is that they are not scalable to the market level; people are not seeing market opportunities, and therefore it can be more cost-effective just to leave those components on the farm and plough them back into the soil and get some soil nutrient out of them that way. If they put in the effort to try and process them into something, they might end up losing money in the end. In other words, those sorts of innovative technologies need to be more cost-effective I think, before we really see a big shift in that area.

Q – Brenna Moore, *World Bank agricultural program in the Pacific*
Thank you to all the presenters for your very interesting presentations. I have a question for Rodrigo Ortiz on the AgResults Program in Kenya, which I think is a program very applicable to our region as well. My question is on the pricing. You mentioned that companies can charge a price that both gives them a profit and still is affordable for smallholder farmers. That is quite an interesting and unusual outcome. My question is in two parts. First, are the companies

differentiating their prices between smallholder farmers and medium or large-scale commercial producers? Do they take into account the farmer's ability to pay when they are setting the price? Second, do you think that this low price is sustainable, going forward, as these companies perhaps move into new areas beyond the pilot regions?

A – Rodrigo Ortiz
They are maintaining a consistent pricing structure, and as part of our verification process we have an external verifier, which validates and ensures that there is not a differential pricing scheme or a dumping of any sort. For instance, sales support through donor/giveaway programs does not qualify for the prize, so we have put into effect a verification scheme to ensure pricing remains fair.

I think that, over time, the benefits will spill over into other regions that produce maize outside the Rift and Eastern regions. The benefits are becoming very obvious, so we feel that will spill over.

I also think that, over time, the prices of the products will go down, because there is a lot of competitive pressure that did not exist there before.

Andrew Campbell, Chair
I am very sorry but we need to call this extremely illuminating session to a close. I agree with Denis Blight's comment that there has been a terrific flow of information, with a masterful keynote and then the overview and then some solutions and success stories from the field. There is a rich ecosystem of possibilities out there.

Innovating to save on wastages in agri-value chains: global and Indian experience

Professor Ashok Gulati
Indian Council for Research on International Economic Relations

ABSTRACT: Globally, about one-third of food produced for human consumption every year (approximately 1.3 billion tonnes) is either lost or wasted while moving from farm to fork. In developing countries, like India, losses occur more from poor supply chains because of poor infrastructure, while in developed countries it is wasted at the retail and consumer end because of higher standards or sheer neglect. Apart from leading to less food available for all, food loss and wastage entail loss of precious scarce resources – water, land, energy, labour, capital – and adversely affect the environment with greater greenhouse gas emissions, leading to global warming and climate change. Both sets of countries need to do a lot to transform this situation, and save precious natural resources. It is much more cost-effective and sustainable to save the food already produced rather than to keep producing more and more to rot. This can be done by building strong, efficient, compressed and reliable value chains in developing countries through investment in infrastructure, institutional changes and innovation in technology, products, practices and policies. Particularly, the role of packaging at the farm level before moving the produce to processing units/wholesalers/retailers needs to be recognised in a country like India where packaging is minimal and the absence thereof causes qualitative and quantitative food losses. The situation in industrialised countries requires better production management, de-emphasising appearance standards, more explanatory date marking systems, and raising awareness among consumers about better buying, cooking and recycling methods. This can save food wastages at the retail and consumer levels.

Keywords: innovation, services, policy, handling and storage solutions

I am going to give a brief overview of the global situation, and then focus more on South and South East Asia. As the Food and Agriculture Organization of the United Nations (FAO) has been telling us, almost one-third of the food we produce (1.3 billion tonnes) is being either lost or wasted. The value of that is US$680 billion in industrialised countries, and roughly US$310 billion in the developing world. If only one-fourth of that were to be saved we could feed roughly 870 million people who are underfed and going hungry.

Also, if we can save food a little better, that should give some people a little higher income, with better prices to farmers and lower prices to consumers, especially in the part of the world where I come from, South Asia. On the whole, that will be true for Africa, too.

This is an edited transcript of the presentation, with some of the powerpoint slides shown.

	Agricultural production	Postharvest handling and storage	Processing and packaging	Distribution	Consumption
Cereals	6%	7%	3.50%	2%	3%
roots & tubers	6%	19%	10%	11%	3%
oilseeds and pulses	7%	12%	8%	2%	1%
fruits and vegetables	15%	9%	25%	10%	7%
Meat	5.1%	0.3%	5%	7%	4%
fish and seafood	8.2%	6%	9%	15%	2%
milk	3.5%	6%	2%	10%	1%

	Agricultural production	Postharvest handling and storage	Processing and packaging	Distribution: Supermarket Retail	Consumption
cereals	2%	2%	0.5%, 10%	2%	27%
roots and tubers	20%	10%	15%	7%	30%
oilseeds and pulses	12%	0%	5%	1%	4%
fruits and vegetables	20%	4%	2%	12%	28%
meat	3.50%	1.00%	5%	4%	11%
fish and seafood	12%	0.50%	6%	9%	33%
milk	3.50%	0.50%	1.20%	0.50%	15%

Figure 1. Estimated or assumed waste percentages for each commodity group in each step of the food supply chain, in South and South East Asia (top), and in North America and Oceania (below). *Source:* FAO (2011).

We all know food loss is mainly accidental. No-one wants spillage or spoilage to happen, but it takes place in developing countries because people do not have the resources to prevent it. On the other hand, food *waste* (left to spoil, or discarded) is more or less intentional. That is what is happening in supermarkets and even in our fridges when food is left too long, for whatever reasons. In industrialised countries, over 40% of food is wasted.

In South and South East Asia where there is still considerable poverty – in fact the largest concentration of poverty globally – food losses are highest post-harvest (Figure 1) in handling and storage, and minimal at the consumption end of the supply chain because people are so poor they do not want to waste anything. That is an important observation when considering innovations where interventions need to be made.

In North America and Oceania, much more of the loss takes place at the consumption end of the chain (Figure 1), in fridges or superstores, amounting to

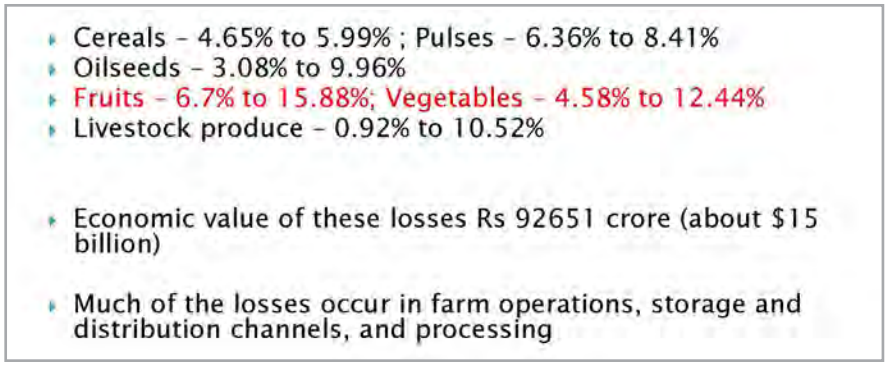

Figure 2. Food loss estimates for India in 2013–14. *Source:* ICAR-CIPHET (2015).

US$630 billion overall. To solve that is a tougher challenge. Interventions here need to be directed at supermarkets and consumers rather than post-harvest.

I come from India, which annually achieves about 800–900 million tonnes of agricultural produce overall, and still has the largest number of poor in the world despite the fact that our country is growing at 7–8% per annum. Our institute, ICRIER, estimates food losses for India, and while they differ from the global estimates they are still substantial in fruit and vegetables (Figure 2).

Causes and innovative solutions

Farm equipment

In developing (low-income) countries, food losses begin with the lack of proper farm equipment (harvesters, threshers, etc.), and that is where innovations would be needed. In a country like India, 85% of farmers are smallholders; they own less than two hectares each, and about 66% own less than one hectare. Even if we can mechanise farming at that scale, with the best machines in the world, how could they afford to use them? When governments offer farmers a subsidy on capital to buy equipment, they still cannot afford to use that machinery optimally, and that leads to over-capitalisation and high cultivation costs. In fact, buying a tractor becomes a problem because they still have to pay the interest.

Here is the innovation that I want to talk about for farm machinery. If we can have Uber taxis in urban areas, why not have Uber tractors, Uber harvest combines, Uber threshers? We have to think outside the box! That is the type of innovation we need. The farmer is willing to pay for a service. If the government wants to give out farm subsidies, let them not be on the price of the machinery, because the manufacturer normally will raise the price to capture all that subsidy. Instead, give the subsidy directly to the farmer's bank account and let him choose the service provider who gives best service at the lowest cost. This is where we need innovation – in policy and in practice. Offering access to these good machines that can save on wastage means the farmer saves on the wastage and that helps him afford the service. That is the type of innovation I am talking about.

Figure 3. Proper packaging can reduce losses in transportation, and wastage.

Packaging and transport

Another cause of food loss and waste is in packaging, which is another challenge for a smallholder. For example, the normal practice for onions on the farm is to leave them loose (Figure 3). The farmers cannot transport loose onions to the markets which may be 20–30 km away. One response in a smallholder economy is aggregation or clustering. This is an innovation in institutional engineering, and India has already demonstrated success in this kind of innovation in the milk supply chain.

Farmers have surplus milk – maybe two litres, three litres, half a litre – and now they have developed aggregation at farm level. Producers with small volumes of surplus milk take it to a central point where each lot is tested for fat content, using a special machine, and paid for on the basis of the fat content. This innovation has been revolutionary in country areas.

India in 1951 was producing only 17 million tonnes of milk per year, whereas the US was producing 53 million tonnes. Today, India produces more than 150 million tonnes annually, and is the world's largest producer (the US currently produces 92–93 million tonnes). Milk production in India is all done by smallholders. Revolution can happen – you need institutional engineering!

This is the type of innovation that is needed in fruit and vegetables, which are not one commodity but 20 commodities – and that is the challenge. We need to start somewhere. When I worked with IFPRI in Indonesia, we visited a

one-hectare farm. This smallholder was part of a cluster of 30 whose produce was collected at his farm, where it was graded, sorted, washed, packaged and barcoded for traceability so the buyer could know where it had come from. The big retailer would arrive in the evening and take that entire produce. The next day the retailer sent their next order for produce, so the farmers knew how much of what commodity they needed to supply the next day. We can come up with this kind of innovation in India.

Market information

The whole system of production and food supply needs to be turned upside down, I believe. Instead of farm to fork it should be plate to plough. Food supply systems should be demand-driven. Farmers should know what the consumer is looking for, what quality, what quantity, so that he can avoid the gluts.

Normally, farmers look at last year's price when deciding what to produce this year. Here is an example. Onions in India are in daily use and there is no substitute for their pungency. Onions have destabilised and unseated the government because the onion prices last year went right up, very high. As a result, this year every farmer was growing onions. Last year he was receiving 30 rupees/kg; this year he can only sell onions at 5 kg/rupee. Onions are being thrown away on the road, in the field, all wasted, all because the farmer could not see what the price would be this year because there is no futures market in onions. A solution – another innovation – would be to bring in a futures market so the farmer can make his planting decisions by looking at the futures prices, not at the past prices. That would be one way to bring some symmetry between a demand-driven system and what the supply can be.

Storage infrastructure

Lack of proper storage infrastructure is another cause of food loss in developing countries – and again the classic example comes from onions. Onions are harvested and then have to be kept for five months to feed us before the next crop comes in. For storage locally, they are put onto a bamboo and cement platform, and tied together. If the weather is hot – and in India the temperature goes to 40–45°C – the onions lose 30% of their weight. If it rains, the onions sprout. Losses like these in traditional storage can be 25–30%, but modernised cold storages at 4°C are available, at a cost of 1 rupee/kg/month, for five months. Onions can be bought from the farmer at 10 rupees, and sold at 15 or 20 rupees, making a profit and stabilising prices. The technology is there, but government policy is interfering with its use. They say: 'You are hoarding, and we will not allow the private sector to hoard. This is an essential commodity.' So what do you do? We need another innovation, first to change the policy and then to bring in the new technology and reduce the losses from 30% to 3% only.

Levels of processing

In considering processing, look again at fresh onions – a classic case which I am using time and time again because it is relevant for India, Bangladesh, Pakistan, Afghanistan, all that belt. If you dehydrate onions you lift their shelf life to two years; 85% of an onion is water. That technology is readily available, so levels of processing that would increase the shelf life and reduce the loss, would be perfectly possible.

Figure 4. Better pushcarts for retail can reduce losses.

Retailing

Finally, the retailing near the end of the supply chain for fruit and vegetables (Figure 4). In India, some small retailers use pushcarts. You could design a pushcart with a solar panel on top, and a little storage container. The retailers cannot sell by night, but they still have to keep the produce fresh. Where can they keep it? They do not have big enough refrigerators at home to keep all this food, and at daytime temperatures of 40–45°C the loss in quality is tremendous from day to day. A simple innovation like a powered storage pushcart could save a lot of loss at the retail level. For cold storage, by the way, the cost of solar panel-produced power has come down below the cost of power from burning coal and the cost of electricity from the grid. Solar power generation on farmers' fields could enable cold storages in rural areas, drastically reducing the losses. This a great product that is already available, and needs to be even more so.

Industrialised countries

Professor Louise Fresco, in the Sir John Crawford address, has told us that Coles supermarkets will have electronic chips to tell them what they need to order at what time. I wish our fridges also had chips to tell us: 'Now this food is one week old and needs to be eaten, otherwise it will go stale.'

Here is a brief outline of some causes of food loss and waste in high-income countries, and some interventions that could help reduce it.

Causes and possible innovative solutions

- **Cause**: Production greater than demand; surplus sold cheap, e.g. for animal feed.
  Solution: Communication and cooperation among farmers to prevent the risk of excess production.
- **Cause**: High 'appearance quality standards' for fresh produce in shape, weight, size.

Solution: De-emphasise 'appearance quality standards'; conduct consumer surveys to better understand consumer preferences on food appearance; shorten supply chains so there are fewer quality and standards checks.

- **Cause**: Failure to comply with food safety standards.
  Solution: Adhere to food safety standards to avoid risk of rejection.
- **Cause**: Rigid/misunderstood date marking with Best before/Use by dates.
  Solution: Improve the accuracy of date marking rules, such as labelling it "safe to consume during this (longer) period", and improving consumer understanding of the labels' meanings.

So many innovations are possible, and you in the industrialised countries will know about them better than I can.

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Towards eradicating a major cause of food unavailability: on-farm losses

Simon Costa
United Nations World Food Programme

ABSTRACT: We are part of a world where an estimated 925 million people are undernourished as a result of ongoing hunger. One in every three children suffers stunted growth, and nearly one in every two deaths in children under five is hunger-related. Such alarming statistics seem incongruous with the fact our world actually produces sufficient food to feed all 7 billion people. Our world's agricultural research funding is mainly dedicated to increasing food production, yet we continually overlook the causal factors of insufficient food supply, emanating from ineffective post-harvest handling and preservation practices. If hunger (responsible for more deaths every year than war or disease, and the loss of more lives than AIDS, malaria and tuberculosis combined) is not attributable solely to inadequate production of food but rather to insufficient availability of food, why is more not being done to reduce the shameful levels of food loss occurring in developing countries? This presentation highlights how these significant food losses are a clear indication of a poorly functioning and inefficient food system. The area of highest concern (where the greatest percentage of crop losses are recorded) is pre-farm gate, where poor harvesting, drying, processing and storage of crops occurs. Recent large-scale practical implementation work with farmers has achieved very significant results in sustainably reducing food losses in sub-Saharan Africa. This has seen reductions in food losses of up to 98% for over 50,000 farming families.

Keywords: preserving farm produce, equipment, education, support

I am here to talk about a real-life practical example of what can be done about food loss, and to try and give you a factual illustration of what we have been working on over the last four years in sub-Saharan Africa. Unlike most of the people at this conference, I am not a doctor or professor of agriculture. I am a businessman, and in previously running a large organisation my job was not to deal with symptoms but to try to get to the causes of problems. And that is also how I approached the role I had with the United Nations. If possible I shall leave you with two take-home messages today: do not let people tell you what you cannot do; and do not let people tell you what is not possible. Certainly try and understand the huge difference we can each make as individuals.

Now, I shall try to tell you what we have been doing, working with a hundred thousand families – in six minutes!

We all see the quotes. The amount of food that is lost every year is shameful, and I can give you 50 examples of people talking about this ... but what has been

This is an edited transcript of the presentation.

done about it? Hundreds of studies have been done, with detailed reports and massive white papers. In fact, there is a study by the World Bank that is a study on all the studies, there is that much focus on the research! However, if you try to find examples of implementing the proposed solutions, they are not available.

The principal reasons for these food losses are fundamentally logistical. (It is important to differentiate between food loss and food waste, which are completely different subjects even though they are often spoken of together.) Ninety-five per cent of all food loss stems from supply chain inefficiencies. Fact.

We see the statistics over and over again and, whether it is the number of people who are severely malnourished or starving, or whether it is the number of children or families that have stunted growth resulting from a lack of the required sustenance, it is lack of food that is our number one killer of people in the world. We know that the world is producing enough food supposedly to feed seven billion people, so if it is not a problem of capacity, what *is* the problem?

It seems to me that fundamentally the problem is apathy. I would argue that although there are a lot of big problems, the world's greatest *solvable* problem (and that is the difference) is the issue of food losses.

This case study is focused predominantly on the sub-Saharan region, although in quantity the food losses are actually greater in Asia. The statistics can be numbing. We hear about 1.3 billion tonnes of food, but what does 1.3 billion tonnes look like? I do not know. I know what a silo holding one tonne of grain might look like, and I know what a one-tonne van looks like. Can you visualise 1300 million one-tonne vans? That gives you some context. Now try and imagine that amount of food every year. It is enough to fill the Sydney Harbour twice, and the Melbourne Cricket Ground from the grass to the top of the stadium 628 times, every single year. This is not a small problem; it is enough sustenance to feed three billion people ... and this is food that is never consumed, every year.

More statistics: in the last half-hour, the statistics will tell us that 50 people will have died of a hunger-related issue. What are we doing about it? What about the tragedies when a plane goes down and a couple of hundred lives are lost? It is a terrible terrible tragedy, and if you got up this morning and a hundred planes had gone down, do you think that would be front-page news? What about if you get up the next day, and the next day, and the next day, and the next day, and another hundred planes, and another hundred planes were lost, each day, do you think we would get everyone's attention at that point? Put deaths from hunger into that context and you become really tired of the talk and the studies to define the problem.

When I got to Africa, I was working at the other end; I was working with the displaced families, the suffering families, the emergencies. I was in one particular camp on the border of Somalia and Kenya where 300,000 people had *nothing*. During each day I was watching families move in their hundreds of thousands; seeing dead people lined up on the side of the road; families bringing in their child and asking: 'Where can we bury the child?'. At night I was sitting in my tent saying, 'What can we do about this? We've got to do more.' During the day I was putting Band-Aids on the problem, and at night I was trying to think how to get

to the cause: Why were these people displaced? How do we shake the apathy and the acceptance that this happens? It is a tragedy, and it is happening. How do we get past the reporting and work on giving them the support they need to overcome the situation? I keep coming back to this point, because we tend to get blasé about it; 1.3 billion tonnes is such a big number, such a lot of food.

There is a huge link between food loss and poverty. When we talk about a farmer losing 30% or 40% of his crop, that represents 100% of his income. He has no surplus. He can sell nothing. He has not enough to feed his family, so there is no surplus to sell, and no income, no way of buying medicine, clothing, education. The bottom line is that food loss underpins many of the fundamental poverty issues. When we talk about making poverty history, this goes to the heart of that.

In her Sir John Crawford address, Professor Fresco shared with us the problems that the world's best minds are turning their heads to: such as, how can we produce more food on the same amount of land? Now I challenge you, is that the right question? Andrew Campbell in Session 1 mentioned the FAO statement that we need to increase food production by 70%. Is that the right goal? Our world has a finite natural resource base. We cannot just keep producing more and more, even if we know how.

I came across a detailed study by the World Bank which said that somewhere around the middle of this century, when there are over nine billion people, we shall require an additional 900 million hectares to feed those people. I contacted the author and said: '900 million hectares sounds like a lot of land! How much land have we actually got if we disregard the environment and deforestation and impacts on the land?'. And he estimated about a hundred million hectares. Nine hundred million needed; a hundred million available. It seems to me there is a fundamental error – which I have identified in all my studies – that we have investment error. Of all the money invested in agricultural development, 95% of it has gone into pre-harvest.

How do we make the farmers more productive? You can give them better seeds, better fertilisers, better irrigation, herbicides, pesticides, and the kinds of post-harvest benefits that Professor Gulati presented (this Proceedings), but the more you put into pre-harvest – say they increase productivity by 50% – the net losses also go up by 50%. That does not resolve the problem.

Clearly, the number one priority must be preserving what has been grown. If we can preserve the crops that are already being grown, the world will be already hundreds of millions of tonnes ahead in food every year. You achieve that without any extra land, any extra water, any extra labour materials, resources, and with no biofuel issues. These are the things to look at.

The gains from reducing food loss are not just for consumers. The benefits for farming families and their communities in sub-Saharan Africa, are massive. I work with governments and political leaders discussing what it means to become an export nation as opposed to an import nation, and the benefits are massive in that context also. There may be costs in reducing the food losses, but

they are a miniscule percentage of 1% of what it costs to make farmers more productive.

Solutions

Three basic things are needed. The farmers need education: they need to know that they can handle the crops better. The farmers need equipment: we should not give them training and then give them no tools to use. And they need support. What if you go and help a farmer be much more productive and produce more crops ... and then he does not have a market? What has he gained? Nothing.

To tackle this I set up an action-research trial, with 800 farms in East Africa, and 800 farms in West Africa. There were fundamentally three steps: training, equipment, support. After a hundred days we had reduced food losses for those 1600 farms by 98%. In addition to reducing their losses by 98%, every one of those farmers who had previously had nothing to sell now had something to sell.

As you can imagine, instead of selling in January, they were able to be selling in April and March. They were getting large amounts of money that they had not been getting before. That was a small trial, and for every single crop, whether pulses or other seeds, after a hundred days we had similar results. The major crop in Africa is maize. After the maize harvest, in two weeks all the crop is gone if managed in traditional ways, so the farmers' reaction to these results was unbelievable. To them it was magic, something they could not have imagined.

We increased to 17,000 farmers. I called in the Massachusetts Institute of Technology University from Boston because the results needed credibility that they did not have if I was the only one reporting them. They sent a team of their brightest and best, and those six people thoroughly examined and confirmed this project with 17,000 people and 98% reduction in losses for those 17,000.

We had to teach the farmers how to build silos because there was no silo industry there. We had to teach them how to test that the silos were hermetically sealed, and then we had to encourage them to change from their traditional storage methods to this new way of storing the grain. I have videos of the farmers' reactions to see this way of saving their crops. We expanded to 50,000 families, and then to 80,000 families. We had massive support from donors, with hundreds of millions of dollars in donor funding. The donors were saying: 'You are getting to the heart of the problem'.

The challenge now is to get it to scale.

In summary, globally we are losing 1.3 billion tonnes of food annually. The value of inputs we are sending to Africa exceeds $50 billion. There are 1.2 billion people starving in the same region where there is 1.2 billion tonnes of food losses. Yet proven simple solutions exist. Our global responsibility is to take those solutions up to scale.

Remember the two take-home messages I gave you at the start of this presentation. So many people within the UN told me that I was not allowed to do this. So many people told me: 'You cannot do this'. Yet I *could* do it, because I was a volunteer.

Simon Costa is the former CEO and Group Managing Director of one of Australia's largest private organizations and the largest horticulture and supply-chain company in the Southern Hemisphere. With over 13,000 employees and 65 business operations, Simon made the decision in 2011 to resign from all corporate responsibilities and focus his time and attention fully on improving the lives of others. A 6-month voluntary position with the UN became a 4-year mission and, in December 2015, Simon and his team were awarded the prestigious United Nations Global Innovation Challenge Award, for the initiative with the greatest 'disruptive potential' for far-reaching societal change (creating a tangible impact towards eradicating global hunger and saving millions of lives every year).

Postharvest physical risk factors along the tomato supply chain: a case study in Fiji

Salesh Kumar[1], Steven Underhill & Sunil Kumar

[1]College of Agriculture, Fisheries and Forestry
Fiji National University

ABSTRACT: Poor produce quality and inconsistent supply currently impede smallholder vegetable growers in Fiji from accessing high-value domestic markets. The available produce destined to go to the market is further lost through poor postharvest handling practices, road conditions and absence of a cool chain. The increasing importance of food and nutritional security in view of climate change factors affecting Pacific Islands Countries intensifies the need to reduce horticultural food loss. Postharvest losses were measured from harvest through to product arrival at the Suva municipal fruit and vegetable markets, with post-municipal market losses determined using simulated storage conditions. In this study, 32.9% of the harvested product was removed from the commercial supply chain. Poor temperature management during on-farm product ripening, and limited on-farm postharvest hygiene were key contributors to the observed loss. Contrary to expectations and comparable studies in other less developed countries, the losses due to transportation to municipal market were low (0.1%). While we found negligible in-transit physical damage to the product in the case study, this does not imply that existing road infrastructure is not an issue in Fiji, or that postharvest quality is not adversely influenced by in-transit conditions. A significant number of high intensity vibration events were recorded along the transport chain, most of which were restricted to a relatively small portion of the western bank Sigatoka Valley road. The small losses post-farm gate (in transport or at the market) are due to fast-to-market transport over relatively short distances and fast on-selling, involving few intermediaries, once at the market.

Keywords: tomato supply chain, temperature, vibration, Fiji

This presentation is from a research study conducted in Fiji, through the University of the South Pacific, with assistance from an ACIAR (Australian Centre for International Agricultural Research) project in collaboration with the University of Queensland and the University of the Sunshine Coast.

Our aim was to assess postharvest risk factors, and for a commodity we chose tomatoes. From talking to farmers in Fiji we see their problems are similar to those faced elsewhere: limited access to high value markets because they cannot achieve the required consistency in the supply and quality of products.

This is an edited transcript of the presentation, with some of the powerpoint slides shown. The paper was co-authored by Professor Steven Underhill (University of the Sunshine Coast) and Sunil Kumar.

Figure 1. The tomato growers use a range of production practices (4 images at left) and a range of situations on-farm for storing and ripening the crop postharvest (4 images at right).

Through the ACIAR project, we set up a 'participatory guarantee scheme' (PGS) between growers and hotels based on agreed quality and quantity demanded. We supported this relationship with 'grower collaborative network assistance' and protocols to improve postharvest handling. To study the postharvest handling aspects, we aimed to analyse the risk, quality and losses in pre-existing postharvest vegetable supply chains. Then we developed tailored low-cost technologies as solutions specific to the local conditions in Fiji.

To analyse the risks, we compared the different modes of transport, road conditions, time to market, packaging and the maturity of the product, as well as post-market shelf conditions, to see where problems were occurring.

There is a range of production practices (Figure 1). Growers use a rain-fed system; some grow the tomatoes on trellising; the crop is usually picked green, by hand, into a bucket or a bag. Tomatoes are ripened on the farm, laid out on a flat surface, such as on the house verandah. Some people when they have extra crop to harvest, lay them out on the floor of a bedroom. If the farm is away from the house, the grower may have a small on-farm shed for ripening the crop. Some farmers have a well set-up storage shed.

Growers also use a range of packaging and transport options that have evolved over the years, with ripened tomatoes variously packed into open drums, boxes, baskets or closed sacks, and transported in closed private cars or vans or in sacks loaded onto open trucks (Figure 2).

Postharvest handling project

Our project focused on Viti Levu, the largest island in Fiji, and on the Sigatoka Valley, where most of the horticultural produce is grown. We observed a range of growers, beginning our observations on Day 1 of the harvest. Ripening on-farm took several days (Figure 3), and then we observed the growers packing the produce, and loading it and transporting it to Suva (Day 6 in Figure 3), arriving in

Figure 2. The growers use various packaging options (4 images at left) and a range of vehicles to take the crop to market (4 images at right).

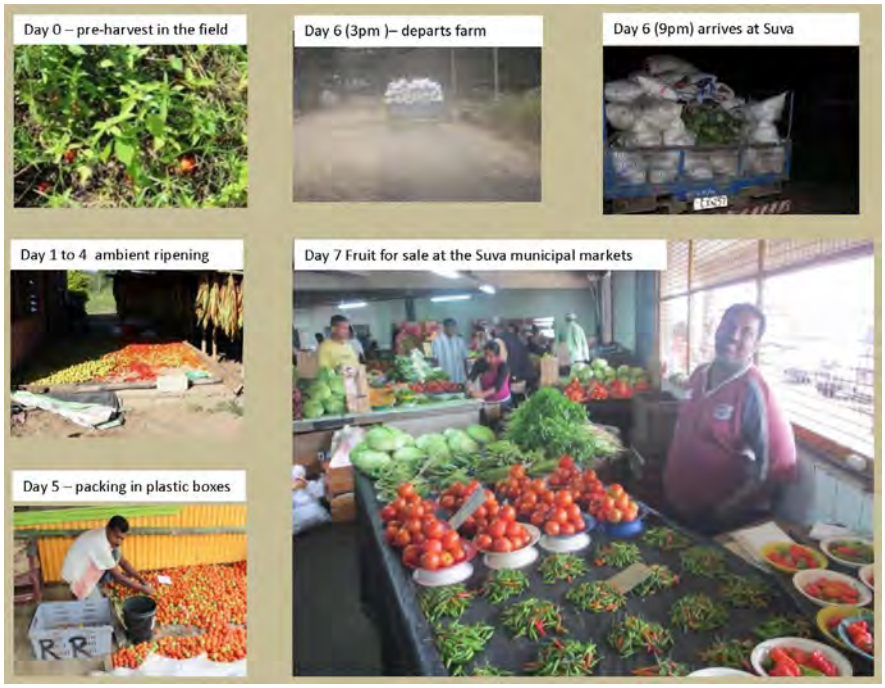

Figure 3. Some examples of the process from picking to marketing for several growers from the Sigatoka Valley who sell their produce at the market in Suva.

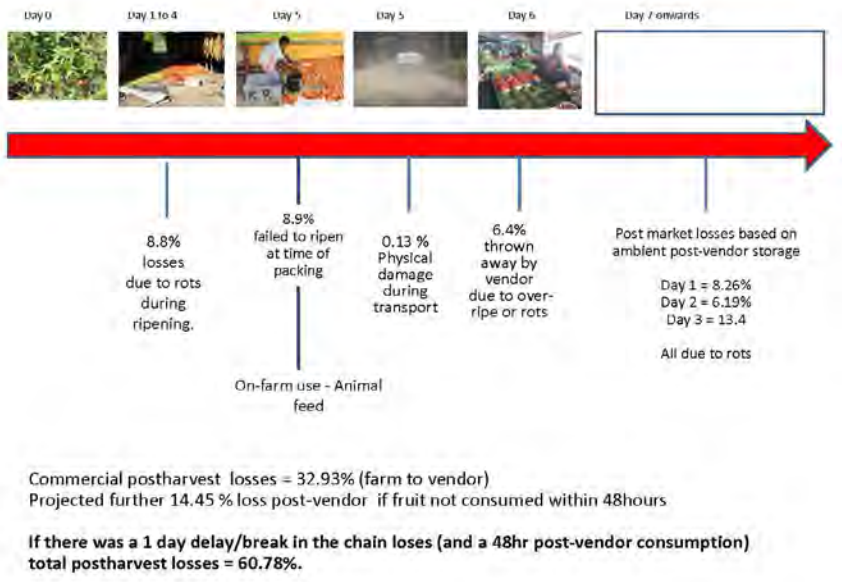

Figure 4. Analysis of typical losses along the observed supply chain.

the evening, around 6–9 pm. The next day (Day 7 in Figure 3) the tomatoes were on sale at the market.

We estimated and analysed the losses from Day 1 onwards: how they happened, and what happened. Figure 4 shows typical results: 8.8% losses due to rot during the ripening process; 8.9% failing to ripen (not a loss, because they were used on-farm for animal-feed); 0.13% physical damage during transportation; 6.4% thrown away by the market vendor because they were overripe. Then post-market over three days there were further losses from rotting because of storage conditions (Figure 4). We also simulated the effects of natural events such as flooding interrupting the process and preventing the produce reaching the market (Figure 4).

We measured the ambient temperature around the produce, from Day 1 of the harvest onwards. If tomatoes should be kept at around 25°C after harvest, the measurements (e.g. Figure 5) showed that during travel that was the case, but not during on-farm storage and ripening.

For the transportation stage, we fitted a Global Positioning System (GPS) and vibration recorders and data loggers onto the truck so we could see what was happening throughout the journey from the valley to the main municipal market in Suva. During transport, there were vibrations damaging to tomatoes on a particular section of the road to Suva (Figure 6), specifically 30 minutes and eight seconds after leaving the third farm in the pick up truck! The data-loggers showed when the truck stopped; the driver behaviour; all those details.

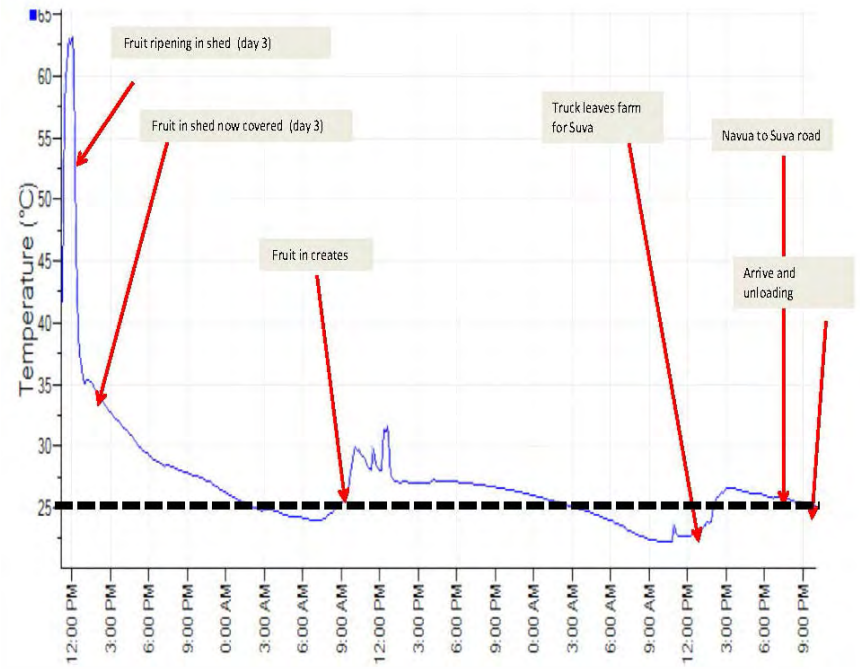

Figure 5. Tomato storage temperatures on-farm and during transport to Suva markets.

Findings

In this study, postharvest loss of tomatoes along supply chains was 32.9%. We found out that the road conditions are poor. Also, that the packaging was not ideal. However, the key postharvest challenge in terms of quality is on the farm, because of the on-farm ripening process.

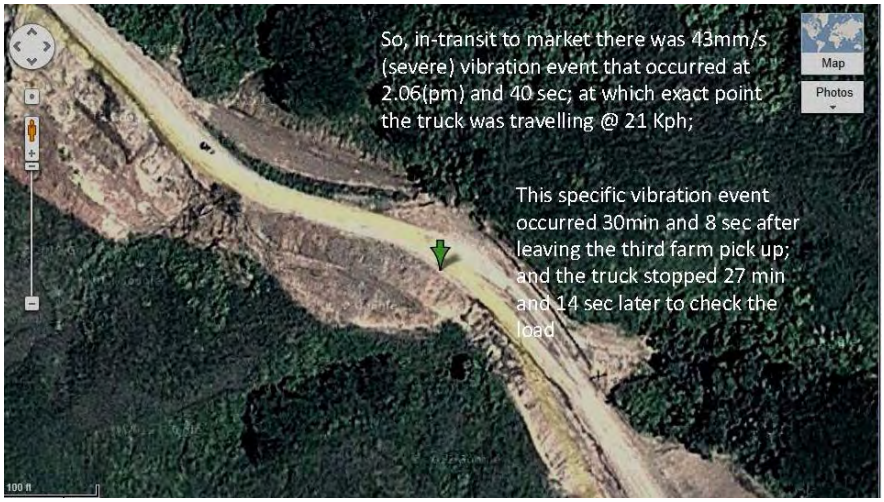

Figure 6. The exact spot where the vibrations were worst in one recorded journey!

Growers need to apply better ambient ripening practices on-farm, and better postharvest hygiene and packaging. Farmers are busy with many activities and are not necessarily harvesting the tomatoes at the best stage of ripening. They need to sort the picked fruit and remove tomatoes showing signs of rot, to reduce the build-up of pathogens in the rest of the harvest.

Postharvest and post-ripening, other factors can be modified to reduce losses. Plastic crates (recycled to save money) for packing give the tomatoes better protection than bags. Positioning on the truck is another factor. Putting the tomatoes at the front of the truck, with other vegetables further back, would reduce the impact of the vibrations on the tomatoes. The speed of the truck also matters – driving more slowly, especially in heavily loaded old vehicles, would reduce the effects of the vibrations. And on-farm ripened fruit is less prone to vibration stress.

Postharvest capacity-building

We aim to build postharvest capacity in Fiji and in Solomon Islands, by:

- helping growers gain knowledge to support better agribusiness decisions;
- exploring alternative postharvest strategies by providing simple low-cost tools to do that;
- using relatively high-tech equipment in a participatory learning environment to highlight relatively fundamental handling practices; and
- highly targeted remediation.

Salesh Kumar is a lecturer at the Fiji National University in the College of Agriculture, Fisheries and Forestry, based in Koronivia, Nausori, Fiji. He is undertaking his PhD at the University of the South Pacific under the University of the South Pacific–ACIAR Scholarship Program. His research focus is postharvest handling practices of high value horticultural crops along the value chains in Fiji, under the guidance of Professor Steven Underhill, University of the Sunshine Coast, Australia. Salesh has attended conferences and published articles originating from his ongoing postharvest research work. He has accumulated considerable experience in the agricultural sector having worked for the Fijian Ministry of Agriculture for over 15 years. He is currently involved in an ACIAR-funded tropical fruit project with postharvest work to commence in Fiji, Tonga and Samoa.

Scavenging for protein and micronutrients: village poultry in Timor-Leste

Dr Joanita Bendita da Costa Jong
Veterinary Services, Ministry of Agriculture and Fisheries

ABSTRACT: Food loss and waste in Timor-Leste has been identified as a critical factor contributing to human undernutrition. Our project enhances natural scavenging systems by improved poultry production, with improved management, vaccination against Newcastle Disease (ND) and logistical support. We are working with the University of Sydney to implement the sustainable use of heat tolerant ND vaccine, administered as eye drops triennially by trained paraveterinarians. The Australian Department of Agriculture and Water Resources conceived and jointly manages the project with the Timor-Leste Ministry of Agriculture and Fisheries. They provide training in national biosecurity and biosecurity practices applicable to village poultry. Management systems are supported with locally made shelter to protect from predation. With the help of Berrimah Veterinary Laboratory we are improving cold chain management and vaccine potency verification. The project is funded by the Australia Department of Foreign Affairs and Trade. Increased poultry production with these improved systems leads to improved scavenging systems – more hens equals more effective searching for scraps, insects and other invertebrates as they fend for themselves with minimal carbohydrate input provided by their owners. In return more hens are available to produce eggs for sale or chickens for consumption. Each of these activities results in better availability of balanced protein and bioavailable micronutrients for growing and lactating humans. Once households observe that their flock dynamics are no longer subject to dramatic decreases, the consumption of eggs becomes an option rather than prioritising them for hatching to obtain replacement birds.

Keywords: village poultry, vaccine, protein, nutrition, women and girls

In Timor-Leste, according to the 2015 census, our human population is 1,167,242. We have a tropical climate with a wet and a dry season. There is stunting in 50% of children under five years, due to lack of nutrition and micronutrients and the energy deficiency of food for children and pregnant women. People have poor dietary diversity, with low intake of animal-sourced foods because those are expensive, especially local chickens. That is why we are trying to improve animal production, through local chickens, to feed our community and especially community farmers in the rural area.

This presentation relates to my job as the Program Coordinator for Village Poultry Health and Biosecurity. My Directorate runs the animal health services for the whole country, especially focusing on places where there are many animals and people raising animals. Expansion is bringing the animal health service closer to the community, to give them better access to it. We run

This is an edited transcript of the presentation, with some of the powerpoint slides shown.

Details	Numbers	Percentage (%)
Total Households (HH)	184.000	-
HH with Crops	160.000	86 %
HH with no Crops	20.000	10 %
HH with Livestock	178.000	97 %
HH with Chickens	146.000	79 %
HH with Pigs	177.000	96 %

Details	Numbers
No of Chicken	929.000
No of Chicken/HH	6.35
No of Pigs	420.000
No of Pigs/HH	2.5

Figure 1. Agricultural population data for Timor-Leste.

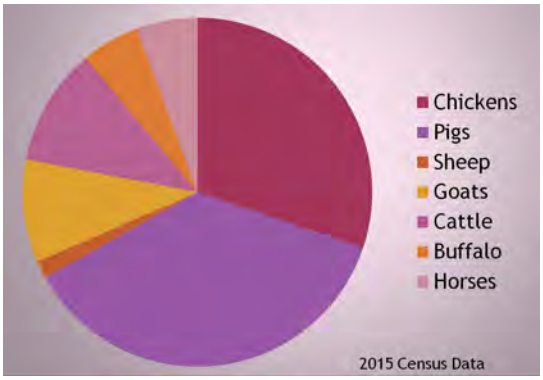

Figure 2. Livestock ownership by 178,363 agricultural households.

vaccination programs for cattle, buffalo, pigs and chickens. The agricultural population figures (Figure 1) show that of the total 184,000 households, 160,000 grow crops (86%) compared to households with no crops (20,000; 10%). However, almost all households (97%) have livestock, and 96% of those households raise pigs and 79% raise chickens.

Most households have both chickens and pigs and the farmers raise more than one type of animal (Figure 2). Households with livestock also keep sheep, goats, cattle, buffalo and horses, as well as the 420,000 pigs (2–3 pigs per household). Each household with chickens has up to six birds, totalling 929,000 chickens.

However, we are losing village poultry because of high animal mortality. The main problems in raising local chickens are:

- Newcastle Disease which is endemic, and when there is an outbreak it kills all the local chickens;

Figure 3. We are vaccinating the chickens against Newcastle Disease in three pilot villages.

- predation, because local chickens find their own food by scavenging in the forest in the day time, and are taken by wild animals, feral cats, dogs, snakes, eagles and humans; and
- under-nutrition in the chicks.

With this particular project – Village Poultry Health and Biosecurity – we are trying to increase the consumption of chickens, as a source of animal protein for the children. Currently, people only eat chicken meat during periods of high chicken mortality from an outbreak of disease.

The project, founded by the Australian Government Partnerships for Development, aims to:

- improve production of local chickens in three pilot villages, and
- strengthen biosecurity arrangements in Timor-Leste.

One village is in the western part of the country, one is in the centre, and one is in the east. We are trying to engage the community to be involved in the vaccination programs to improve the local chickens so they can be used to feed their children and the pregnant women.

In reality, at the moment, when communities produce extra chickens, extra eggs, they prefer not to eat them but to sell them and buy something else, such as frozen chicken from Brazil, or sausages or fish. However, having bought these from the supermarket, they travel home without using ice or anything to keep them cool. There is no refrigeration in the districts anyway to keep the food fresh, so the extra production is actually creating problems in the country.

The Village Poultry Health and Biosecurity project has three main components:

- village poultry health and management, including disease investigation;
- an effective cold chain for the poultry vaccine, so as to keep the vaccine cold until it is dropped into the eye of a chicken, and for this we are collaborating with the Department of Agriculture and Berrimah Veterinary Laboratory; and

- strengthening poultry biosecurity, through better quarantine, for which we are working with Australian quarantine authorities to see how to set up import conditions into Timor-Leste.

Achievements so far

The project started in March 2014. We launched our first vaccination campaign in the three pilot villages in November 2014 and so far have run five campaigns including the one in March 2016 (Table 1). Up to one-third of households in the villages have been involved so far, and the number of chickens vaccinated per household has increased over the 18 months.

The project so far has produced a number of highlights. By improving the health of village poultry, there is:

- decreased loss of chickens and eggs,
- an increased amount of chicken products available for consumption or sale, and
- improved standards of living for communities.

In Timor-Leste, livestock have a critical and complex role in food security because, as you have seen, almost every household has animals. Even in Dili, people have chickens and pigs so there is no waste food at home. Anything we do not eat ourselves goes to the animals. People buy the waste food from restaurants to feed their pigs and chickens.

For us, food security is equivalent to nutrition security. This is very crucial for our developing country.

Another important point I want to leave with you is this: we are trying to encourage investment in women and girls, to get them involved in this work. I am a veterinarian, and a field veterinarian, and I am working very closely with our farmers, especially the women and girls, to improve their livelihoods for the future. If we can convince more women to become involved in this project, and even get more women to become involved in the agriculture sector, there will be good returns to their villages.

Table 1. Summary of available data from five vaccination campaigns

Details	Nov 2014	Mar 2015	Jul 2015	Nov 2015	Mar 2016
Total number of chickens vaccinated	1865	2429	4218	3028	3076
Total number of households vaccinating	251	408	351	345	257
Percentage of households vaccinating	20.4	33.1	31.0	28.0	20.9
Average number of chickens vaccinated per household	7	8	12	11	12

The Timor-Leste Government, through the Ministry for Agriculture, also wants to encourage the community to be more involved in the agriculture sector, because as a country we cannot rely on petroleum or other industries to bring us national benefits.

Acknowledgements

I would like to thank the Crawford Fund, the Australian Government Department of Agriculture & Water Resources, the University of Sydney for designing the project, and also Australian Aid, for supporting our government of Timor-Leste, especially the Minister of Agriculture, to deliver this three-year project.

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Dr Joanita Bendita da Costa Jong, the first female veterinarian in Timor-Leste, is the newly appointed National Director for the Veterinary Directorate in Timor-Leste's Ministry of Agriculture and Fisheries. As a National Director, her role is to supervise three departments: the Department of Public Health and Animal Welfare, the Department of Controlling Medicines and Equipment for Animals, and the Department of the Veterinary Diagnostic Laboratory. All three departments play very important roles within the country's animal health development. Joanita is responsible for the supervision of data collection for Timor-Leste's national animal disease reporting system, and the management of data collected from vaccination programs for cattle, buffalo, pigs and chickens. She also performs ante- and post-mortem inspections at the national slaughter house. In her ten years there, Joanita has made significant contributions to the development of her profession through capacity building within the country's network of Livestock and Veterinary Technicians, Extension Workers and other animal health staff, as well as local and international NGOs.

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Session 3 Q&A – From farm gate to fork

with Professor Ashok Gulati, Simon Costa,
Salesh Kumar & Dr Joanita Bendita da Costa Jong

Chair: Dr Helen Garnett

Q

Today we have seen a lot of statistics around food loss and food wastage, currently estimated at 1.3 billion tonnes. We have not really been talking about how wastage is impacting on malnourishment in the sense of micronutrients. My question is about something that I perceive as food wastage, because it is intentional. What is the panel's view on the way we under-utilise animals and animal-source foods: animal parts such as offal, which are very nutrient dense, and can be quite critical for those most vulnerable, such as children and pregnant and lactating women?

A – Ashok Gulati

Combating malnutrition and devising innovations to get better protein or vitamins, particularly at low cost in developing countries, those are challenges. Here is one example. In her Sir John Crawford address, Professor Fresco talked about the possibility of 30% of the protein in your meat coming from soya bean or lupins, through innovation and product development. In India, which I am more familiar with, for poor people the protein source is dahl – the pulses, the lentils. Pulse prices have been increasing at 30% per annum. There is a shortage. However, we have about 10 million tonnes of soya bean. In talking to farmers who produce soya bean, about 100 of them, I asked if any of them consume soya bean themselves. They said, 'Is it to be eaten? We thought they take it away, extract the oil and then export the oil cake.' So my team looked at the situation, and found that soya flour mixed with wheat and rice can be reconstituted into a dahl. It is half, or less than half, the price of regular pulses, and has better protein content. We cooked it and it tastes very good. It is going to be launched as a product soon.

Lupins are a very nutritious food, yet they are being sold at $300 per tonne as feed for livestock, while we pay $900–$1000 per tonne for other pulses. Surely we can innovate? The food technologies of today are capable of making lupins more palatable. As another example, in Japan, China and South East Asia, tofu (which is made from soya beans) is a basic staple. In South Asia we use paneer, a cottage cheese, in a similar way, but it is double the price of tofu. By innovating, the simple food technologies of today can give us very good protein foods for humans from materials which are currently sent to feed cattle, or rejected. No other crop can give you cheaper amounts of protein per hundred grams than soya beans. By comparison, protein from milk products is very expensive – too expensive for poor populations. We need to start paying attention to developing these alternatives to produce food at a lower cost.

Helen Garnett, Chair
Dr Jong, in East Timor I think people will eat most of an animal. They eat the parts that we in Australia would call 'offal' – such as the liver. You eat the whole chicken, do you not?

A – Joanita Jong
Yes, we do eat the whole of the local chickens. The frozen chickens from the supermarket include only the bones and the meat. That is why when the people in the villages have a guest they will kill a local chicken. One or two local chickens can feed all the people in the house.

Q – Alejandro Trujillo-Gonzalez, *James Cook University*
Thank you for the presentations. My question and comment are about biosecurity. Professor Gulati, I love the idea of Uber tractors, but they are a textbook example of what not to do if you want to prevent a combination of diseases or potential parasites moving between farms. I agree with you that innovation and education of farmers is important, so I'd like to ask how much of a priority is biosecurity in India? Is biosecurity something that should be considerd when training farmers?

A – Ashok Gulati
Labour costs are increasing in the rural areas of India by about 15–20% per annum in nominal terms, and about 7% per annum in real terms. We are almost at the inflection point where capital is going to be cheaper than labour. This transition that we are making is not just a textbook example. One of the biggest companies making tractors in India, Mahendra and Mahendra, which controls about 45% of the market share, just last week announced that they are going to try making Uber tractors available. I am asking them to take that further and include farm implements such as threshers, because threshing and winnowing are done manually in the field, and materials are lost and left on the ground. Your question, about transmission of diseases from one farm to another, is not something we have really thought about. However, I am not sure that mechanisation is a real cause of diseases moving from one farm to another. We will have to think about that, and look into it. I do not have a ready answer to your question.

A – Joanita Jong
We are implementing simple biosecurity in the villages. When there has been an outbreak of disease, the people have not known they are the ones that are transferring the disease from one place to another place. That is why in our project we are teaching the community that if there is a disease outbreak then you have to be careful what you do with the dead chickens. If there are dead chickens in a neighbouring village, you should not bring in new (live) chickens from that village, because they already are diseased, and viruses in those new chickens can affect the chickens already here in this village. That is very straightforward. My team also deals with biosecurity and the broader picture, because we share a border with Indonesia. There are many illegal movements of materials across that border, and that is also part of the project I spoke about. I deliver education on how dangerous diseases such as rabies or avian influenza

– which are in Indonesia – can affect our country at any time. That is our task in relation to biosecurity.

Q – Jenny Goldie, *Sustainable Population Australia*
My question is to Ashok Gulati, but others on the panel may care to comment also. I was entranced by your food cart that had solar panels on the roof, and it reminded me of E.F. Schumacher's 'appropriate development' from the 1970s. I wonder, to what extent do you think that technology can be scaled up to solar-powered trucks for carting fruit and vegetables? Or do you think it will be confined to food carts?

A – Ashok Gulati
If you look at what is happening to solar technology, since 2010, 2011, the costs of solar power have come down by 70% – a dramatic decline. Globally, about 140 gigawatts of power are being generated by solar technology today. In India, today, 8 gigawatts of power come from solar, and India has set a target of 100 gigawatts by 2022. That is the biggest target set by any country in the world. Now, it is not going to be coming only from the rooftops in urban areas, because there are not enough roofs. But there are all sorts of possibilities, including having a solar 'crop' at 15 feet above the ground. That is, the farmer can have a traditional crop growing in the field, and at 15 feet high you put in a chessboard type of configuration so there is enough light for the traditional crop to photosynthesise as well. This could give the farmer a regular monthly income. It is just one of the ideas we are talking about with the government at present. It could unleash a revolution, give higher incomes to farmers, and change the rural landscape because, at present, power is not available in the rural areas. All the energy goes to Delhi dwellers and Mumbai dwellers and others in the urban areas, and the rural areas get hardly any electricity. For eight hours per day they do not have electricity. Once you generate electricity in rural areas, it can be distributed, and surplus power can be fed into the grid. You have to think totally 'out of the box' from the farmers' fields to these carts. This could increase the shelf life of the commodities, via cold storage. It is going to take off, and we are already in discussions on these questions. I can send you some more literature. Five, seven years back, the costs of solar power were very high compared to traditional thermal power. Now, they are lower than from burning coal.

Q – Tony Fischer, *Crawford Fund*
Mr Kumar, you mentioned the hotel market at the beginning of your talk, but then you focused on the vendors in Suva. In many parts of the world, tourism is very important, and I wonder what success you had in getting tomatoes at a good price to all those big tourist hotels in Fiji?

A – Salesh Kumar
Thank you. I started with the 'participatory guarantee scheme' project between growers and hotels based on agreed quality and supply, and it was successful, and there is further funding of that via ACIAR – thanks to ACIAR. At one time, the hotels were importing tomatoes at $18/kg. To analyse the situation for our project, we did a market transformation study. After changes of chefs and of management in the hotels, they agreed that if the local growers were able to

provide good quality tomatoes and a consistent supply, then definitely they would buy those instead of importing. The hotels are not prepared to pay local growers $18/kg, but they would buy local tomatoes at $4/kg. In fact, because tomatoes are seasonal, being either in-season or off-season, when there is a glut in-season the growers would be happy if they get $1/kg. But these hotel personnel have agreed that they are prepared to pay $4. So that is where the market stands.

Q – Peter Wynn, *Charles Sturt University*
Simon Costa, a question to you about Africa. With true free-market forces prevailing in the marketplace, as I think happens for example in Niger, I have heard of nomadic farmers having their market destroyed by the dumping of European Union milk powder. Do the farmers you are dealing with, or were dealing with, really have the incentive to invest in storage solutions to improve their marketing?

A – Simon Costa
The very short answer, Peter, is 'yes'. There were no external players involved. They could just market the crops they had available, and were able to sell their crops at times when others did not have crops available. The large-scale projects I was talking about were in the east of Africa, and large consortiums out of Kenya, for example, were willing to come and pay for the produce, because it did not have aflatoxin contamination. We were focused on not only more quantity, but also better quality. From all the testing now, we are aware of the enormous impacts that aflatoxin contamination can have on the health of the locals. The better quality, healthier product these farmers were providing to the markets was reflected in the prices that people were paying. They did not just have to accept what the locals would pay. The other massive difference was that, for the first time ever, these farmers had control over when to sell. Every other smallholder farmer in that region must sell when the buyer comes to town, and if you do not sell to him, you do not sell to anyone. But these people, for the first time, could say, "I won't sell this week. I won't sell this month. I've got a foodbank there that I can draw from. And if I need to hold it for six months, I'll hold it for six months." That was unheard of; it was like science fiction for these people. When you have the farmers from a district who can not only identify what crops are in storage, but also the volume of it, you have created a decentralised storage platform, instead of putting in massive centralised storage hubs. If you can imagine just a thousand farmers with a thousand kilos each safely stored, you have got a million kilos, and that lifts the food security for the region. Coming back to your question about the individual farmers, they have control over when they sell, and control over who they sell to, and the benefits just keep flowing from there.

Helen Garnett, Chair
It's my pleasure to thank our four speakers this morning, coming from different parts of the world, for sharing – from the farm gate and packaging, to the processing side – that education, new technologies (and those new technologies can be very local) and new logistics are making a huge difference.

Food loss in supermarkets: what can supermarkets do to reduce food loss?

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ABSTRACT: Food loss occurs along the entire food chain, including losses at wholesale and retail markets. Among retail markets, supermarkets have important roles in food chains since they are located close to the end of the food chain. In developing countries, supermarkets are increasing, and are making a significant contribution to national retail food sales. Along with rapid development, food loss occurs in significant amounts in supermarkets since they sell large quantities of food. This paper aims to review and estimate food loss and food waste in Indonesian supermarkets focusing on fresh fruit and vegetables, fish and meat products. First we review food loss in supermarkets from the previous literature. Then we report on a case study conducted with a leading supermarket in Indonesia in order to estimate its food loss and its efforts to prevent the amount of food loss. Reducing food loss in supermarkets is an important issue in terms of the efforts to increase profit in supermarkets, to increase income for small farmers supplying to supermarkets, and to improve food security in urban areas, as well as avoid environmental problems caused by food waste.

Keywords: food losses, food waste, supermarkets, Indonesia

Food loss is an emerging issue in the food policy agenda because of its contribution to financial losses, food security issues, and waste of natural resources. According to some estimates, about one-third of food products intended for human consumption is lost or wasted globally, which amounts to about 1.3 billion tonnes per year (FAO 2011). When such a large amount of food goes to waste instead of being consumed by people, a lot of money will be lost (Ventour 2008). In addition, large amounts of limited natural resources dedicated to food production are wasted.

Food moves from farm to the table of consumers, and loss occurs along the entire food supply chain including (i) loss at farm level, (ii) loss at the wholesale and retail level, (iii) loss at the consumer level (Buzby *et al*. 2009). At the farm level, over-production, poor balancing of supply and demand, and inefficient supply chains contribute to food waste. Losses at the wholesale and retail level occur in both traditional and modern markets, and are caused by poor handling, poor transportation systems, and poor analysis of demand and supply. At the consumer level, losses include cooking loss and uneaten food such as plate waste which can be caused by insufficient purchase planning by the consumers.

This is the paper and some of the illustrations presented by Dr Daryanto at the conference.

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Loss at the retail stage is a relatively small share of the total food loss across all stages of food chains. Göbel *et al*. (2012) and Jensen *et al*. (2011) reported that the retail sector contributed about 3% to food loss in Germany and 3.8% in Sweden. Although the retail percentage loss is relatively low, the total loss (on a weight basis) is relatively high, about 95–115 kg/person/year in developed countries and 6–11 kg/person/year in developing countries (FAO 2011), or 39,000 tonnes per year in Sweden (Jensen *et al*. 2011) and 4.4 million tonnes per year in the European Union (EC 2010).

Among retail markets, supermarkets (a term which, in this study, means modern food retailers including supermarkets, hypermarkets and convenience stores) have important roles since they are located close to the end of the food chain. In developing countries, supermarkets are making increasingly significant contributions to national retail food sales. In Indonesia, the number of supermarket outlets increased significantly particularly in the period 2009–14. During this period, the number of hypermarket outlets grew about 12.7%; supermarkets by 15%; and convenience stores (mini-markets) by 34% (USDA GAIN Report 2015). In 2014, the number of hypermarkets, supermarkets, and convenience stores reached approximately 300, 1400, and 22,800, respectively. Supermarkets make a significant contribution to national retail food sales including of fresh fruit and vegetable products. Sahara *et al*. (2015) reported that in the three leading supermarkets in Indonesia, fresh fruit and vegetables contributed about 15% to supermarket sales in 2015. It is expected that supermarkets' share of retail food sales will continue to increase along with rapid growth of per capita income, urbanisation, and liberalisation in foreign direct investment.

Food loss in supermarkets can reduce profit, and the products most susceptible to loss are fresh products including fruit and vegetables. From a microeconomics perspective, examining the amount of fresh products that go unsold in supermarkets is timely, to understand where and how much food loss can be reduced to improve supermarket profitability (Buzby *et al*. 2015). In addition, as is the case in many developing countries, the majority of fresh products in supermarket chains in Indonesia are supplied by smallholder farmers (Sahara *et al*. 2015). Given this situation, a reduction in food losses might affect farmers' income. From the macro perspective, reducing food loss can contribute positively to food availability and food security particularly in urban areas, as well as saving natural resources. Unfortunately, studies on food loss at supermarkets are very limited, particularly in developing countries including Indonesia. This paper aims to review and estimate food loss in supermarkets, focusing on fresh products: meat, fruit, vegetables and fish.

Methods

The data in this study is based on a **literature review of studies** related to food loss at retail outlets, particularly supermarkets, and a **case study** performed in a leading supermarket chain (which we shall not name) in Indonesia. Fresh products are the main focus in the study, and for the case study we selected four fresh products including fruit, vegetables, fish and meat.

During the case study, we conducted a face to face interview with the director of the fresh product department in the leading supermarket chain regarding food loss of the fresh products that were the focus of the study. The leading supermarket is currently running two types of business stores: wholesale and retail (Table 1). The term 'wholesale store' refers to large stores mainly supplying hotels, restaurants, catering and other small retailers. With that kind of market segmentation, the wholesale stores sell large quantities of products at lower prices than in the retail market. The term 'retail store' refers to hypermarket and department stores mainly supplying households. The products sold by retail markets are more varied than those in wholesale stores, but relatively small in terms of quantity and value. The data for wholesale stores is available for a period of 27 months (January 2014 – March 2016). For retail stores, data is only available for the 24-month period January 2014 – December 2015.

Table 1. Types of stores run by the leading supermarket chain in this study 2014–16

Type of store	**2014**	**2015**	**2016**
Wholesale store	24	24	25
Retail store			
– Hypermarket	13	13	14
– Department Store	1	3	2

Fruit, vegetable and seawater fish are sourced from farmers or middle men and sent to the distribution centre owned by the leading supermarket chain. For meat and poultry products, the products are sourced from farmers or the slaughterhouse before they are delivered to the distribution centre.

All the fresh products need to meet the quality and quantity standards required by the leading supermarket chain. Checking for the quality standards of all the fresh products is conducted at the distribution centre. Products that do not fulfil the requirements are rejected and sent back to the farmers or middle men. Products that have met the quality standards are distributed to the stores run by the leading supermarket.

This study examines food loss occurring from the distribution centre to stores run by the leading supermarket, on a value basis. Following Lipinski *et al*. (2013), we define food loss and waste as edible parts of plants and animals that are produced or harvested for human consumption but that are not ultimately consumed by people. In this study, the food waste calculation is based on the ratio between the value of food losses (unsold products) and total value of sales in each store run by the leading supermarket chain (Figure 1). Due to

$$\text{Percentage of food loss} = \frac{\text{Value of food losses}}{\text{Total sale value}} \times 100\%$$

Figure 1. Formula used in this study for calculating the value of food waste.

confidentiality issues with respect to the data, particularly the values of food loss and sales, we can only display the final results of the calculation as percentages.

Results and discussion

Review of food loss studies at the supermarket and retail levels

Despite increasing attention to the food loss issue among researchers and policy makers, empirical studies examining the amounts of food loss for fresh products in supermarkets are still limited, particularly in Indonesia. A few studies have examined causes and amount of food loss (and waste) in supermarkets and how to reduce the number (FAO 2011; Eriksson 2012; Bond *et al*. 2013; Lipinski *et al*. 2013; Buzby *et al*. 2015). The definitions of food loss vary among the studies and are sometimes interchangeable with food waste. As such, the estimates from previous studies are not directly comparable, making it difficult to perform precise comparisons across the studies.

Eriksson (2012) examined food loss at six supermarkets in the Uppsala-Stockholm region of Sweden. The study defined food loss as food waste: the products discarded in the supermarkets, irrespective of whether they belonged to the supplier or the supermarket. In the study, Eriksson (2012) focused on pre-store waste and recorded in-store waste. Pre-store waste refers to items rejected by the supermarket at delivery because of non-compliance with quality requirements. Recorded in-store waste refers to products discarded by supermarkets when there is little or no possibility of selling the products. The estimate was based on weight. The study found that loss in the fresh food and vegetables department was dominated by pre-store waste compared to in-store waste, 3% versus 1.3% respectively. The main cause of pre-store waste was rejection because the supplier could not meet the quality standards needed by the supermarkets. Tomato was the most wasted product followed by banana and lettuce. Among fresh products sold in the supermarkets the organic products contributed the highest percentage of waste.

Buzby *et al*. (2015) assumed that 'shrink' for fresh fruits and vegetables was food loss, when they estimated fresh produce and food loss of US supermarkets. In the study, 'shrink' is defined as the produce that is delivered into supermarkets for sale but is not sold for any reason. The estimate was based on weight. They found that in the period 2011–12 the shrink rate for individual fresh vegetable products ranged from 2.2% for sweet corn to 62.9% for turnip greens. During the same period, the shrink rate for individual fresh fruit products ranged from 4.1% for bananas to 43.1% for papayas. On average, the annual food losses for fresh vegetable and fruit products were about 6.1 billion pounds and 5.9 billion pounds, respectively.

Other studies on food loss highlight food losses occurring along the entire food chain including losses at the supermarket level. FAO (2011) examined food losses in the entire food chain by utilising the definition of food losses as the decrease in edible food mass throughout the part of the supply chain that specifically leads to edible food for human consumption. In the study, food losses taking place at the end of the food chain (retail including supermarkets, and final consumption) are called food waste. In some countries, the researchers calculated food loss at the supermarket level, but in most cases they calculated

the loss for all retail including loss in supermarkets (Table 2). On average, the loss rate for fruit and vegetables was the highest, and was above 10% in all countries, followed by waste of fish and seafood products and meat.

Table 2. Fresh products waste at the retail level (%)

Countries	Fruits and vegetables	Meat	Fish and seafood
Europe including Russia (supermarket retail)	10	4	9
North America and Oceania (supermarket retail)	12	4	9
Industrialised Asia (all retail including supermarket)	8	6	11
SubSaharan Africa (all retail including supermarket)	17	7	15
North Africa, West and Central Asia (all retail including supermarket)	15	5	10
South and South East Asia (all retail including supermarket)	10	7	15
Latin America (all retail including supermarket)	12	5	10

Source: FAO (2011)

Similarly, Bond *et al*. (2013) examined food loss along the entire food chain in the UK. In their study, food loss refers to all food and drinks discarded throughout the entire food chain, from production through to post consumption. The research focused on the whole food products, not differentiated between staple foods, fruit and vegetables, meat and fish. The estimate was based on weight. For all food products focused on in the study, losses within distribution and retail reached about 3% of total losses, equivalent to 366,000 tonnes/year.

While most previous literature has estimated food loss on a weight basis, Lipinski *et al*. (2013) estimated food loss based on weight and then converted the weights into calories. They argued that measuring food losses by weight does not consistently reflect the energy in food products that could have been consumed by people. They defined food loss as the edible parts of plants and animals produced or harvested for human consumption but not ultimately consumed by people. Similar to Bond *et al*. (2013) and FAO (2011), this study also estimated loss at any stage of the food value chain including waste at the supermarket level. They also examined food loss for different food commodities including loss for cereals, roots and tubers, fruits and vegetables, oilseeds and pulses, meat, milk, fish and seafood. In all stages of the food chain, fruit and vegetable products were the largest source of loss on a weight basis – about 44% (where 100% = 1.3 billion tonnes). If the calculation is instead based on loss by kcal (kilocalories), fruit and vegetables contributed about 13% (where 100% = 1.5 quadrillion kcal). For meat products, loss rates based on weight and kcal were about 4% and 7%, respectively. For fish and seafood commodities,

loss rates based on weight and kcal were about 2% and 1%, respectively. For all food commodities, loss rates (on the basis of kcal) at the distribution level varied among countries, ranging from 7% (in North America and Oceania) to 18% (in North Africa, West and Central Asia).

A wide range of approaches for reducing food loss particularly at the retail level (or distribution level) have been highlighted by previous studies. They include: improved packaging, facilitating increased donation of unsold food, changing food date labelling practices, changing in-store promotions, and providing guidance on food storage and preparation to consumers (Lipinski *et al*., 2013). Eriksson (2012) suggested making a clear definition with respect to quantity requirements, in terms of quality and quantity; using more advanced packaging, sticking with the 'first-in first-out' principle, maintaining storage temperature, and establishing good ordering systems. Buzby *et al*. (2015) introduced three strategies for reducing food loss: reduce, recover and recycle. Reducing food loss can be achieved by improving product development, storage, shopping/ordering, marketing, labelling and cooking methods. A 'recover' strategy can be established by connecting potential food donors to hunger relief organisations, e.g. food banks. A 'recycle' strategy can be managed by giving food to feed animals or by creating compost, bioenergy and natural fertilisers. FAO (2011) suggested reducing package size, and for supermarkets to conduct consumer surveys to identify consumers' specific requirements.

Case study results

The flow of fresh products in the store

The flow of products in all stores run by the leading supermarket has four stages before they can be sold to consumers: receiving (Figure 2), transiting (Figure 3), storing and displaying.

Figure 2. Quality checking and distribution in progress at the distribution centre.

Figure 3. A typical transit area at a supermarket.

Receiving stage. Fresh food products are received from various suppliers at the distribution centre owned by the leading supermarket chain in Jakarta. The distribution centre can accommodate 35–40 tonnes of fresh food products per day which consist of 60% vegetables, 30% fruit and 10% seawater products. The products received in the distribution centre are checked and distributed (Figure 2) to stores located in Jakarta, Bogor, Depok, Bekasi and Serang (the most populated cities in Indonesia). The receiving process is conducted from 1 am to 3 am. After quality checking, the products are distributed to all stores in the distribution centre's coverage area at 6 am. At that time, the temperature is good enough to maintain the quality of the products since the leading supermarket does not operate a chiller truck.

Transit area. Each store has a transit area (Figure 3). At this stage, the quality and quantity of the products are re-checked before the goods are placed into the storage room.

Storage activity is applied at each store before the products are displayed on the shelves. Fresh food products are perishable, and they are stored in the chiller room. Some activities take place before the goods are put into the chiller room. For example, meat and poultry products are cut to various sizes at this stage.

Products are **displayed** on the shelves in each store. Consumers can choose items they would like to buy by selecting the best quality in terms of appearance, size and colour. Therefore, frequent physical contact between products and consumers may occur during this selection process, increasing the probability of products' damage. During the display stage, the staff in each store check the quantity and quality of fresh products twice a day, in the morning and evening. Quality checking is conducted to prevent rotten products from infecting others.

The causes of waste

At every stage as outlined above, there are some factors causing waste of fresh products (Figure 4), including over-ordering, lack of quality checks, temperature problems, bad handling, and failure to apply the 'first-in first-out' principle.

Over-ordering of fresh products occurs when there is a lack of coordination between supply and demand in each store. The shelf life of products, the stores' selling capabilities and the stock of fresh food products are crucial factors when the stores send their orders to the suppliers. Order decisions should

Figure 4. Causes of food loss and waste.

also consider the number of buyers visiting the stores from time to time. For example, the amount of fresh products ordered for the weekend will be higher than the amount ordered for weekdays. Similarly, for special occasions, e.g. Eid celebration and Christmas, the amounts of fresh products will be higher than in normal situations. If staff who are responsible for ordering fresh products do not have enough experience to decide the right amount to order, there is greater probability of over-ordering.

If **staff lack the ability to perform correct quality checks**, this can also increase the amount of food waste. By performing quality checks based on the standard quality, the leading supermarket chain can prevent product rejection at the consumer level. Consumers prefer to buy high-quality fresh products and they will reject products that cannot meet their standards.

Since fresh food products are perishable, maintaining **temperature** is important for each store to ensure the quality of fresh products prior to selling to their buyers. Failure to maintain temperature, particularly at the storage stage, increases food waste. **Bad handling** can also increase the amount of food waste. For example, if the staff is late in moving products from the receiving area to the storage room, that will reduce product quality. Crushing and bruising, particularly of soft fruit, increases when the handling process is not performed correctly.

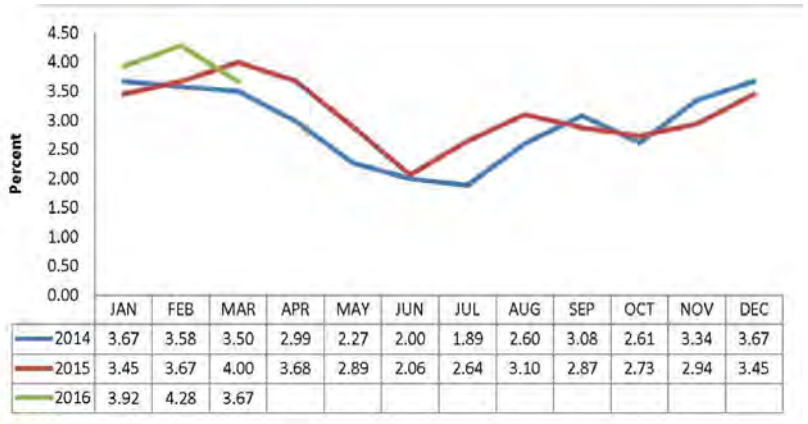
Each store has established the 'first-in first-out' (FIFO) principle. In FIFO, fresh products are sold in the same chronological order in which they arrived. This is related to the perishable nature of fresh food products, so sales of goods must be prioritised to the earlier-arriving products. Staff sometimes make mistakes in applying the FIFO principle.

Quantification of loss values

As outlined previously, we quantified food loss in the two types of stores run by the leading supermarket, on a value basis. The average loss rates for four fresh products in the wholesale stores were estimated for the period January 2014 – March 2016. In the retail store, the loss rates were estimated for the period January 2014 – December 2015.

In the wholesale stores, the average loss rates during the 27 months (January 2014 – March 2016) for four fresh products (fruit, vegetable, fish and meat) ranged from 1.89% to 4.28% of their total sales (Figure 5). For the retail stores, the average loss rates were higher than in the wholesale stores, ranging from 6.05% to 8.24% of their total sales (Figure 5).

Store policies that require retail stores to sell a range of products including fresh products might explain higher rates in the retail stores than the wholesale stores. Also, as discussed previously, the wholesale stores focus on sales to hotels, restaurants and catering; therefore, they are more concerned with selling products in packs or bundled in large numbers. In this situation, the sale values will be higher compared to the retail stores that focus on direct sales to consumers. As we know, the numbers of products bought by final consumers tends to be lower than the numbers of products bought by hotels and restaurants.



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2014	3.67	3.58	3.50	2.99	2.27	2.00	1.89	2.60	3.08	2.61	3.34	3.67
2015	3.45	3.67	4.00	3.68	2.89	2.06	2.64	3.10	2.87	2.73	2.94	3.45
2016	3.92	4.28	3.67									

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2014	6.87	6.75	6.69	6.90	7.02	6.30	7.32	8.00	7.63	7.13	7.25	7.71
2015	8.24	8.30	6.51	7.00	6.05	6.45	7.49	7.60	7.26	7.27	7.23	8.40

Figure 5. Estimated losses in four fresh products: wholesale stores (*top*); retail stores (*bottom*).

In both stores, there was a month to month fluctuation with respect to the loss rates (Figure 5). Month to month fluctuations in demand and supply of individual products contributed to the differentiation of loss rates in each month. For example, the highest rates of loss in the wholesale and retail stores tend to occur from December to March. This is because of the seasonality of fruit. In these periods, the stores are selling fruit and that increases the amount of loss. According to the director of the fresh food department, fruit makes the highest contribution to food waste in the leading supermarket chain.

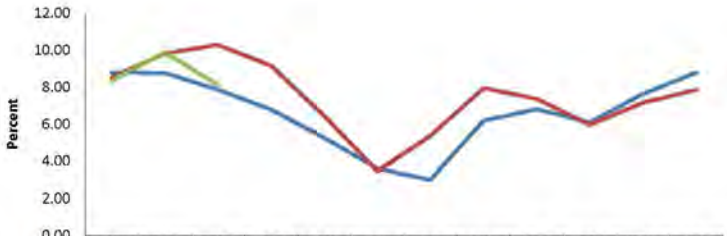
The loss rates for fruit products were 3.01–10.29% in the wholesale stores and 7.28–10.56% in the retail stores (Figures 6a, 6b). These findings are similar to those of FAO (2011) and Lipinski *et al*. (2013), in which fruit products contribute to the highest level of supermarket loss. Both wholesale and retail stores sell local and imported fruits. Peak season for local fruits (e.g. durian, mango) is from December to March, and that contributes significantly to fruit waste in that period. In the same period, the number of imported fruits (e.g. mandarin, orange, grape) was also higher than in other months because that is the peak season for these fruits in their countries of origin. Buzby *et al*. (2009) reported that the majority of fruits are soft. When consumers select fruits displayed in the stores, the probability of crushing and bruising of the fruit will increase. In addition, poor handling can also contribute to crushing and bruising of fruit products, increasing the number of fruit losses.

For vegetable products the estimated loss rates varied from 1.81% to 4.01% in the wholesale stores and from 6.85% to 11.10% in the retail stores (Figures 6c, 6d). Vegetable products, particularly leafy greens such as spinach, water spinach and lettuce, are relatively more prone to loss than many other types of products and this likely contributes to higher shrink. Products such as tomatoes, chillies and green beans are usually sold in bunches and are not protected by packaging. All vegetable products need to be refrigerated promptly in order to maintain their quality and freshness. Failure to maintain temperature at the vegetable space leads to higher waste.

Fish contributes a relatively small share of food losses both in wholesale and retail stores. This is because the fish products sold in both stores are mainly in the form of chilled fish (in retail stores) or frozen fish (in wholesale stores). Such types of products have longer shelf life than fresh or live fish. The stores sell only a small amount of live or fresh fish. The fish loss rates at the wholesale stores and the retail stores varied as shown in Figures 7a, 7b.

In agreement with FAO (2011), this study finds that meat products made the smallest contribution to the loss rates in both stores. The percentage loss rates on the value basis were about 0.24–1.06% in the wholesale stores and 2.43–5.77% in the retail stores. Compared to the wholesale stores, loss rates of meat products in retail stores were higher (Figures 7c, 7d). The wholesale stores focus on selling meat in frozen form, while the retail stores sell meat mainly in chilled form. The frozen meat has longer shelf life than the chilled meat. Longer shelf life leads to lower loss rates of meat products.

(6a)



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2014	8.79	8.77	7.86	6.79	5.25	3.61	3.01	6.19	6.81	6.10	7.63	8.79
2015	8.54	9.82	10.29	9.16	6.44	3.46	5.37	7.95	7.37	5.97	7.16	7.85
2016	8.34	9.9	8.11									

(6b)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2014	9.17	9.20	8.49	9.23	9.05	7.98	9.31	9.33	10.16	8.18	8.42	10.26
2015	10.37	12.19	8.42	9.26	7.49	8.17	8.93	9.82	8.96	7.28	8.37	10.56

(6c)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2014	2.74	3.12	3.45	2.88	2.08	2.22	2.39	2.29	2.72	2.35	2.64	2.74
2015	2.92	3.05	3.50	2.86	2.89	2.89	2.77	1.90	1.63	2.31	1.81	2.63
2016	4.01	3.98	3.60									

(6d)

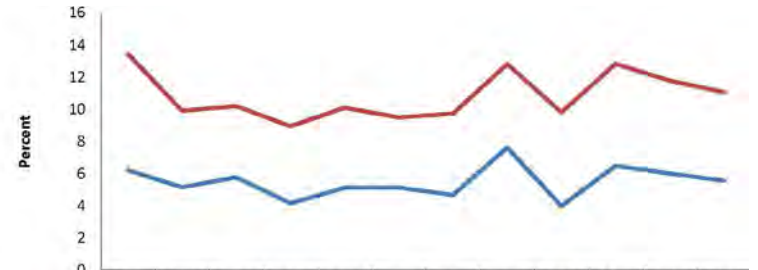
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2014	7.18	7.58	7.65	9.02	8.90	7.99	9.41	9.16	8.17	8.43	9.35	9.68
2015	9.43	9.24	7.75	8.11	6.85	7.98	9.30	7.85	7.58	9.69	9.34	11.06

Figure 6. Estimated losses of fruit products in wholesale stores (6a) and retail stores (6b) and vegetable products in wholesale stores (6c) and retail stores (6d).

(7a)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2014	2.59	1.96	2.07	1.68	1.45	1.91	1.65	1.52	2.22	1.96	2.04	2.59
2015	1.83	1.33	1.73	2.02	1.78	1.58	1.9	1.98	2.01	2.07	2.42	2.37
2016	2.73	2.71	2.48									

(7b)

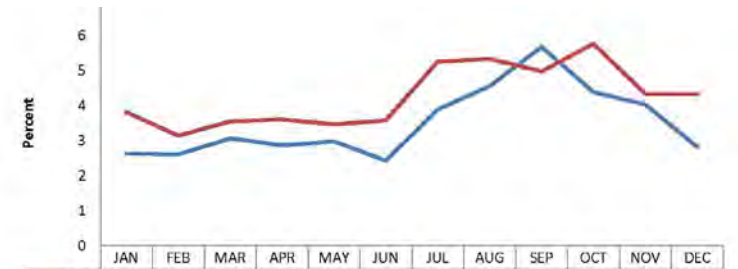


	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2015	7.23	4.75	4.42	4.79	4.97	4.36	5.06	5.19	5.83	6.34	5.76	5.51
2014	6.22	5.16	5.78	4.16	5.13	5.14	4.68	7.62	3.99	6.49	6.02	5.56

(7c)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2014	0.56	0.45	0.62	0.6	0.3	0.24	0.49	0.4	0.57	0.04	1.06	0.56
2015	0.51	0.46	0.46	0.67	0.45	0.32	0.53	0.56	0.48	0.57	0.36	0.94
2016	0.61	0.54	0.48									

(7d)



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2014	2.63	2.61	3.06	2.87	2.98	2.43	3.89	4.56	5.68	4.39	4.03	2.82
2015	3.81	3.14	3.55	3.61	3.46	3.58	5.26	5.34	4.98	5.77	4.34	4.34

Figure 7. Estimated losses of fish products in wholesale stores (7a) and retail stores (7b) and meat products in wholesale stores (7c) and retail stores (7d).

Conclusions and implications

This study has reviewed food losses at the retail (supermarket) level in several countries and estimated the level of loss rates for four fresh products (fruit, vegetable, fish and meat) in a leading supermarket chain in Indonesia. The review indicates that the definitions of food loss varied considerably across the studies, making it difficult to conduct precise comparisons across the studies. In general, the studies found fruit and vegetable products contributed the highest share of food loss at the retail (supermarket level).

In agreement with those previous studies, this study also demonstrates the highest loss rates for fruit and vegetable products in the wholesale and retail stores. Our estimates are based the proportion of losses for each product in relation to the total sale values in each store. Higher loss rates at the retail stores, compared to the wholesale stores, related to the supermarket chain's policy that requires retail stores to sell a wider range of products. This study also identified factors contributing to the losses of fresh products in the leading supermarket chain. They include: over-ordering, lack of quality checks, temperature problems, bad handling, and failure to apply the 'first-in first-out' principle.

As we know, fruit, vegetables, fish and meat are considered high value agriculture products. It is expected that demand for high value agriculture products will tend to increase in the future along with increases in consumer income and consumers' greater concern about their diet.

For supermarkets, reducing food waste is very important to improve their profitability. In such situations, actions that could be performed to prevent and reduce food losses in the supermarket chain include:

- Managing and establishing good ordering systems based on historical sales for each store
- Improving space management at the display area
- Improving quality control at the receiving area
- Improving handling at the receiving, storage and display areas
- Maintaining temperature at the receiving, storage and display areas
- Conducting training in the handling process
- Sticking with the 'first-in first-out' principle
- Improving in-store promotion strategies.

The estimation of food losses in this study relies on the case study data in one leading supermarket chain in Indonesia, though we have covered all stores run by the leading supermarket chain (e.g. 40 stores in 2015). Future studies need to include other supermarket chains in Indonesia. Currently, there are at least three leading supermarket chains in Indonesia and each of them operates several stores.

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The mega cities, mega waste 'last mile' challenge

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Australian Centre for Sustainable Business and Development,
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ABSTRACT: Across Asia, rapid growth of mega cities is driving change in retail outlets and consumer purchasing. Mega city economies are increasing the purchasing power of millions of people, creating the middle class of Asia. Many Asian consumers are internationally educated and are adopting the food habits of western consumers. Increasingly, shelf-ready packaged meats, cheese and imported fruit and vegetables are now purchased from supermarkets rather than local wet markets. In the past, most of Asian food wastage occurred post-harvest, during distribution to wet markets. Congested mega cities have limited cold storage systems and most food continues to be transported in non-refrigerated trucks. Travel times have increased along congested roads and much imported and local food has lost its freshness long before it reaches the consumer. This results in very short shelf life and increased waste. The systemic failures across food distribution and waste management systems are resulting in mega waste. Unsorted waste, from the 'last mile' (distribution centre to consumption), ends up in open landfills on the edges of cities. The challenge is immense. This and the next four presentations explore some of the technology and policy drivers that can help us to understand the problem, including creating energy from waste, and helping consumers make informed choices.

Keywords: Asia, regional value chain, chilled food, food quality

This overview focuses on the stage of the food supply chain just before the supermarket stage that we heard about from Dr Daryanto (this Proceedings). My presentation is particularly about the issues common to the 'last mile' – the mile between the food reaching the city and its arrival at the retail environment.

The growth of mega cities is exponential. In the 1950s, the world had half a dozen large cities and they were mainly in Europe. By 2015, there had been a shift and Asia has become the epicentre of growth. There are cities of over 35 million people across Asia and they are constantly growing.

To get a feel of what that mega city is like, imagine we bring an extra 500 people into this room, and we turn off the air conditioning and we bring in a few trucks and waitresses and we all try and grab food. As well, we have only got one or two fridges, and the electricity has just gone off because a monsoon has occurred so we have an 'on–off' state of infrastructure to deal with.

That is the type of complexity and chaos that is defining the 'mega city' experience in many of these emerging countries. It is a long way from the organised environment of Canberra. Keep that in mind, because we need to

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This is an edited transcript of the presentation, with some of the powerpoint slides shown.

Figure 1. Australians need to understand developing food trends and challenges in Asia.

think in a different paradigm when we are considering some of the issues around food waste (Figure 1).

The other trend that is happening in Asia is that food is changing. People are becoming busier – becoming like us, with Western-style jobs in these cities. They are taking on our lifestyles, urbanisation, skyscrapers ... and our types of food. That is, food that is emanating from other parts of the world rather than locally: particularly protein, chilled packaged foods, milk, cheese, and so on. Supermarkets are replacing wet markets.

The food-buying environment, the way people buy food, has changed also. E-commerce is rapidly becoming a way of buying food, because of the congestion. In Western cities the big supermarket chains have put their supermarkets at the outside edges of the cities, on the assumption that everybody has a car. That model failed quickly in Asia, and is being replaced by a new model of how people live and buy food in these condensed cities.

This is resulting in mega waste. These cities are the entry points for numerous supply chains – regional, rural, and global supply chains – and the cities are developing so quickly that they do not have the cold chain and food storage infrastructure that large Western cities have developed incrementally over the last 50 years as those cities have slowly expanded.

Types of supply chains

To explore the functioning of supply chains we looked at fresh food coming into Thailand from, say, Australia. We looked at grapes. They came in refrigerated containers by ship, were off-loaded, kept refrigerated, went into an Australian-owned cold-store chain and then either went straight to high-end supermarkets in Bangkok, or to Bangkok's regional wholesale market. This market occupies 80 hectares. It is under cover, but is otherwise in the open air with no air conditioning.

From the wholesale market the grapes were shipped out either to local wet markets (Figure 2) or to somewhere else across that Asian region. The bottom

Figure 2. Aspects of supply chains for fresh food, observed in Thailand.

photo in Figure 2 shows the type of truck that would carry these grapes, which had arrived by first class delivery from Australia. This truck was probably going to take them to Cambodia – hundreds of kilometres in tropical heat.

The ASEAN regional value chain is the third type of supply chain involved here, apart from the global and rural supply chains. Massive amounts of food and animals – live or dead – and various grains are being transported across continents on regional supply chains. These continents have highly variable infrastructure, and numerous logistics providers: from large corporates such as LinFox, Toll, DB Schenker, through to small family businesses and single providers, through to people who borrow somebody's car and shove the food in the back to take it to the market.

The consequence of this is huge differences in quality, all the way across the supply chains, and there is also a lot of waste across these chains (Figure 3). You can imagine the condition of those grapes after they had gone from Bangkok to Cambodia on a bumpy road. They would have been sold, but probably half of that truckload would have been squashed.

Chilled food chains

The other mega-trend that is taking off in Asia is chilled food. Asian customers are moving from wet markets to supermarkets, with shelved packaged meats and dairy, and all the things that we have in our supermarkets; those long counters where we have grown accustomed to choosing a product, reading its use-by date, and taking it home to our fridge.

Figure 3. Some characteristics of regional value chains inland in Asia.

These are temperature sensitive foods (Figure 4) and they are different to frozen foods. Frozen foods, a carcass or a block of ice, can take hours to defrost. However, when chilled foods are transported over large distances, the temperature should only vary by one or two degrees. If drivers and local people in regional areas are not familiar with these types of foods, they turn off the truck when they stop for a coffee break and a smoko, and that will also turn off the refrigeration around the chilled food. We had discussions in Vietnam and Thailand about our suspicions about chilled foods and supermarkets. People are not sure how to handle the chilled foods, so there is a great deal of education to do for this new trend. Yet at the same time, just one chain is starting 10,000 new supermarkets in Vietnam in the next five years. The growth is exponential.

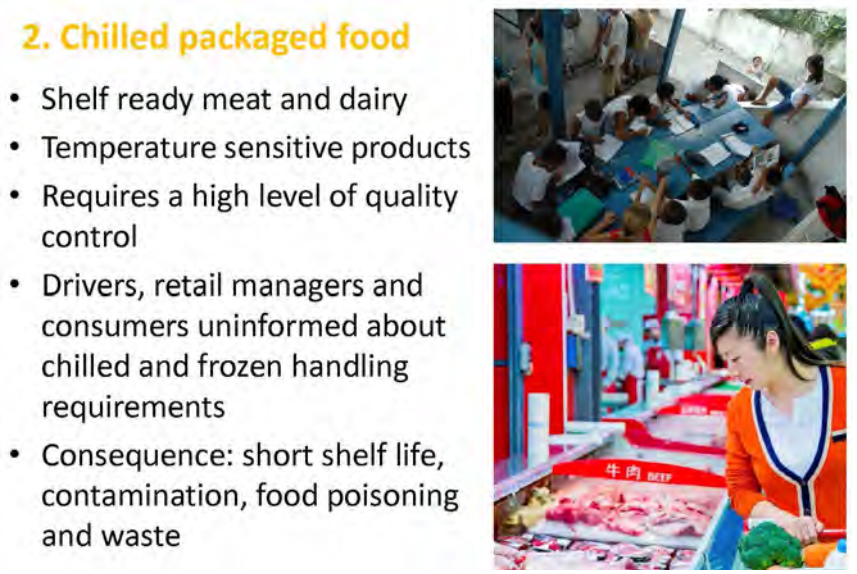

Figure 4. Availability of chilled packaged food is another new mega-trend in Asia.

Figure 5. In Asian mega cities, the last mile looks like this.

The last mile

In Asian mega cities, the last mile looks like Figure 5. Compare it to Australia and our comfortable highways. Some countries, such as Thailand, have fairly good highways, but the cities are so huge that the traffic gets very congested at the end of the journey. Other countries have virtually no infrastructure: perhaps only one or two cold rooms in the whole country, and the rest of the road network looks like Figure 5. This has problems because it is very hard to manage food quality in this very complex and diverse environment. That is why understanding food distribution and trade is very important for our region, because, speaking as an Australian, it is very hard for us to export products into many of these countries. We cannot control how the food will end up by the time it gets to the supermarket.

On the other hand, the Vietnamese farmer, say, cannot export food products because they do not have the infrastructure to get the produce to the port in the premium condition that the export market requires. This is why our research is focusing on this particular area of understanding: how to manage food distribution for importing and exporting, to deal with this new trend.

Challenges

Challenges arise because development is rapid, chaotic and uneven, and it is causing systemic failures in food distribution. The waste that is produced from these food chains is packaged; it contains inorganic materials including plastics; it is unsorted; and many of these mega cities do not have the facilities that we have in Australia to deal with that type of waste.

Another challenge is that we tend to talk mainly about either the high-end consumer with the fridge, or else about the farm waste, on-farm and that early supply-chain stage. We need to think about this middle area – this pre-supermarket space, this very crowded room – before we start sending goods into that space (Figure 1). These mega cities are growing without the infrastructure to deal with their own growth and so this waste problem is just going to be exacerbated.

Policy challenges

From the policy point of view, there needs to be a focus on structures that can be set up to deal with the problems. Among these will be cold chain logistics and infrastructure. Education can play a huge role: education about food quality and management; the requirements of chilled food; why chilled food is different.

Other policy areas will be how to separate waste; how to regulate for that. Most of the local government areas in Asia do not charge rates. A lot of these people are at a different point in the socio-economic scale. Consider how Australian cities' rates have crept up as we have moved along a 20-year trajectory of managing waste. For many of these cities which do not have that type of infrastructure, private partnerships will be really important. The logistics companies, the supermarkets, they have an interest in this space. Waste is costly for them. Food loss is huge and they cannot grow their businesses without growing in the way they manage their products. There is a huge role here for R&D.

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Every nutrient is sacred: developing a nutrient retention paradigm to aid global food security

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ABSTRACT: It is estimated that the world currently loses close to 90% of its nutrients between the farm and the fork. Future global food security will consequently not only be reliant on reducing the third of food produced that is currently lost or wasted, it will also require the development of a nutrient retention paradigm as part of the circular economy. This talk discusses a logical approach to nutrient retention, including transformation technologies, to ensure that the greatest amount of nutrient is retained in the human food chain. It details how high value and nutritionally enhanced functional foods can be created from such an approach, for the economic benefit of innovators in the field. Notwithstanding, it also discusses the importance of reinvigorating the lost art of utilising food leftovers to retain nutrients, because over half of food waste occurs in households in the developed world. The development of a new paradigm of nutrient retention within the circular economy will be essential for global food security – with nutritional security for all, not just food security, being the ultimate aim.

Keywords: food loss and waste, source retention, food recovery, targeted fertilisers, sewage, leftovers

I have an important and simple message to give here: that is, if we are going to talk about food security, we also need to be talking about nutrient security.

Globally, we are losing up to 90% of the nutrients gathered by our food production systems. About 50% of the fertilisers we put into the ground do not reach their target. About 20% of the food that is produced in primary production and processing is lost, with nutrients also being lost during processing. Then we waste about 20% of the food that enters our homes. We also lose nutrients in the cooking process as many of you will be aware. What is worse is that we also send many of those nutrients out to landfill in wasted food, and via sewerage into the sea, which creates dead zones.

This is a worrying trend, because food is becoming less nutritious and chronic diseases are on the rise (Figure 1). These topics have been the subject of a number of publications recently in *Scientific American*, and they are quite well understood. Yet we continue to lose or waste 30–40% of the food that we produce in Australia.

The bar chart (Figure 2) is from the work of Carlos Beteta, a Masters student working with me in 2015, who critically analysed where we are in terms of

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This is an edited transcript of the presentation, with some of the powerpoint slides shown.

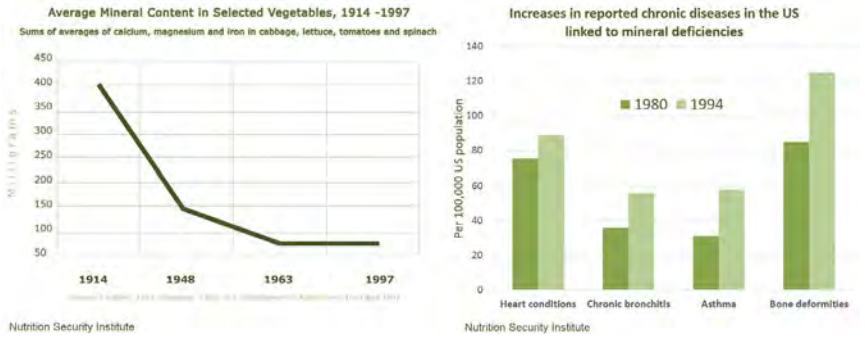

Figure 1. Decline in mineral nutients in vegetables (*left*); and increase in chronic heart, breathing and bone disease in USA, 1980–1994 (dark–pale) (*right*).
Source: Nutrition Security Institute.

food loss and waste in Australia, and these are the latest figures. This is a work in progress, and the production losses are still yet to be completely mapped out. We talk to a lot of the major commodity groups, so as the production bar potentially rises as a percentage, the bars for household and food service will come down a bit, but overall our findings are similar to the figures used by the Food & Agriculture Organization of the United Nations (FAO) for North America and for Oceania including Australia. Figure 2 shows that household consumption and food service are real culprits in food loss in Australia. However, we can also do more about the food loss from farms.

There is a food recovery hierarchy in use around the world at the moment that is actively used in Australia (Figure 3). We have a good food recovery system via groups like Foodbank and Second Bite, to name just two. Also we send food that is lost in primary production and processing to animals, and so it does re-enter the food chain. Other food waste goes to biodigesters, such as the one used in Perth, Western Australia, run by RichGro; and some excellent composting companies around Australia are doing great work with the materials they are receiving.

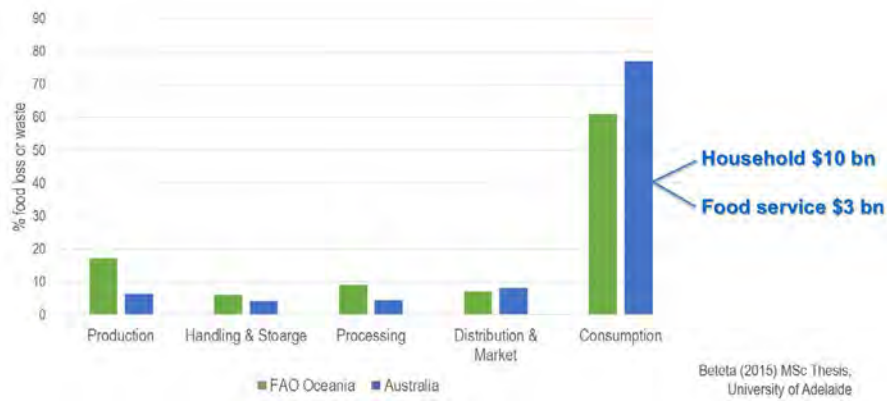

Figure 2. Percentage food loss or waste in Australia (blue) and Oceania (green, FAO data), in production, handling/storage, processing, distribution/market and consumption.
Source: Beteta (2015).

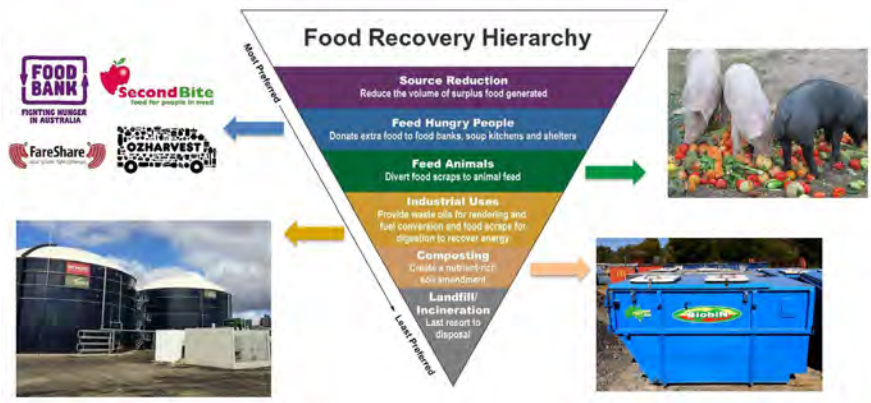

Figure 3. Source reduction is most preferred (top) and composting slightly better than landfill or incineration (tip) in the food recovery hierarchy.

However, the fact remains that we are losing a lot of nutrients in that process and it is a very linear system. We need to be talking about a *circular* economy system. To me, this means we must include new innovative solutions that direct, retain and recover nutrients. We need better targeted fertilisers – as used in some of the new production systems coming on-line now, such as at Sundrop Farms near Port Augusta, which are quite amazing. Every nutrient in that closed system is either taken up by a plant or it is recycled. There are no wasted nutrients from that production system. The system will not suit every crop but it will certainly work for many.

It is also possible to reduce processing losses. For example, we worked with groups like Clean Seas Ltd in South Australia, on Yellowtail Kingfish. The aim is to make sure that all the meat is extracted off that kingfish frame, because normally it contains about 50% more meat than is taken off in the two single fillets.

Valuable nutrients in lost food

At the moment I spend a fair bit of time on the recovery of nutrients from lost food. There's a plethora of techniques out there. They are coming down in cost and they are increasing in availability, and that is something that we need to be taking a serious look at before we send our food off to landfill or to animals or to compost (e.g. Figure 4).

It may be controversial, but we need to extract nutrients from sewage before we send it out to sea. Sewage contains phosphorus – prime fertiliser – which will be a limited commodity when the mineral phosphate mines run out (see also Cordell, this Proceedings). Phosphorus has been extracted from sewage in America and then fed back into farms, and there are plenty of other nutrients that can be extracted from sewage. The reason we need to do this is to develop the nutritionally enhanced foods of the future.

Whether you agree or not, we are taking food in a different way. We are taking in nutrients in a different way (e.g. Figure 5). We are choosing functional foods,

Figure 4. The nutrient retention paradigm must include new innovative solutions to direct, retain or recover nutrients.

Figure 5. Nutritionally enhanced foods available now – e.g. functional foods and nutraceuticals – and in the future, e.g. printed food with tailored nutrition.

such as enhanced yoghurts, omega-3-enriched eggs, fermented milk drinks, and others. We are choosing nutraceuticals. You only need to look at the share prices of vitamin and supplement manufacturers such as Blackmores or Swisse to see that we are choosing them in a very big way. In the future, we will be choosing 'printed food' which will include tailored nutrition. You will wake up and have your 'printed' eggs or breakfast cereal, and that will carry in it the nutrition that you need for the day. Obviously we need the feed stocks for that nutrition.

What we can all do

We all can work to preserve nutrients (Figure 6). Everyone has a really simple role to play, and it starts in the home. There are the 'ugly fruit and vegetables' initiatives of Walmart in USA and Woolworths with 'the Odd Bunch' in Australia. However, we just need to be less choosy when we're buying fruit and veg at the supermarket. Rather than going in search of packaged 'ugly' products, just grab the produce in front of you, so the farmer can get a premium price for it as well.

We need to make ourselves more educated in how to reduce food waste. In fact, we need to revive the kitchen practices of the Depression era and the post-war years, in many ways, because certainly there was no food waste then.

As other speakers have mentioned, as incomes increase, food waste increases, and that is why we need to return to habits such as eating leftovers. Using up

Figure 6. Everyone has a role to play: whether buying ugly fruit and vegetables, not buying excess fresh food, and composting scraps, or using up leftovers in tasty meals.

leftovers tastily used to be an art, but it is now a lost art in many homes, though it is starting to make a comeback, with Jamie Oliver recently publishing a book on it: *Save with Jamie.* It is a key way we can keep nutrients in the home, not only in our food systems. We also need to compost and use that compost to grow more vegetables. For people living in high-rise apartments, there are community composting areas popping up in Adelaide and in Sydney and Melbourne, so no-one really has an excuse not to compost – except of course that we are all time-poor.

In summary, nutritional security for all, not just food security, must be the aim. Some excellent papers have come out in the last few months on this topic. It seems to me that developing the circular food economy will be integral to success in this, where everything is recycled until it no longer has a value.

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From plant wastes to sustainable aquafeeds: the Novacq™ case history

Cedric Simon, Nigel Preston & Andrew Chalmers
CSIRO Integrated Sustainable Aquaculture Production Program

ABSTRACT: Every year 20–30 million metric tonnes of fish, one-third of the global fish catch, is used to produce aquafeeds. This practice is unsustainable and a critical threat to the viability of the global aquafeed industry. Efforts to find alternatives that totally match or improve the cost-effectiveness and nutritional performance of wild fish products, while reducing the burden on the natural environment, have failed, until recently. Now, an innovation using natural marine microbial processes has achieved this goal – a world-first success, improving the sustainability and cost-effectiveness of aquafeeds. The technology uses natural marine microbial processes to bio-convert plant wastes, such as bagasse or rice straw, into a bioactive product (Novacq™) that improves the growth and health of farmed prawns and eliminates the need for any wild harvest fishmeal in prawn feeds. The technology is patented and in full-scale commercial production by several licensees in a number of countries. The development of Novacq™ (an abbreviation of 'novel aquafeed' ingredient) is an example of why we need to rethink the way we produce aquafeeds. We need to continue to learn from nature how to produce sustainable aquafeeds and industrialise these processes in cost-effective ways.

Keywords: plant waste, prawn feed, Novacq™

NovacqTM is a feed ingredient for use in sustainable aquaculture of prawns, developed by CSIRO over the last 12 years. Fittingly, Nigel Preston called the present case study a 'case history' because of the time and effort from a dedicated group of scientists it took to come into being. Novacq™ is the solution to a very important underlying global issue that has hampered the development of truly sustainable prawn aquafeeds.

In 2014 we reached approximately 160 million tonnes global seafood production. We have now achieved the major milestone of aquaculturing more seafood than is wild caught. This growth of seafood production is a trend that is likely to continue, because of the growing global population as well as an increasing demand for good quality nutrients from seafood. However, it is important to note that a lot of aquaculture is reliant on fish meal, which is produced from one-third of the total fisheries. This means there is a real need to find alternative sources, other than fishmeal, so we can sustain aquaculture growth for the next generations. Currently the aquaculture sector uses 73% of all fishmeal and 71% of all fish oil produced. The leftover fish oil is principally used by the nutraceutical industry as fish oil pills.

This is an edited transcript of Dr Simon's presentation, with some of the slides shown. The paper was co-authored by Nigel Preston (Director General, WorldFish, Penang) and Andrew Chalmers (Business Development and Commercial, CSIRO Agriculture, Canberra).

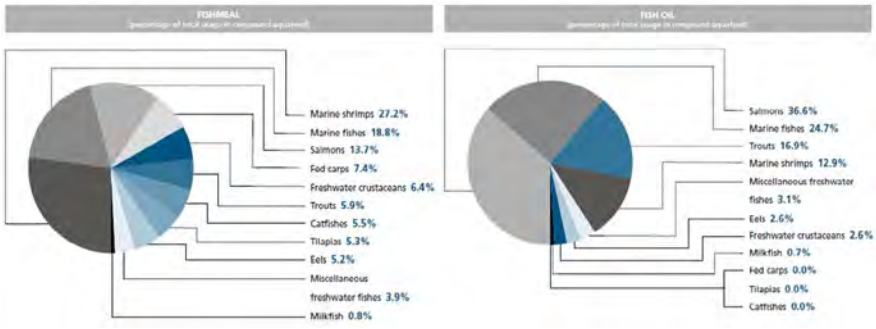

Figure 1. The use of wild harvest fishmeal and fish oil is most pronounced in higher value species such as salmon, other carnivorous marine fishes, and prawns. *Source*: FAO 2012.

As per Figure 1 (FAO 2012), aquaculturing marine shrimp uses almost 30% of the total fishmeal, and growing marine fish and salmon uses another 30% fishmeal. Salmonids use the bulk of the available fish oil however, with salmon and trout using more than 50% globally. Salmon, carnivorous marine fish and prawns are high-value species – and Australia produces all three.

Finding a substitute for wild fish products

There has been a lot of work aiming to replace the fishmeal in fish and prawn feeds, for example, using a range of alternatives mainly from terrestrial protein sources. Legumes and grains have been shown to be good substitutes for fishmeal, except that they lack some key micronutrients found in fishmeal. Furthermore, it can be argued that although using terrestrial crops to feed fish may be more sustainable than using fishmeal, it would be better to use crop by-products and the crop wastes instead, as these are a cheap and abundant source of carbon and do not use material that would otherwise be suitable for human consumption.

Prawns are one type of seafood that is disadvantaged by the lack of bioactive nutrients in plants used in aquafeed. Prawns in the oceans are a primary consumer of marine bacteria and plankton, which are dominant elements in the marine environment (Figure 2). The mass of bacteria and plankton in the oceans exceeds the total mass of all ocean-dwelling plants and animals – and marine bacterial processes are also dominant and vital parts of marine nutrient cycles.

Combining these ingredients, our CSIRO team has devised a way of using natural microbial processes to convert the waste carbon from crops into a novel bioactive aquafeed ingredient, which we have called Novacq™. The CSIRO process uses commonly used equipment and facilities (Figure 3). We take waste carbon from a source of solid or liquid waste, and add some specific micronutrients along with a source of nitrogen which can come from fertiliser. Converting these ingredients requires low-cost systems that are adaptable all around the world where prawn farming occurs. The CSIRO team started with small-scale tanks and moved into larger-scale ponds to produce greater quantities of Novacq™.

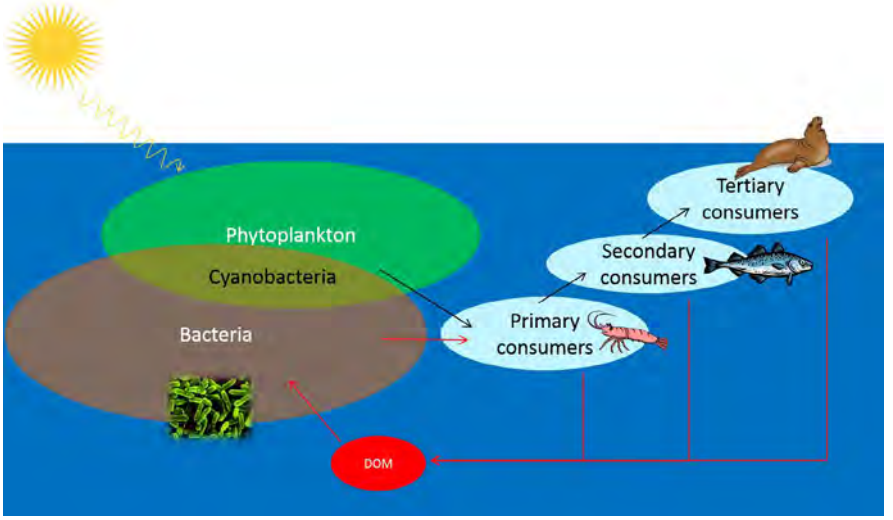

Figure 2. Marine microbial processes have a critical and dominant role in marine nutrient cycles.

We find Novacq™ has outstanding effects on the culture performance of prawns. With Novacq™ we have been able to improve prawn growth and health – and even to grow prawns without any fishmeal in their diet (Glencross *et al.* 2014).

The CSIRO team has also demonstrated that the growth benefits of Novacq™ remain in selectively bred prawns (Glencross *et al*. 2013). There have been several other experiments by CSIRO and more recently by Ridley Corporation, our Australian Novacq™ licensee that is actively involved in R&D, confirming outstanding improvements in growth rates in the order of 20–50% depending on the particular Novacq™ batch and feed formulation used.

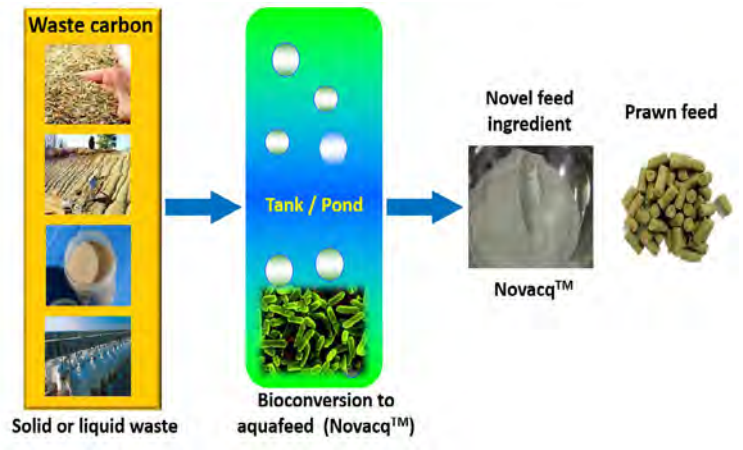

Figure 3. Novacq™ is a natural bioactive that improves the growth and health of farmed prawns and eliminates the need for any wild harvest fishmeal in prawn feeds.

The Novacq™ technology is adaptable everywhere prawn farming occurs, including in developing countries. CSIRO's aim is to facilitate the distribution of Novacq™ throughout the world, via our current licensing partners: one in each of Australia, China and Vietnam which can produce and sell Novacq™ exclusively in their respective territories. Ridley has multiple production and distribution territories including Australia, Thailand, Indonesia, Malaysia and the Philippines.

The global adoption of Novacq™ has the capacity to revolutionise feeds for cultured prawns, and potentially other commercially relevant crustaceans, while reducing the pressure on wild fish stocks.

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Cedric Simon is the Aquaculture Nutrition Leader for the Integrated Sustainable Aquaculture Production team, part of the CSIRO Agriculture and Food Business Unit. As a Senior Research Scientist, his role is to initiate, lead and contribute to a wide range of research projects which assess, review and analyse impacts of dietary changes on aquatic animal production. This is done within national and international settings and is integrated with complementary work in genetics, reproduction biology, aquatic animal health, environmental management and socio-economics. Cedric has broad research interests, including the digestive physiology and nutritional requirements of crustaceans, fish and molluscs, the non-invasive assessment of nutritional condition, feed additives, and sustainable aquafeed ingredients and formulation. He holds a PhD in Marine Science from the University of Auckland and a BSc in Aquaculture from James Cook University.

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Waste-to-energy innovations powering a circular economy

Associate Professor Bernadette McCabe
National Centre for Engineering in Agriculture,
University of Southern Queensland

ABSTRACT: The benefits of better food waste management extend to community-building, liveability and poverty reduction in cities. Waste-to-energy (WtE) technologies provide elegant solutions for food waste management with tangible and usable products including energy and fertiliser, and attractive environmental and social benefits. When combined with food security they provide a powerful case for city and rural communities alike. The majority of waste-to-energy facilities in the world are in Europe, Japan, and the US. In developing countries such as African nations, a very limited share of waste is recovered and reused, and only major or capital cities have waste management systems. In a number of these countries the use of waste to generate electricity could have a significant impact. Waste can make a very high contribution to providing electricity to citizens and alleviating energy poverty, especially in countries with little access to electricity and low electricity consumption per capita. For isolated, rural and less wealthy populations, the benefits of an effective circular economy are even more direct than for a Western urban population. The production of biogas from organic waste via anaerobic digestion is one such technology that fits perfectly in a circular economy and engenders the energy independence needed by these communities. This case study presentation gives an overview of the different waste-to-energy technology options that exist, and highlights some key innovations across the globe. A particular focus is novel approaches that have been used in developing countries, and the impacts on food loss and waste, livelihoods and food security.

Keywords: waste-to-energy, biogas, quality-of-life benefits, anaerobic digestion, biofertiliser

My presentation is about waste management and innovations powering a circular economy, and should be a good complement to Steve Lapidge's presentation about recovering nutrients to go back into a circular economy.

As well as recovering nutrients we can also capture energy from organic waste. This talk highlights a particular waste-to-energy technology – anaerobic digestion. I think it is a great example that integrates both nutrient capture and energy capture, and it really embodies what a circular economy is about. First I shall give you a bit of information about waste-to-energy technologies, WtE, or W2E as they are sometimes called.

The term 'waste-to-energy' refers to any waste treatment that creates energy from a waste source, such as mixed waste which could include both inorganic

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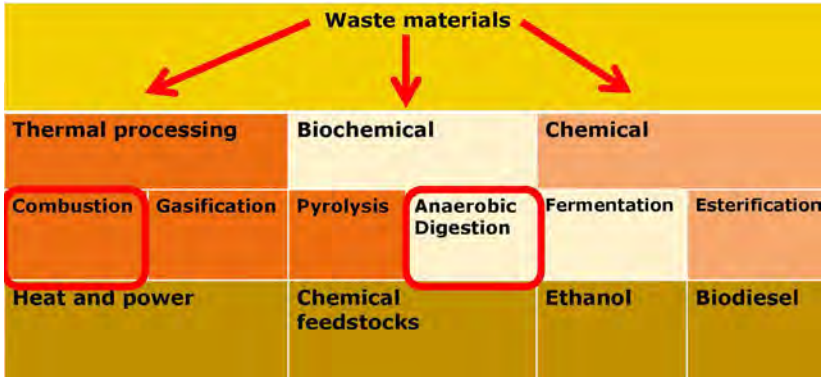

Figure 1. Waste-to-energy (WtE) technologies.

and organic waste. Essentially, through waste-to-energy technologies we are aiming to produce heat and power, chemical feedstocks, ethanol or bio-diesel (Figure 1).

In thermal processing (orange-coloured cells in Figure 1), the most common method of converting municipal solid waste (MSW) to energy is actually combustion, incineration. That method is used primarily with mixed waste input – inorganics or organics. The world leaders in the use of this technology are in Europe where there are about 450 combustion facilities, and Japan (around 100) and the USA (nearly 100).

Gasification and pyrolysis are emerging technologies in 'thermal processing', and they operate in the absence of oxygen, whereas combustion uses oxygen. Both the gasification and pyrolysis technologies are still at pilot scale and demonstration scale, and not in widespread use.

Under 'chemical conversion' (pink-coloured cells in Figure 1), the main techology is esterification. That process will produce bio-diesel, and again it is very much in its pilot stage and not really economically feasible.

The third category is 'bio-chemical conversion', both by anaerobic digestion and by fermentation. The end product of fermentation is ethanol and I am not discussing that here. Anaerobic digestion, however, produces both heat and power, and it also has the benefit of producing large amounts of materials that can be used as a nutrient-rich fertiliser.

Biogas

I shall now focus on biogas and the central issue of food waste, and how we can get more benefits from food waste. Biogas is produced from anaerobic digestion, a naturally occurring process through microbial action in the absence of oxygen. Biogas consists of approximately 60–80% methane, and the remainder is carbon dioxide. The methane can be used to produce electricity, heat and fuel. The material left after anaerobic digestion (the 'digestate') is also very valuable as a rich fertiliser and soil conditioner, which can be used to grow food.

Figure 2. Anaerobic digestion of food waste produces a range of benefits.
Image source: http://www.projectdirt.com/project/14209/#1journal_entry/34491

These products of anaerobic digestion (Figure 2) can support small businesses, organisations and community groups, not only by providing energy but also through soil additives for agriculture. The technology also creates job opportunities which are far more sustainable than those created by some other renewables – say, solar installations and the like.

In Australia

Yesterday I published an article in *The Conversation*, titled 'Australian communities are fighting food waste with circular economies' (McCabe 2016). *The Conversation* is an online magazine in which academics write about research or a topic of interest in language that suits the average non-academic reader. My article describes my observations as related to this conference.

Overseas, the European Council adopted an ambitious circular economy package in December 2015, which includes revised legislative proposals on waste, to stimulate Europe's transition towards a circular economy. In Australia, we do not have anything similar.

Although around 4 million tonnes of food reaches landfill in Australia each year, there is no federal directive on its management. However, I have observed (through pilot plans and various activities) that directives *are* being put forward. They are coming from state and territory governments and from local government and also from communities that are taking it upon themselves to repurpose waste and convert it into energy and by-products such as fertiliser. My article highlights some case studies and projects.

In South Australia, SA Water is using co-digestion in a sewage treatment plant. Most biogas in Australia comes out of sewage treatment plants, but SA Water has commissioned the first co-digestion plant in Australia, and it has been operating for three years. They are using the wastewater treatment plant like a waste management facility and they are bringing in different waste streams to increase the generation and use of the biogas.

In Victoria, in a newly developed study, a team in the Yarra Valley aims to emulate what SA Water has done. Another example, still at the proposal stage, is at Cowra in central New South Wales. The community is coming together, supported by State Government funding and local government funding, to explore a multi-stream waste model. The idea is that the community can gain benefits from both the energy and the fertiliser.

In developing countries

In developing countries, biogas technology is considered to be an excellent tool for improving livelihoods and health. Worldwide, around 16 million households are using small-scale bio-digesters. The process is a boon for developing countries for creating low-cost energy for cooking and lighting in homes. China, India and Nepal have mastered the use of this technology and are employing it as part of development schemes and also investing in it.

As examples of the value of this technology, here are three case studies in Africa. The first one is called Cows to Kilowatts, and it is located at Ibadan in Nigeria. The project centres on the construction of a biogas plant and wastewater treatment facility to run on abattoir wastewater, creating a really cheap source of domestic energy. It also abates pollution and is mitigating the production of greenhouse gases. Figure 3 shows part of the biogas facility at the abattoir. This is a community-driven biogas facility using somewhat sophisticated technology called anaerobic fixed-film technology (AFF). It is providing affordable environmentally-friendly safe cooking gas and organic fertiliser, which benefits the urban poor and provides income to farmers. Traditionally, the main fuel for cooking is kerosene, wood or charcoal. They are expensive and labour-intensive and also a very unclean way of cooking. The value proposition of this project is its impact in improving health and producing a digestate that is useful as fertiliser, thereby reducing the use of chemical fertilisers which cost more and

Figure 3. Cows to Kilowatts project in Ibadan, Nigeria.

Figure 4. Use of kitchen waste in Uganda (RUDMEC 2013).

Figure 5. A biogas rucksack in Ethiopia. Photo: James Jeffrey

pollute the environment. Another benefit of this project is that it will eliminate slaughterhouse-borne diseases that affect public health.

Another example is the kitchen-waste project in Uganda, using up foodscraps that people did not know what to do with (Figure 4). Here again, the project is creating an income – that is a highlight of this project – and the digestate is used as a fertiliser, and is far more nutritious than synthetic fertiliser. It is not only improving yields but also enabling multiple crops per year. The farmers are harvesting and selling surplus produce, which also increases household incomes.

Finally, a biogas project in Ethiopia is boosting incomes there. People can cart away the biogas on their backs (Figure 5). The bag in Figure 5 contains around four-hours-worth of cooking biogas. Imagine how much drudgery would be involved in collecting and carting enough *wood* for four hours of cooking.

Summary of biogas benefits

In summary, biogas is having a really huge impact on the quality of life for these people.

- They have cleaner cooking, and a reduced workload in firewood collecting and fire tending which are women's tasks.
- There is better gender equality, because the women can spend less time on those household matters and more time in other activities such as education.
- Health and sanitation are improved by replacing kerosene, charcoal and wood (which produce a lot of smoke and respiratory diseases) by clean biogas for cooking.
- There are education benefits, because burning biogas provides better light than burning kerosene. Therefore children can spend up to two hours more on study each evening, and their mothers can help them, having more time.
- Food security is also improved through the use of the digestate as productive fertiliser.

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Bernadette McCabe's specific research interest is in energy capture and resource recovery of waste and has attracted over $1.3M in nationally competitive grants and/or research contracts since 2010. She was recently awarded an Advance Queensland Mid-Career Research Fellowship working in partnership with NH Foods Australia, Oakey Beef Exports. She has expertise in the monitoring of wastewater, biogas production and assessment of biosolids as fertiliser replacement. Bernadette collaborates at an international level as National Team Leader representing Australia in the International Energy Agency (IEA) Bioenergy program Task 37: Energy from Biogas. IEA Task 37 is an international working group made up of 15 member countries that exchange global best practice trends in biogas production. Through this role she has established a wide network of national and international research, industry and government contacts.

Towards global phosphorus security through nutrient reuse

Dr Dana Cordell
Institute for Sustainable Futures, University of Technology Sydney
and
Global Phosphorus Research Initiative

ABSTRACT: It is not widely recognised that the reuse of phosphorus will be crucial to achieving future food security, supporting farmer livelihoods and buffering against emerging geopolitical risks. All farmers need access to phosphorus fertilisers to grow crops, yet just five countries control 85% of the world's main source: phosphate rock. Morocco alone controls three-quarters of the world's remaining phosphate. These phosphate reserves are non-renewable, and becoming increasingly scarce and expensive. Already one in six farmers cannot access fertiliser markets. The 800% phosphate price spike in 2008 demonstrated the vulnerability of global and local food systems to even a short-term disruption in supply. At the same time, a staggering 80% of phosphorus is lost or wasted in the supply chain between mine, farm and fork. Much of this ends up in rivers and lakes, leading to widespread nutrient pollution and algal blooms. The good news is that phosphorus can be recovered and reused from all organic sources in the food system: food waste, human excreta, manure, crop waste. Indeed, there are over 50 low- to high-tech solutions. However, phosphorus vulnerability is very context-specific, and what works in one country may be inappropriate or ineffective in another region. This case study highlights a path forward, including examples from Vietnam, Malawi and Australia. Investing in phosphorus reuse creates locally available 'renewable fertilisers'. This simultaneously: reduces dependence on imports from geopolitically risky regions and therefore buffers against future price spikes and supply disruptions; reduces phosphorus waste in the food supply chain; and reduces the risk of nutrient pollution.

Keywords: phosphorus recovery, fertiliser price buffer, food security

This paper is about nutrient reuse in response to one of the biggest emerging global sustainability challenges for food security: global phosphorus scarcity. Without phosphorus we cannot grow food anywhere in the world. Hence we urgently need to be looking at innovative ways to recycle phosphorus and other nutrients. There are many dimensions to the global phosphorus challenge (e.g. Figure 1), including reuse of waste. Eighty per cent of phosphorus is lost between mine and farm and fork. Much of that lost nutrient ends up in waterways where it can feed toxic algal blooms.

Phosphorus is a resource that every farmer in the world needs; yet the world's high-quality mineral resources are finite and becoming increasingly

This is an edited transcript of the presentation, with some of the powerpoint slides shown.

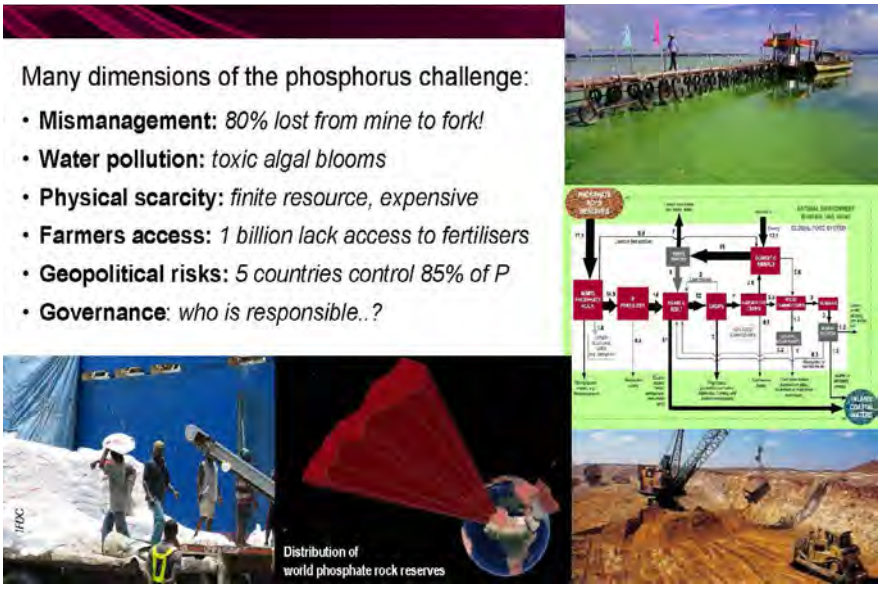

Figure 1. The global phosphorus challenge.

scarce and expensive. Several scientific studies suggest demand could exceed current supply by mid-century. Yet even today there are already up to a billion smallholder farming families in the world who cannot access fertiliser markets. In landlocked countries in sub-Saharan Africa in particular, farmers can pay 2–5 times more for their fertilisers than farmers do in, say, Europe.

Perhaps one of the most concerning dimensions of global phosphorus scarcity is the geo-political risk. Only five countries control 85% of the world's remaining phosphate rock, and one family alone controls three-quarters of that supply.

Given the gravity of this situation, it is quite concerning that there is scant or no effective governance on global, national or local scales to ensure phosphorus security into the future. We define phosphorus security as ensuring all farmers have access to phosphorus; that our soils are fertile and agriculture is productive; that up to 9.5 billion people have access to healthy diets; and that our rivers, lakes and oceans are clean, free from nutrient pollution.

The good news is it is possible to avert the crisis. Indeed, there is a whole toolbox of technologies and behavioural change options that we can think about, systematically through the food system. Examples (Figure 2) of this spectrum range from efficient phosphorus use on-farm, to changing diets, to recycling of phosphorus from manure or food waste, crop residues and human excreta.

Even for recycling phosphorus from human excreta, there are over 50 different technologies available, from the small-scale low-tech urine-diverting composting toilet which can be used, for example, to grow onions in Burkina Faso, right through to the large-scale high-tech expensive technologies like phosphorus recovery from wastewater treatment plants. The bottled white crystals (Figure 2,

Figure 2. Toolbox of sustainable phosphorus supply and demand measures.
Source: Cordell & White 2013

bottom-left) are struvite, produced by dosing a side-stream of wastewater with magnesium; pure magnesium ammonium phosphate crystals emerge, which a wastewater treatment plant can bag and sell on-site.

These technologies are all context-specific. Although there is a suite of options, it is very important to implement only those that are most appropriate and cost-effective for a given city, country or region. Implementation also needs policy instruments, and for policy makers and other stakeholders to make the right technologies work effectively in practice.

Case studies of phosphorus recovery and recycling opportunities

Malawi

In Malawi, agriculture is largely based on subsistence maize farming. The fertiliser subsidy was scaled back somewhat in the last budget. The country is vulnerable to phosphorus scarcity, partly because it is landlocked and very heavily dependent on phosphate imports via their neighbours – hence good relations with neighbours such as Mozambique are important (Figure 3).

We have calculated that human excreta in Malawi contains roughly as much phosphorus as they are importing from Morocco, China and other countries. There is only one major fertiliser company in this country, and one product manager. There is an opportunity to see how Malawi might implement some of these phosphorus recovery options. While there was not much initial interest in phosphorus recovery from human excreta, it emerged that a major concern was the economies of scale: 'Don't talk to me about five tonnes a day. Come back when you've got a hundred tonnes a day and then we'll talk business.' So now we are looking at how we can mobilise action there.

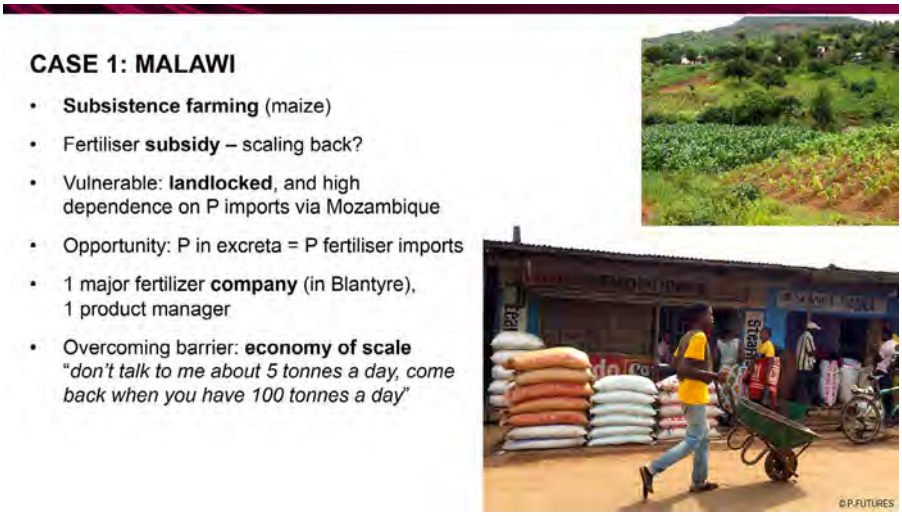

Figure 3. Phosphorus recycling opporunities in Malawi

Vietnam

The next case study comes from peri-urban Hanoi, in Vietnam (Figure 4). This city's jurisdiction recently expanded to 'Greater Hanoi' which now encompasses one-third of the province, including areas that used to be rural and that, because of the centralised governance in that part of the world, were designated 'safe food districts'. One district might be designated for fruit and vegetables, while another might be the livestock district. Traditional recycling of organic waste meant that there was some reuse of manures, but not much reuse of household organic waste, most of which went to landfill. However, in some instances, mixed municipal waste (topped with some sewage sludge) is composted but

Figure 4. Phosphorus recycling opporunities in Hanoi, Vietnam.

largely untested. So the levels of pathogens, heavy metals, etcetera, are largely unknown to farmers who are collecting the compost for free and using it on their farms.

Hanoi has an extremely ambitious and green '2030 Greater Hanoi Master Plan' which includes targets for 70% recycling of compost. Therefore, working with urban planners and other stakeholders in Hanoi can potentially fast-track phosphorus and nutrient recycling through these ambitious targets.

I want to stress the importance of engaging urban planners when we are talking about food consumers, who are largely in the cities. We need to be thinking about strategically designing waste-recycling systems upfront.

Australia

My final example comes from Australia (Figure 5). Although Australia is a net food-producing country and food exporter we are very vulnerable to phosphorus scarcity, though in a different way. Australia is a net importer of phosphorus, because while our soils are largely naturally phosphorus deficient we have invested quite heavily in phosphorus-intensive agricultural export industries. In our beef and live animals, wheat and dairy products, we are literally shipping phosphorus off our shores. Even if we were to recover all the phosphorus in human excreta in Australia, it would represent less than 5% of Australia's total phosphorus demand.

We need to think about different options in this country. Up to 90% of Australia's population lives in the cities, and they are therefore phosphorus hotspots for excreta and food waste and other sources. My team has been geo-spatially mapping those hotspots. We are also working with the major fertiliser retailer in the Sydney Basin.

This fertiliser producer has a really innovative business model, selling not a product but a service. When a customer comes to them asking for fertilisers,

Figure 5. Phosphorus recycling in Australia may include innovative business models.

they only sell them fertiliser after they have tested the customer's soil. Most (99%) of the time the soil is already saturated in phosphorus largely as a result of the use of excess poultry manure in the Sydney Basin. This business is selling an agronomic service, and this is a really good business model which is a win–win for them and gives them a market edge. It is good for the farmer customer's productivity and it is good for the environment because it results in less phosphorus being applied to the soil to later run-off into our waterways.

Why recycle phosphorus and nutrients

Recycling can and must play a role in achieving future phosphorus and food security, both in this country and in the rest of the world, because it creates locally available renewable fertilisers.

We talk about renewable energy, and we really need to become serious and talk about *renewable fertilisers* as well. Human excreta alone can contain 3 million tonnes every year of elemental phosphorus, globally. The opportunities are right there.

Recycling also would facilitate what we can call 'phosphorus sovereignty', particularly for communities around the world where farmers have poor access to fertilisers.

At the national scale, renewable fertilisers can reduce countries' dependence on imports from some of the geo-politically risky areas where phosphate is being produced, and so buffer against some of the future price spikes and supply disruptions. You may not have been aware that in 2008 there was an 800% price spike in phosphate. It had dramatic consequences around the world, including in Australia.

With the shorter phosphorus cycles in a circular economy, of course we have less waste and potentially less lifecycle energy – and of course less risk of phosphorus run-off to waterways, feeding algal blooms.

Important considerations

Finally, a few considerations we need to keep in mind on this pathway towards nutrient recycling and phosphorus security (Figure 6).

- **Context matters**. We have all these technologies available, and we cannot import solutions from one country to another. Therefore there needs to be a framework for thinking about the most cost-effective and appropriate measure for each situation.
- **End-user preferences matter**. In designing new products, we need to engage the market end-user to understand their needs and preferences, because that is often where some of the barriers are.
- **Look for partnership opportunities**. In a circular economy, we need to be forming new partnerships between the sectors and stakeholders in the circular value chain. As I mentioned, those partners also need to include the urban planners when talking about cities.
- **Look for new business models**, such as selling services instead of products. Using 'Uber farm machinery' (Gulati, this Proceedings) is another example.

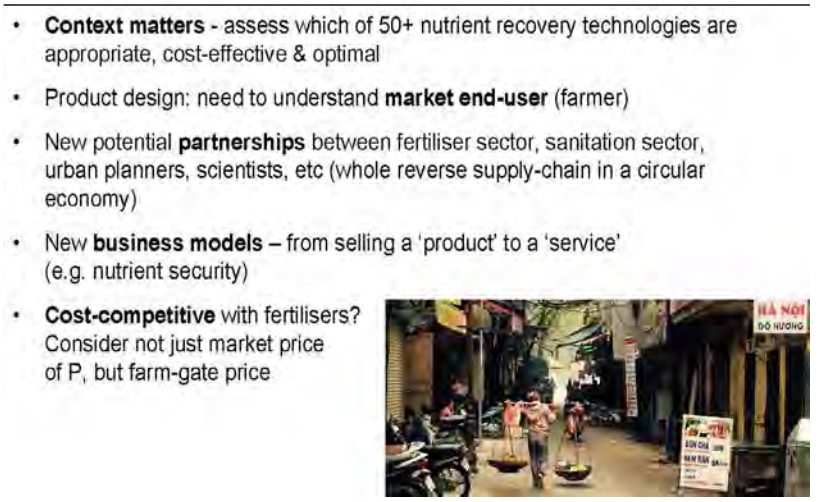

Figure 6. Considerations on the pathway to nutrient recycling and phosphorus security.

- **Cost competitiveness**. Is recovering nutrients cost-competitive with fertilisers based on rock phosphate? It is not appropriate to compare fertilisers on the basis of the market price alone, because for the farmers it is the farm-gate price that matters. If recovered nutrients are compared to rock phosphate fertilisers at the farm-gate price, then there are opportunities to show that recovered phosphorus can be a cost-competitive product that has the added advantages of building food security, environmental integrity and livelihood security as well.

Acknowledgement: The partners named in the image below, as well as numerous others, support this work.

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Dana Cordell leads and undertakes international and Australian research projects on sustainable food and resource futures. Many projects involve high-level stakeholder engagement to improve the policy relevance and impact, and foster mutual-learning. Dr Cordell leads the collaborative P-FUTURES project across Australia, Vietnam, Malawi and the US, which, together with local stakeholders, aims to identify how urban food systems can cope with or transform in response to the emerging global phosphorus challenge. In 2008, Dr Cordell co-founded the Global Phosphorus Research Initiative – the first global platform to undertake research, policy and public engagement to ensure food systems are resilient to the emerging global challenge of phosphorus scarcity. Dr Cordell currently leads the Mapping Sydney's Potential Foodsheds project, which brings together key stakeholders such as NSW Farmers, Department of Primary Industries, Department of Planning and RDA-Sydney. The project aims to increase the resilience of Sydney's food system to global and local challenges (from climate change to urban growth) through participatory stakeholder workshops and geospatial mapping scenarios. As a global food security expert, Dr Cordell provides expert advice and commentary to the United Nations Environment Programme (UNEP), Australia's Chief Scientist and the UK Parliament. She most recently joined UNEP's Global Environment Outlook team as a global food security contributor. Dr Cordell's research contributions have led to numerous prestigious recognitions, including one of Australia's top science prizes, the Eureka Prize for Environmental Research (2012). She has been named as one of the 100 Women of Influence (*Australian Financial Review*/Westpac 2013) and the Top 100 Most Influential People (*Sydney Magazine* 2012). She is frequently interviewed for the media, including Radio National, ABC *Lateline*, and *The Times* in UK.

Sessions 4 & 5 Q&A – Supermarkets & the management and reuse of waste

with Dr Arief Daryanto, Professor Alice Woodhead, Dr Steve Lapidge, Dr Cedric Simon, Dr Bernadette McCabe & Dr Dana Cordell

Chair: Ms Jo Evans

Q – Isaac Jones, Western Sydney University
Bernadette McCabe, I know it wasn't the focus of your talk, but with municipal solid waste I know one of the key issues is heavy metal residue in soil and also physical particles of glass and things like that. Does the incineration of municipal solid waste (MSW) alleviate those problems and also, in your opinion, is incineration of MSW even adequately viable, or would you prefer one of those other options?

A – Bernadette McCabe
To answer your last question first, no, I do not think incineration of the MSW is the best use of it. I will reiterate a point from Professor Fresco's Sir John Crawford Address last evening, and say that what we need to do is to get the most benefit out of our waste, whether it is inorganic or organic. The 'jury is still out' on incineration as a recovery method, though a decision is being spurred on by legislative requirements and landfill and so on.

Australia has huge potential for using sewage digestate that may contain heavy metals. We need to consider digestate handling and use, and at the moment our wastewater treatment facilities are not using sewage in the best way. They may be trucking the sewage and ploughing it into land without knowing what heavy metal accumulation could be happening.

If you look at the UK experience with WRAP (Waste & Resources Action Programme), they have done some brilliant work around bio-solids application, and understanding dosages. What farmers really want to know when using bio-solids on land is what sort of NPK levels they are applying, just as they do when using a synthetic fertiliser. If you are going to put a tonne of digestate onto land, you do not want to be guessing what you are adding. Some of the guidelines that are coming out are giving users a better idea of the content, so that farmers can be confident in what they are applying. I think that is something that Australia should really look at, in closing the nutrient recovery loop, as well as understanding dewatering technologies and granulation of bio-solids.

Q – Sally Beer, University of New England
My questions are for Steve Lapidge and Dana Cordell. Steve, could you clarify what 'printed food' is. Dana, how are you planning to overcome consumer resistance to using excreta as fertiliser? I am thinking there could be some logistics issues in that.

This is an edited transcript of this Q&A session at the conference.

A – Steven Lapidge
Printed food is a new idea coming from the Netherlands and a few other countries in that part of Europe. It is amazing. They use a feedstock such as food waste to print a 3D carrot or a biscuit. You can put whatever ingredients and nutrition you want in there, so it certainly may be something we can use in the future. At this stage it may look quite crazy, but if you think about elderly people who may not want to bite into a hard carrot but would like the nutrition that comes in the carrot, this technology means you can 'print' a 3D carrot with whatever texture you want and whatever nutrition you want, so it meet the consumer's needs. They reckon the costs of food printers will be down to a few hundred dollars in the next 1–2 years. I am sure we shall be using this idea one day.

A – Dana Cordell
Fertilising crops with excreta is already happening in many parts of the world. For example, when I lived in Sweden for six years, on a farm near a very small town, we could go to our local hardware store and buy a urine-diverting composting toilet that we could put in our house. Then we could use our urine to fertilise our gardens for example. Urine is perhaps the most confronting, because it is used without being processed in any way. I think it becomes much more socially accepted once people understand why we are doing it. A lot of studies have actually engaged with users of these new types of toilets and also with consumers of the food that has been produced using human excreta and other forms. You find that when you engage people so they deeply understand the why, then they become much more open to the idea. You especially need to answer their questions around health concerns, which of course are the number one issue after the yuck factor. There are a lot of examples showing how objections can be overcome. There's a professor in Sweden who talks about 'urine blindness' for example. He is referring to the blindness of policy makers and industry to the fact that wastewater treatment plants, say, are sitting on a gold mine because excreta is going to become one of the most valuable of resources in the future. The reason they are not there yet is all because of this yuck factor – which we can overcome. We are toilet trained as we start life, and we can be toilet trained again, to use these different types of toilets and to understand why we should be eating these food crops, and that we do not necessarily need to feel concern over their healthiness.

Steve and I both showed photos of struvite. It looks exactly like fertiliser. It is pure white crystals and so in appearance it is far from the idea of human waste. It looks very nice and clean. I have a jar of it on my desk at work, as well as a jar of other things I will not tell you about. Use of these materials will become normalised once we realise there is so much value in them. In some parts of the world, they cannot afford to acknowledge the yuck factor. Farmers realise that some of these products are 'clean' and processed. They produce higher yields and farmers can see their benefits. It is just a no-brainer really..

Q – Gerry Gillespie, *Resource Recovery Australia*
This question is specifically about source separation of organic waste and I think Alice Woodhead will be the most appropriate person to answer it. According to the New South Wales Department of Primary Industries, in Australia 75%

of our agricultural soils have less than 1% organic matter, so we have a soil-organic-matter crisis in Australia. In 2011 we passed a piece of legislation in Federal Parliament called the *Product Stewardship Act 2011*. Currently we use that legislation on a mandatory basis, just to recycle computers and televisions. If about two paragraphs of it could be modified, that legislation could direct every bit of organic waste in Australia to be source-separated and returned to agriculture as a high-quality nutrient-rich product. Would that make sense to you, Professor Woodhead?

A – Alice Woodhead
Thank you for that tricky question. Yes, it does make sense, but nothing is ever as simple as it seems it should be. There is always a cost and the question then is 'who bears the cost?'. The Product Stewardship work was done with supermarkets and other sectors, and apart from the supermarkets the stakeholders are not necessarily in a good enough financial position to be able to bear the cost. So you can get a kick back. I am not exactly sure of the details of where the cost would be borne in that particular scenario.

The way to get around that is to create an economy around doing this recovery process and to create a market that rewards the recycling of the goods. But we have always had some resistance to putting an enforced market price on some of these policy initiatives. I think that is the answer to why it is not happening, and yes, it does make sense, in principle.

Q – John Radcliffe, *Australian Academy of Technology and Engineering (ATSE), South Australia*
First, it has to be made clear that somebody has to have a business plan which is positive, before any of these ideas can be pursued. There are a number of ideas around, to do with nutrient recovery. ATSE last year produced a report on the resources in wastewater streams, and that showed clearly that the most valuable components are carbon and water. We have been given the example, today, of SA Water's wastewater treatment plant at Glenelg in Adelaide. South Korea abolished the export or dumping of food waste to the ocean a few years ago, and it now requires it to be combined with wastewater treatment, which generates energy and makes those plants energy-exporting. That is a legislated example.

In Australia, a lot of the current waste systems in urban areas derive from the old Environment Protection and Heritage Council of state and federal ministers, which was abolished two or three years ago. You have to consider the environment and the legislative structure within which people will operate. The people who run the sewage treatment plant at Werribee, near Melbourne, for example, are not going to pursue a couple of tonnes of struvite when they can get much more value by improving the quality of the wastewater that they discharge to ocean so that they are not prosecuted. There are a whole lot of sticks and carrots in this process.

My question is, can we re-establish a Commonwealth–State structure that would facilitate the development of some of the ideas that have been enthusiastically put forward?

A – Steven Lapidge
Environment Minister Greg Hunt announced a National Food Waste 2025 Strategy last year, which is tied to the Emissions Reduction Fund. It will be interesting to see what happens in that space. I am not saying it is the total answer, but certainly in terms of a federal initiative that may see more work in this area, I think it is a promising start. We are yet to see the fine print.

Q – Eric Craswell, *Crawford Fund and the Australian National University*
There was a passing mention about 'peak phosphorus'. I understand the latest estimate is that it is 200–300 years away, because of the revised Moroccan Reserve. However, I want to ask the panel a question in general. There seems to be a trend among the younger generation to look for organically grown food and farmers markets, certainly in Canberra. I wonder whether those two trends are significant enough to affect the waste of food and food losses?

A – Steven Lapidge
Unfortunately there is still a lot of waste happening on organic farms as well that could be utilised. So yes, those trends potentially help with the nutrition side of things, but there is still a lot of waste happening.

A – Dana Cordell
I can add two things in response to that, working backwards. One is a project that my colleague Elsa Dominish and I are working on at the moment. It is about creating demand for recycled organics (compost). Part of that is looking at the demand or the market pull, so it actually engages exactly the consumers you are talking about – those who use farmers markets and who buy organic produce – to understand if we can market, say, vegetables that have been produced using these kinds of recycled organics, such as compost.

Also, about 'peak phosphorus', that revised date you mentioned was not a peak phosphorus date; it was in relation to a new assumption about the phosphorus concentration of Moroccan rock phosphate, updated from 1989. When you use that new reserve data that they have come up with, and put it into a peak phosphorus analysis, it pushes out the peak phosphorus crunch time by a couple of decades. We have moved on to what can we do about sustainable phosphorus use, but there are now a number of studies that show that we could see a crunch time around mid-century, plus or minus a decade or two.

Q
A question for, perhaps, Dr Daryanto and Professor Woodhead. In that 'last mile', if you have printed food and then a shift back to organic farming and famers markets, given the different type of retailing structure in some of these countries, where are those new technologies going to fit in?

A – Alice Woodhead
Well, every technology has to be adapted to the particular situations. If you have organic waste and printed food – which I hope would be organic with some flavours in it – then the solutions are the same as those we need in the current supply chain. If food can be preserved and shelf life extended and infrastructure maintained that keeps the food in a whole state, then you will have less waste.

That is basically the scenario that we work to. Where there is waste, if you can create a by-product rather than thinking of it as a waste, then regardless of whether it is functional food or an organic source of printed food, the same scenario would fit.

A – Arief Daryanto
I think that Indonesia has to deal with food waste issues like those of developing countries and also those of Australia. Jakarta has an inner city population of over 14,000 people/sq km, or over 4000 people/sq km if you consider the metro area as a whole. This is 1.6 times the density in Singapore. We have the highest income and also the lowest one. The Government needs to be balanced, in focusing on food security and on food safety. We have classical food loss from primary products and also processing and service. So we are now introducing industrial models of agriculture industrialisation, to combine primary processing and also the service industry in the one model for our country.

Q – Joanne Daly, *CSIRO*
My question is for Steve Lapidge. You mentioned that 90% of nutrients are lost from farm to fork. It is an interesting figure because most of the speakers have talked about quantities in tonnes or as dollar value. Can you clarify: does the 90% loss, for example, mean that after your tomato leaves the farm, only 10% of its nutrients reach the consumer unless the right quality or processing strategies are applied along the way, or is it that the 90% of the nutrients are the ones that are disposed of before they end up in the consumer market?

A – Steven Lapidge
The figures I've seen are quite general; not specific calculations. Any organic produce that goes back into the soil is obviously adding nutrients back into that soil. If instead the produce goes into landfill or out to sea, then obviously those nutrients are being lost. That is where the bulk of nutrients are being lost, as well as in fertiliser that never gets taken up by the plants. That is where the 90% figure comes from.

A – Dana Cordell
For phosphorus specifically, a lot of the losses occur during mining and fertiliser production. The phosphate mining process used today is the same as was being used 50 or 60 years ago. At the moment, there are no incentives for industry to do things differently. When you produce phosphate fertilisers, for every one tonne of fertiliser you get five tonnes of a radioactive by-product called phosphogypsum which has to be stockpiled. The USEPA considers it too radioactive to reuse because it contains isotopes of uranium and thorium, so there are huge stockpiles of it sitting in Florida. It is another really important pre-farm loss. We often start at the farm. I think we need to go further back, looking at those raw inputs to agriculture as well.

Q – Justin Borevitz, *the Australian National University*
Can anybody on the panel discuss their thoughts about urban agriculture, either high-tech vertical sky-farms or low-tech aquaponic agriculture?

A – Dana Cordell
Can you grow prawn pellets on the top of roofs?

A – Steven Lapidge
Grow the food where the waste is.

A – Cedric Simon
There has been more and more work looking into recirculation systems to recycle nutrients: aquaponics, for example, possibly to produce eels or tilapia. There are a range of aquatic species that can be reared at high stocking density, on top of roofs and in cities. It remains a niche market to provide fresh seafood to local restaurants etcetera, generally associated with low production volumes.

Nestlé's war on waste: a journey through the supply chain

Daniel Lagger
Nestlé Oceania

ABSTRACT: Nestlé celebrates its 150th anniversary in 2016. Behind such a long history, questions of sustainability and protecting the future have always been key. With increasing water scarcity, constrained natural resources and declining biodiversity, we need to protect the future by making the right choices. We focus on continuous improvement in our environmental performance everywhere we operate, to provide products that are not only tastier and healthier but that also are better for the environment along their entire value chain. Our goal is to send zero waste to landfill from our factories globally by 2020. Over the last ten years, our focus on reducing waste for disposal has seen waste reduce by 75%, with one in five factories now generating no waste. However, we also consider waste more holistically, looking at all steps from agriculture and ingredient production, to the factory, in the supply chain and through to the consumer's home. This approach requires detailed target setting as well as an in-depth understanding of behaviours and systems in different countries, both those that lead to waste, and systems that manage waste. In addition, Nestlé is focusing strongly on reducing food loss and waste, both upstream in agriculture and through to the retailer and consumer. This is a crucial part of the journey to feed a growing global population and contribute to meeting the target of the Sustainable Development Goals to halve per capita global food waste by 2030. With 436 factories in 85 countries making products sold in 189 countries, the company aims to improve resource efficiency, quality and productivity in our operations to do more with fewer resources and less waste. The story of Nestlé's approach to waste and recovery is one of both high-level commitment and deeply detailed activity, supported by external collaboration. This reflects the breadth and complexity of its operations. This paper presents broader industry trends with respect to waste, and why this fits in with broader corporate social responsibility and sustainability issues for companies in general, while giving specific Nestlé examples.

Keywords: food losses, food waste, supermarkets

This year, Nestlé is celebrating its 150th birthday. Milestones are a time for reflection – what got us here; what made us who we are; where next? In Nestlé, we ask the same questions: How did we get here? What will take us to another 150 years? How do we protect the future? What are the right choices, now, that will give us genuine sustainability?

Nestlé is a significant business by any scale (Figure 1). The mindset that we bring to our environmental performance is more important than ever. Today,

This is the paper and some of the illustrations that Daniel Lagger presented at the conference.

Figure 1. Nestlé is a significant worldwide business that has been operating now for 150 years.

we confront issues of increasing water scarcity, constrained natural resources, declining biodiversity, and climate change, so the importance of making the right choices could not be more clear. How we think about waste is obviously a key part of this.

Of course, reducing waste should be a no-brainer for every business. Waste has a cost. Waste is things we have purchased or created that have cost us time, money and other resources. To not use them is to have invested resources in something with no return. That makes no sense. This is something the entire food and beverage industry knows.

However, it is not enough to simply say we want to reduce waste. Rather, we have to take an end-to-end look at our supply chain, upstream to basic research and agriculture and right through to the retailer and on to the consumer (Figure 2). We need to deeply understand what waste looks like, how it comes about, and how we can do better. This takes both an eye for detail, and creative thinking.

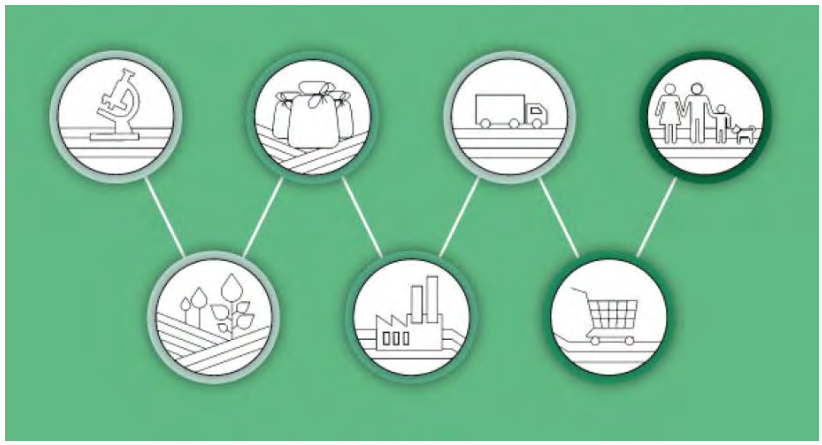

Figure 2. Planning for no waste: set targets, measure, constantly review.

In a world facing increasing constraints on natural resources, Nestlé has set this simple but ambitious long-term goal: zero waste for disposal. We are making progress against a number of interim targets by preventing and minimising the waste we generate in the first place, by avoiding food wastage and improving resource efficiency along the value chain, and where possible we try to reuse materials and create value from them. It is not one project but hundreds, even thousands, across Nestlé's 436 factories, and out to the ends of our supply chain.

Nestlé thinking globally

According to the Food and Agriculture Organization of the United Nations (FAO), about one-third of global food production is wasted worldwide each year (Figure 3). Either perfectly edible food is thrown in the bin, or food is lost when it spills, spoils, bruises or wilts before it reaches the consumer.

In an age where 800 million people go hungry, the significance of that waste is extraordinary; the challenge for our industry no less so.

Food waste causes 8% of human-produced greenhouse gas emissions. If it was a country, this wasted food would be the world's third highest emitter of greenhouse gases, behind China and USA, and the water needed to grow this food would fill Sydney Harbour 475 times.

The United Nations' 2030 Sustainable Development Goals acknowledge the seriousness of this problem. We particularly note Goal 12.3:

> 'By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses.'

In response, in January 2016, our CEO Paul Bulcke joined a new coalition, Champions 12.3, to accelerate progress towards fulfilling this goal. Subsequently, we, together with our peers in the Consumer Goods Forum – a coalition of more than 400 of the world's largest manufacturers, retailers and service providers – resolved that forum members should halve food waste from their own operations by 2025.

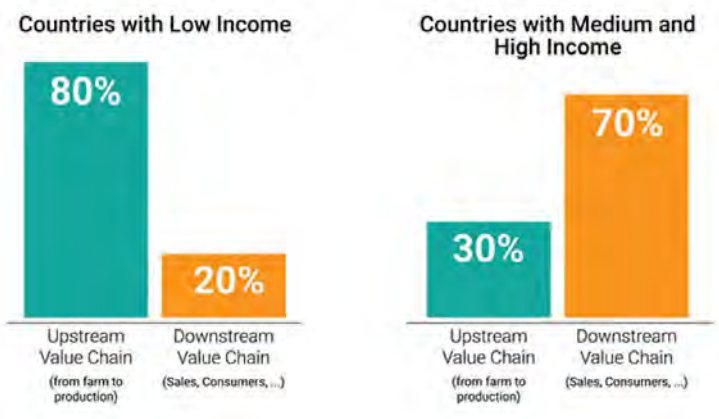

Figure 3. Worldwide, food waste is an issue: resources invested for no return.

One major hurdle to progress for both industry and government has been a lack of consistent guidance on how to reduce food waste. For that reason, Nestlé, as a company already measuring food waste, played a key role in developing the first global standard to help companies and governments reduce food loss and waste (see also Lipinski, this voume). Members of this partnership include the Consumer Goods Forum, the FAO and the World Resources Institute.

This standard, the *Food Loss and Waste Accounting and Reporting Standard* (FLW Protocol 2016), was launched in June at the 3GF Global Green Growth Forum in Copenhagen. It provides the first-ever set of global definitions and reporting requirements for companies, countries and others to consistently and credibly measure, report on and manage food loss and waste. It has been hailed as a real breakthrough because, for the first time, countries and companies will be able to quantify how much food is lost and wasted and where it occurs. Not only can they then report on it credibly and consistently, but identifying hotspots will be the first step towards developing new strategies and monitoring progress.

This serious problem will require a great deal of focus at global and local levels, and for this reason, we are actively involved in a number of other multi-stakeholder initiatives to reduce food loss and waste.

Nestlé acting locally

Internally, Nestlé's Zero Food Wastage Taskforce coordinates our efforts to drive our food wastage initiatives across our value chain, share good practice and guide multi-stakeholder initiatives. Last year, this Taskforce launched our commitment to reduce food loss and waste, which addresses food loss and waste through responsible sourcing, zero waste for disposal in our sites, educating consumers and employees on reducing food waste, and engaging with key stakeholders – such as regulators and scientists – to develop and implement solutions.

Worldwide, 54% of this lost and wasted food comes from the upstream value chain – in production, handling, post-harvesting, and storage – and 46% comes from the downstream – in transformation, distribution and at consumption. In developing countries, this skews more strongly towards production at the farm. These are also the countries where hunger is more likely to be a concern.

At the farm

As a buyer of raw materials grown by more than 4,000,000 farmers, and with direct buying relationships with 760,000 farmers, we have an extraordinary capacity to support change. We can help reduce on-farm losses by helping farmers to farm more productively. For instance:

- in Vietnam, by helping coffee farmers to use the right amount of water – not too much, not too little, and to water at the right time to maximise their productivity without wasting water;
- in the Ivory Coast, by training cocoa farmers to harvest cocoa pods and ferment and dry the cocoa in a way that preserves the cocoa and keeps the quality high – while teaching them to compost the waste for the future of their trees;

- and in farming globally, by continuing to contribute to farm capacity-building – from propagation to post-harvest storage, farm animal health, care and welfare, breeding better plants more fit for purpose, farm management and record keeping, and water conservation, irrigation and soil fertility.

By contributing to the efficiency of their farms and a path to market, not only do we help secure supplies of the agricultural raw materials we need, but we also positively impact society by supporting rural development, water conservation and food security and reducing food waste and farm losses at that critical stage.

Storage, handling and transport

As food moves from the farm towards the factory, food companies are able to help farmers decrease post-harvesting food loss.

To do this, Nestlé has created a new initiative called Vital First Mile, which brings our colleagues with experience and expertise in transportation and storage to Nestlé teams around the work to optimise that First Mile and minimise losses between the farm gate and the factory gate.

Reducing these post-harvest losses in our upstream value chain helps us ensure supply of agricultural raw materials, and also supports rural development, water conservation, and food security. For our suppliers, the Vital First Mile initiative will help farmers, raw material pre-processing suppliers and logistics providers to reduce post-harvest and storage losses and thereby save costs.

Our first Vital First Mile project in Qingdao, China, enabled Nestlé to successfully transform dairy farming operations to dramatically decrease milk loss. Having collected milk in the area for 20 years, Nestlé decided to transform its model with a streamlined approach to milk collection which would reduce milk loss and collection costs while increasing quality and improving dairy farming sustainability. Nestlé provided financial support to help farmers buy equipment to improve cow productivity and milk quality and decrease waste milk production, then backed this up with regular training and technical support for farmers on topics such as reducing milk loss and improving quality.

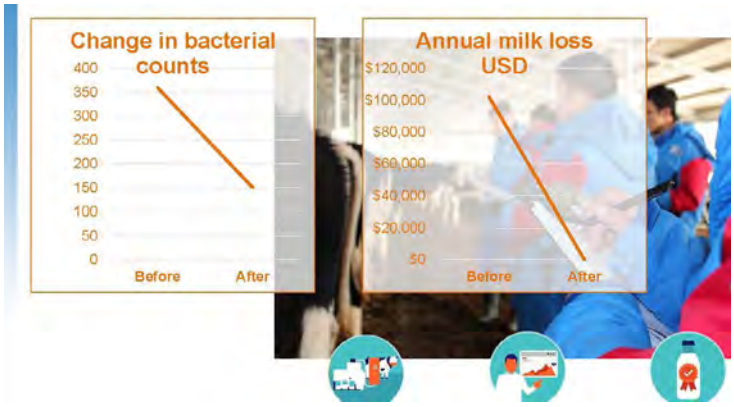

Figure 4. Better milk quality and less annual loss resulting from the Vital First Mile project at Qingdao, China.

The outcomes have been significant. Bacteria counts in milk have dropped by over 50%, and the amount of milk lost to poor quality or because of antibiotic use has gone from US$102,000 worth of milk to no loss at all (Figure 4).

This is a new project for us, but early signs are promising.

In the factory

Clearly, the part of the supply chain at which food companies have most control over waste is in our own factories. Nestlé has set itself the objective of zero waste for disposal across all our 436 factories by 2020, across all forms of waste. Waste for disposal is any material that leaves our factory for final disposal with no economic or ecological value such as landfilling and incineration without energy recovery (Figure 5).

We are well on the way: by the end of last year, 105 factories – that is 22% – had achieved zero waste for disposal.

Using best practice from those factories, we have developed a Zero Waste for Disposal Guideline. We recognise that every factory is different, every factory has different forms of waste and different challenges, and every location has different waste management opportunities. This guideline helps each site to understand the challenge they may face in their journey towards zero waste for disposal; discover the recycling, recovery and reuse destinations of different materials such as coffee grounds, tea leaves and coffee capsules; compare economic costs and benefits of achieving zero waste for disposal; and share tools and examples of best practice implemented across the company globally to help all our sites prevent, reuse and recover waste for disposal and by-products. As a result, every Nestlé factory has projects to reduce waste, with the goal of zero in mind.

As manager of 12 very different factories across three countries, with many forms of waste, I can confidently say that there is no one-size-fits-all approach. But I am impressed by the power that setting a hard target can have on the

Figure 5. Nestlé's objective is zero waste for disposal from all 436 factories by 2020.

capacity of a factory team to grapple in a meaningful way with the waste generated within a factory.

A few local examples will give a sense of the diversity of both the problem and the solutions.

- At our factory in Gympie, Queensland, which makes instant coffee, spent coffee grounds go into a biomass boiler – providing 65% of the energy used at that factory. Not only is it an effective way to use waste, but it has reduced carbon emissions, disposal to landfill, and meant significant cost savings. The same model is used today in 22 Nescafé factories worldwide.
- At the Uncle Tobys snacks and cereals factory on the Murray River between NSW and Victoria, setting a challenging goal led to 46% reductions of waste for disposal, and a further 44% in successive years; the range of approaches include recovering by-products, recycling, and selling oat hulls as animal feed.

I am also inspired by what can happen when people become genuinely engaged with the problem.

- At our Blacktown factory in western Sydney, we worked with the TAFE (technical college) to provide training for staff to encourage them to grapple with the problem of waste. Engagement was so high that our factory workers were using their own personal time to make contact with businesses and local government to try and find better paths for the factory's waste. This very motivated and fired-up group has not only transformed waste at this factory but also the project to manage waste has refired the factory's entire culture.
- At our Milo factory, at Smithtown on the NSW mid-north coast, we are actually using waste from another industry! We take sawdust from the local timber industry and use it as an energy source. As a result, 85% of the energy we use in that factory is not only from a renewable source but is part of ensuring another industry has a stream for its waste. But why stop there? The resulting ash from the biomass boiler then goes to a gardening company for composting.

Chocolate to biogas

There are a dizzying array of innovative different approaches outside Oceania as well. For example, in the UK we have developed an anaerobic digestion system at a confectionery factory which turns confectionery waste into renewable energy and clean water.

Essentially, a 'chocolate soup' of waste is fed into an airtight tank, where bacteria break it down. The biogas that is a by-product of this process produces enough heat and power to meet about 10% of the site's energy needs. While the technique has been used in agriculture and industry for centuries, what makes this factory's process unusual is that it has been designed to handle a high volume of solid and liquid waste within a short time. The system is converting about 4 tonnes of solid waste and 200,000 litres of liquid waste every day. It is also improving the quality of water discharged from the factory so that it is now virtually clean on release from the site.

While the system was expensive to set up, the reduction in the waste-disposal costs and energy bills means it should pay for itself in four years.

There are some challenges we have not solved – particularly in locations around the world where the infrastructure to manage waste is not sufficiently developed. Nonetheless, having met some targets already, we remain committed to our 2020 goal.

Transport and supply

Food and beverage companies have further opportunities to manage and reduce waste as we look beyond the factory gates to the downstream supply chain that takes finished products to warehouses and retailers before consumers buy it.

In Nestlé, we need to be sure that our trucks are fit for purpose. For example, we have purpose-designed trucks (Figure 6) to carry breakfast cereals which are large volume and lightweight. Cereal boxes have different needs to, say, glass jars of Nescafé. Clearly, a truck that is not full is wasting fuel and resources. We plan truck movements to ensure trucks are fully loaded, and partner with others to make sure we are not moving empty trucks. For example, working with CHEP we have redesigned our trucking so that after offloading our products the empty truck is loaded with CHEP pallets to bring to the factory. It is a cost effective arrangement for us both, which has saved 20,000 litres of fuel in a year and significantly reduced the kilometres travelled and greenhouse gases emitted.

We have even found a home for excess pallets by partnering with a charity which uses our excess pallets to transport donations to those in need. Last year, that was 4000 pallets.

We also have systems in place to give unsold food a second chance. In Australia, Nestlé and many other companies donate this food to Foodbank (a not-for-profit food-relief organisation). Foodbank has developed an efficient model to distribute this food to people who need it, via a network of charities around rural and urban Australia. We are told that the food is taken up as soon as it reaches the Foodbank warehouse!

Figure 6. Nestlé has purpose-designed trucks, including those that carry breakfast cereals which are large volume and lightweight.

In packaging

Packaging of food and beverages is crucial to prevent food waste, guarantee quality and make sure consumers are informed about what they have bought. For the food and beverage industry, improving how we design our packaging, the materials we use and the impact on the environment can make an important contribution to environmental performance across the product lifecycle.

The 'dream package' needs to:

- ensure food is safe from bacterial contamination;
- keep food fresh and present it well;
- use as little material as possible, with minimal environmental impact in making the packaging itself;
- run smoothly through machinery in a factory;
- be readily printable, so consumers can read the labels, and so it is easy to add batch and date codes;
- be low in weight, and maximise the amount of product that can be packed on a pallet – affecting the efficiency of transport;
- be made of recycled materials;
- be recyclable or, if that is not possible, add as little as possible to landfill.

And finally,

- consumers have to like it.

I wish all this were possible! However, the length of this list highlights that packaging must have sound science behind it in order for proper evaluations to be made of a package's true impact, and the right choices made. For that reason, since 2007, every pack we have designed has gone through a rigorous lifecycle assessment program.

Figure 7. In Nestlé, we assess the overall environmental performance of our packaging, and set targets to measure and minimise its use.

We can now assess the overall environmental performance of packaging from component sourcing to consumer use and disposal. This is critical for making good choices, and for improving. We also set targets to measure how much packing we can avoid (Figure 7). Industry collaborations such as the Australian Packaging Covenant help improve packaging across industry as a whole.

Here is one example to show you the difference this detailed approach makes. In the last two years in Oceania, we increased sales of our 'KitKat' chocolate bar but reduced the total packaging we used by 138 tonnes. As this packaging is not recyclable, that meant 138 tonnes less to landfill.

We also support initiatives to recycle or recover energy from used packaging. For instance, we have a partnership with TerraCycle who have developed recycling streams for Nescafé Dolce Gusto and Nespresso capsules.

Waste in retail and in homes

I started out by saying that food waste in the developing world happens in agriculture. In the developed world food waste happens much closer to the consumer: in the retail environment, in food service, and in the home.

Let me encourage you to look in a different way at the role of a company in the packaged food and beverage business. The very nature of what we do – that is, taking perishable ingredients such as milk, coffee beans and cocoa and transforming them into safe value-added food products with a better shelf life – means that we have increased the likelihood the food will be consumed before it goes bad. We have reduced the likelihood of food loss. For example, more than 75 years ago we invented a way to use up food that was going to go to waste: namely, an oversupply of coffee beans sitting unsold in warehouses in Brazil. Ironically, that product, Nescafé, is now one of our biggest global brands.

We also design packaging so it can help reduce waste at the consumer's home. For example, we put thought into portion sizes, so that consumers are more likely to eat the whole contents of a package, rather than using some and throwing out the rest.

It's an endless war

There is no single silver bullet for waste. Good waste-reduction starts with drive from the top, plus extensive external collaboration, plus an eye for opportunities that can enable thousands of small and large projects to eliminate, reduce, reuse and recycle. We couple all that with a focus on measuring and tracking – and long-term goals.

Although we face a world with so much food waste and loss, we can turn that tide through ongoing collaboration and commitment.

Those who measure waste can better manage it; those who commit to a path can effect true change.

That is good news for people, business and the planet.

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Daniel Lagger has been in his role as Executive Director, Technical & Production (formerly Operations), since 1 March, 2016. In the preceding three and a half years he was Technical Manager at Nestlé Japan. Daniel began his Nestlé career in 1984 as a Project Engineer in Switzerland. Throughout his 32-year career, Daniel has held different positions in the group, in the Philippines, Thailand and Switzerland. He holds a Masters degree in Mechanical Engineering from the EPFL (École Polytechnique Fédérale de Lausanne) in Lausanne, Switzerland. Daniel believes that the most important part of any role is working as one team to deliver results. Outside of work, Daniel likes sailing, diving and skiing, and discovering new countries.

Panel discussion

with Professor Louise Fresco, Dr Karen Brooks, Daniel Lagger

Chair: Dr Daniel Walker

The panel for this final discussion session comprises today's two keynote speakers – Dr Karen Brooks and Mr Daniel Lagger – and Professor Louise Fresco who presented the Sir John Crawford Memorial Address, 'The Future of Our Food', during dinner yesterday evening. In her address, Professor Fresco gave us an incredibly lucid and accessible account of the global food system. She ended it with a plea for developing a much deeper integration in science, policy and practice between agriculture, food, health and the environment. She asks us to see them as a single system, and to manage them as a single system.

Dr Karen Brooks this morning reminded us that food loss and waste are the outcomes of many millions of personal optimisation decisions and business optimisation decisions. And Daniel Lagger has just given us an overview of the numerous ways in which Nestlé has taken on the responsibility of managing its own processes and products to eliminate waste, and of helping other companies to do so as well.

Now I shall take the chairman's prerogative and ask the opening question.

Q – Daniel Walker, Chair
The Crawford Fund is here to promote and support agricultural research designed to benefit developing countries. How well is the global R&D system set up to address the types of challenges we are tackling, the challenges that have been talked about today, as compared to some of those more directly related to productivity? From your collective experience – in research, in policy, through the FAO and the World Bank, and in the commercial sector – do you have comments around how the global R&D system and innovation system might need to change in the next few decades to address some of these challenges?

A – Louise Fresco
Well I think actually we are much better off today than if you had asked that question five years ago. I think there is a real understanding now in the R&D community that waste is an issue, and it draws people together from a broad range of disciplines. From chemistry, food engineering, toxicology, defence, the economists and so on. I think we are much better off than before with microbiologists. However, we do not have a real vehicle, or a real mechanism, so what you see is some ad hoc programs, transversal programs that bring people together. Certainly at Wageningen we have a program on food waste, and I am one of those Champions 12.3, helping to raise the awareness that is dawning upon CEOs at the level of the World Economic Forum.

But the R&D system is still very much disciplinary, as I think we all agree. So the question is, should we also in our curricula, in the way we train our students, in the way we fund research, get a much stronger message to scientists that

This is an edited transcript of this Q&A session at the conference.

this is really an area in which it is worth investing? I think that understanding is growing, but we are certainly not yet there.

A – Karen Brooks
I would like to respond from the perspective of the CGIAR system, where I am presently located. I have been impressed with the discussion today, and I am coming away with a more profound understanding of what the circular economy means in this issue of managing food waste and loss. I think it is very difficult to separate the productivity part of that from everything else that comes next: from the processing part, from the consumption part, and even from the waste management part, which then feeds back into the production part. It genuinely is circular.

I think that we within the CGIAR system are coming to grips with an understanding of that. Our programs are designed to take a systems approach. We are not as active in the waste management side, although actually IWMI (International Water Management Institute) is working on municipal water management. I think we are proactive in certain parts of waste management, but we are still groping a bit to see where our best contribution is. Historically we have been strongest on the more narrow understanding of productivity, but within IFPRI (International Food Policy Research Institute), the institute that I am involved in now, we are certainly looking at the policy dimensions of food waste and loss 'across the board', and we are partnering with the FAO to develop a technical platform for measuring food waste and loss. So we are definitely getting involved. I can say that we are part of the process of building better understanding and working together for solutions.

A – Daniel Lagger
Maybe I can add just one thing. In industry, we used to work too often in 'silos'. We were saying 'OK, we know what we are producing; we are the experts', and so on. In today's world we see that we need to work much more together, between all organisations, all stakeholders, and understanding the positions of other people, not only our own points of view. I think in this we have improved drastically over the last few years.

A – Louise Fresco
If I may add, one of the issues still is that there is very little private sector funding to the public sector in a kind of private–public partnership to tackle these issues. There are a lot of wonderful statements, but there is rather little money going there. And I do also want to repeat my plea for deeper integration in science, policy and practice between agriculture, food, health and the environment. I think we have to reflect this in the curriculum where we are starting to review our curricula towards a more food-chain based approach.

Q – Tony Fischer, *Crawford Fund and CSIRO*
One issue to which I think we have not given enough attention is nutrient recycling related to the animal feeding stream. I refer to the intensive chicken, pig and dairy systems that we are finding now everywhere in the world, and particularly in the developed world; and also feedlotting. There are feedlots in the US now that have 200,000 animals at any moment in the feedlot. And there are dairies which have 10,000 cows in the feedlot. I think economies of scale are

driving this, but I worry very seriously about getting the nutrients back from such huge concentrations of animals. I will direct the question initially to Professor Fresco, because The Netherlands has a huge positive phosphorus balance, and I would like to know what you are doing about it.

A – Louise Fresco
Well I would like to separate the 'phosphorus' issue from the entire animal production side. I think a lot of the problems in food waste and feed waste are on the animal production side. One of the key issues in developing countries is the lack of hygiene, the lack of adequate slaughterhouses, the lack of a cold chain, and the lack of understanding – and also quality control in the entire animal chain. Something that always surprised me, even in my years in the field, was that we do not have many countries funding this kind of work and this kind of research, because it also requires some applied research to see what is the best solution. I think there is enormous scope in new technologies for cold chains, for example, that are more energy efficient, and for more training in hygiene, for example.

So the animal production chain – and I include in that the fisheries side – is by far the most fragile when it comes to waste. Yes, horticulture is fragile too, but you can still sell part of the tomato crop, even if the others start rotting. You cannot do that with animals. So there's a fundamental difference that makes the animal production chain more complex. At the same time, the animal chain is really full of excellent proteins, minerals and all kinds of chemical elements that we can use as feed, but in a far higher scaling level of using the waste. To map that out, what can be done in different countries, at different levels of development, I think is a real priority. We are not fully grasping the potential there, let alone applying it.

Now on the nutrient side, you are right. The term 'animal production' means, by definition (unless you have animals grazing freely without any added nutrients), that you are concentrating nutrients, often across continents. The international trade in feed – which is the factor that drives the world's cereal and soy prices in particular – is an enormous factor for the concentration of feed. I think we are, at the university in Wageningen, calculating the optimal levels of feed, and the optimal levels at which you can keep cows in a country that is as densely populated as ours. We are doing pretty well when it comes to retrieving all the nutrients, but there is still waste. Ideally you would not add more nutrients than the animals can actually cope with, so that you have a closed system. And that, I think, is the aim. In the meantime, there is a huge debate within the European Commission which I will not bother you with, on how to actually fix those phosphorus targets; what are the adequate levels; how you monitor it; and so on. If we are not careful, this whole system becomes an extremely bureaucratic procedure, and it then fails to show us that the ideal is not managing phosphorus but managing the whole production system, including the greenhouse gas emissions from animals, for example.

What we do know is that if the feed is not adequately balanced, you get more nutrients that are excreted from the animals, and you get lower quality and lower productivity. So the key word, although it is not a popular key word with

the public, is sustainable intensification, and optimisation of the entire chain. Unless we take that chain approach, we will not solve it.

Q – John Angus, *farmer and CSIRO*
I think producers are highly concerned by loss, and not so highly concerned by non-production up to a point. Now I understand the psychology, from personal experience, but I wonder what the economics are? Is it justified? Are we doing the right thing? Do you believe what I am saying? What can be done about it?

A – Louise Fresco
I am sure there are more questions on the economics of all this.

Q – James Ridsdill-Smith, *Crawford Fund and ex-CSIRO*
I would like to ask whether the word 'waste' is what we should be using at all. Waste from, say, insect damage, is not a real loss; it is loss in today's world. Insect damage is really insects affecting the rates plants grow at, rather than waste. So the same question as John's.

Q – Kim Russell, *farmer and Chair of Southern Farming Systems*
One of the issues we have seen today is the economic issue of using wet compostables and dry, the spectrum of waste streams. Making compost is probably the simplest and most commonly used technique for large-scale waste streams, such as from feedlots and that sort of enterprise. But there is probably not enough work done to identify the most economic place to put that compost. It goes on the ground surface in India and China. We ourselves have been doing some sub-soiling with incredible benefits to soils. So my question is about the economics of the use of those products in the whole value chain.

Daniel Walker, Chair
In summary, three questions there about the psychology of loss compared to forgoing yield, when waste and loss might not be waste and loss but part of the ecology of the system, and the economics of reusing parts of the system.

A – Karen Brooks
I think these are all very important points to bring up, particularly at this time of the day and at this stage of our conversation, because they remind us that (to come back to my comment about the many optimisations that are involved here) not everything that we might popularly identify as waste or loss is actually waste or loss.

To some extent, I think we make the best decisions we can, to make the best use of our resources, given the circumstances that we are working with, and that is the fundamental economics of how we manage these very complex processes. There are elements of the circular economy where we consider that we could do much better if we tweaked the incentives, if we provided more information, if we made people more aware of some of the options that they have. Those, I think, are latent opportunities that we can take advantage of, and we might recognise those as waste or loss that we might want to change. But it is not the case that we will go back to a zero baseline on this, because that would not be economic either. This is a complex challenge of managing resources. We may be simply wondering whether we have the right pricing, the right decisions, the

right institutions on the system to be making the best choices, and I think the answer is that we could make better choices, and that is what we are struggling to do.

Q – Daniel Walker, Chair
Daniel, I wonder in your journey to reducing waste (and you did define loss and waste quite carefully), how do you make decisions about commercial thresholds in changing the way you handle resources within your business?

A – Daniel Lagger
It is a very difficult question. Of course, we always have financial indicators and a lot of other constraints; what is important is that on top of all the things we do which have a financial value, we also do things just because it is the 'right thing to do'. Big companies can also invest some money, with lower financial return, in some priority areas; for example, we have different payback thresholds for energy improvement projects or environmental improvement-related projects than for other capital investment projects, but it only goes up to a certain amount; we need to remain competitive.

Q – Colin Chartres, *Crawford Fund and the Australian National University*
It seems to me, listening today, we have the technical abilities to change things. We are also, through links with the business sector and the supply chain, developing a sort of business model approach and the economic incentives. I want to hear your opinions about whether or not, particularly in developing countries, we have the policy framework right with the governments we are dealing with. I suspect we have not, but I would like to hear your opinions.

Q – Ali Bajwa, *the University of Queensland*
We are talking about food safety and quality assurance. On the other hand, in the developing world, especially in South Asia and many African countries, we have issues of food security. We are talking about how to preserve our resources, and how to improve the quality chain, but if we are talking in a developing-world scenario we most of the time talk about how to improve yield. That is still the major issue in those countries, such as Pakistan, India. I am wondering how we can work together on food security and food safety? Is it a matter of priority only in the developed countries, or is it also important in developing nations? What do we need to put first? Is it food security, and how can we work together on food safety *and* food security, side by side? What kind of policies should be adopted in those scenarios?

Q
I am from Charles Sturt University. Just adding to the points made just now, I am wondering how you develop policy with governments or corporate entities like Nestlé and others, to manage waste etcetera? For instance, how does government develop policy to handle corporate entities' management of waste in an intensive developed country like yours, Professor Fresco, and how, Mr Lagger, do you develop a policy with governments to try and remain a good corporate citizen, and work with governments in developing countries where the challenges are significantly greater?

Q – Malcolm Wegener, *the University of Queensland*
My question follows on from the last one that was answered, and relates to some of the comments that Dr Brooks just made about the rolling incentives and changing practices, which are some of the things that are associated with market failure. Would you go as far as to say there is market failure in achieving your optimal level of food waste? And is it a question of whether we can let companies do their thing, and find profits in reducing waste? Or to what extent should government intervene and try and introduce regulations to achieve this?

Daniel Walker, Chair
In summary, a series of questions there about maturity of policy settings and efficiency versus resilience trade-offs and public–private intersections.

A – Karen Brooks
To take the simple question first, if we look at the developing world, do we have the right set of policies in place to facilitate agricultural growth and development, and appropriate management of waste and loss? And the answer is no, of course we do not. Look at the numbers of hungry people. Look at the numbers of poor people, and look at the magnitude of loss and waste. Even if we do not have precise numbers we know that it is quite large, and much of it is very close to those who are very poor and would greatly benefit from reduction in those losses and waste. So no, we do not yet have the policies in place.

The policies that I see as most important for moving us globally in different directions are those that would remedy the under-investment in agricultural research. It is not just general agricultural research, but very specifically agricultural research that addresses some of the climate challenges, that addresses sustainable intensification, that builds in the new technologies, that will address making the crops and livestock more resilient to storage and to shocks associated with pests.

There are agricultural technical solutions to some of these problems, if we think about agricultural research in new ways, and if there are adequate flows of investment, not just from the international community. This is not a plea to give money to CGIAR. Rather we are very concerned about the adequacy of investment of our partners on the ground. We cannot work together well if our partner organisations in agricultural research in developing countries do not have the support of their own governments. We are very concerned about the flow of resources going into agricultural research in the poorer parts of the world. That is a policy decision, the adequacy of levels of investment by developing country governments.

Also, let us look at the relatively straightforward agenda of addressing losses close to the farm, and in getting products to market. Basically it is a need to be building infrastructure. And yet when the decisions are made about what infrastructure to finance, where to put it, whether to do a road, what kind of power, etc., the question 'What will this decision mean for managing food loss?' is not always included. Often it is simply 'Can we get things to market?'. There is the agricultural and rural development dimension that comes into the decisions about infrastructure planning, but not necessarily the issue of what specific

products are going to be moving over these roads. What kinds of conditions do we need? Do we need water supply in the markets in order to address food safety issues? Where should we be putting the rural electrification? If we added some consideration of managing loss and waste in those decisions about infrastructure, maybe we would get a different configuration, or a different timing of the investment in rural infrastructure. Very important.

We are concerned about the hunger issue. As I said earlier today, we need special instruments to address hunger. It is not just food production and getting products to market at affordable levels. We need specific programs. Safety nets. Social protection programs. We need insurance. These are special purpose instruments that address the hunger in targeted populations. Those are policy issues. I think we have tended, historically, to think of urban development and rural development as separate issues, and to some extent in competition with each other. But I think if we look at the framework of circular economies that we were talking about today, and if we look at the development of supermarkets and the waste management challenge in towns and cities in the developing world, clearly we have to put aside that separation between rural development and urban development, and recognise that there are very strong linkages there, and there is a critical need for investment in municipal waste management, and then to link that in with production processes in rural areas.

I think all of these, the issues of under-investment and policy gaps, are approachable, remediable, through policy reforms, but also very challenging. It is not easy to make those policy reforms. The fact that we have had these problems with us for so long is an indication that they have not been addressed adequately yet. But I think we will also see a tremendous momentum of problems worsening if these things are not addressed. We see the urban development, we see the development of the supermarkets. We see the increase in loss and waste as production increases. There is an urgency to addressing these. I really welcome the chance to look at these issues together.

To the question 'Is there market failure?' my answer is yes. No question. Part is policy failure and part is markets failing because they are not getting the right signals. I think some of those signals can be remedied by regulation. Regulations are hard to enforce, however, particularly in the environments where they are needed most. I think of the area where I live, in the part of Washington, D.C., where there is intensive chicken production with a lot of chicken waste flowing into Chesapeake Bay. That has been regulated for many many years, and yet the enforcement of those regulations has been a real challenge and Chesapeake Bay is still not cleaned up. So I think it is one thing to say 'Yes, there are regulatory solutions to quite a bit of this'. The challenge is to enforce those regulations.

A – Louise Fresco
Shaming and naming, I would say. There is no other way you can get companies to comply, and you have to do that very strongly.

Just a couple of comments. First, I am not sure that you can make a direct link between poverty and waste. I do not think it is that easy. It is not because we have poor people that there is more waste, because in fact what you see is that

poor people are often very creative in using all kinds of by-products, and even consuming products that, in other countries, would be considered already ripe for the waste heap. I think that the relationship is quite complex, and maybe it takes a kind of U-shaped curve, where some of the waste is actually used quite well in poor countries. A key issue is that before waste occurs at consumer level there are lots of other types of losses that poor people cannot address. The basic issue remains the quality of the produce and the low yields as they come off farmers' fields. And that links into the question about food safety and food security.

I firmly believe that you should never separate food safety and food security: the two should be addressed together, because if you have no safety, you also have no security. You do not have the adequate kind of calories according to the FAO definition. There is no way in which we should condone double standards in that respect. So a policy on waste should also be part of a policy on food safety and on food security.

Now do we have a policy failure? Yes, I think we do. But it is a complex one. The main issue is not to have a law regulating waste or waste reduction. It has to do with a lot of physical measures, and even with simple things like Customs regulations. I remember seeing, in West Africa, tomatoes and horticultural products that spent three or four days at the border between Mali and Senegal because they could not get through, because of a combination of corruption. By the way, we have not discussed corruption very much. Corruption is a real cause of food waste because things are held up. There are all kinds of parallel systems using food that is actually off, and bringing it back again into the food chain in a distant way. So let us not forget that dimension. Fiscal and Customs measures are really quite important. I agree with you on the municipalities. They have an important role to play.

The great thing about waste is that it is something that nearly everybody, every consumer, can relate to – and that is a factor we should mobilise much more. Everybody knows waste, and most people, even in rich countries, feel slightly guilty or upset when they have to throw things away. I know a couple of younger generation people who feel it is quite OK to throw away half a chicken, but they will not do it if I am around! I think waste is a fantastic opener of a debate, and a topic that links the urban middle class. Do not forget the middle class in developing countries is also growing by 10–12% per year. The middle class brings a new dimension to the waste problem.

I think the fact that we now have Sustainable Development Goals, and the World Economic Forum, and the Fast Moving Consumer Goods forum, and so on, these actually make the policy failure a lot less of a problem, because at least the big companies are quite in line, the Nestlés of this world, with the governments.

Last week I had a chance to speak at Nespresso with one of Nestlé's directors, and he was proudly telling me, 'You know, we are collecting all these little aluminium capsules'. And I said, 'What are you doing with the coffee drab that is still inside?' And he said, 'That goes to landfill, or it goes to chickens'. But I said, 'You know, that's full of fantastic chemical elements. There is lots of stuff

in there in terms of flavours. All kinds of compounds that are really high-level chemistry. Why not try to take that out?'. Nobody had ever thought about that at Nespresso. So there is still scope, even at Nestlé ... but I'm joking!

More important, I am not so worried about large companies. I think they are aware enough. I am worried about small and medium enterprises because, for them, investing in research – and even monitoring of waste – is much more difficult. That is, I think, where governments and municipalities have to help. To form a roster of best practices. To find easy monitoring techniques that are not too cumbersome for those small companies.

And lastly, the prospect of having a carbon price, at some point in time, and a carbon market, which I think probably will happen at some stage, will help people to look again at the efficiencies all along the chain. Not just in terms of energy, but also in terms of, for example, what can we do to the soil? What can we do to improve soil quality? All that carbon capture, or carbon improvement of the soil will then carry some kind of positive incentive.

Q – Daniel Walker, Chair
From a Nestlé point of view, you manufacture in 85 countries, you export to 189 countries, so you are the beneficiary of an enormous amount of policy around the world. I wonder if you have any reflections from the other side of the fence?

A – Daniel Lagger
Yes, we have concerns and issues. Yes, we have difficulties. All countries are different, with different legislation, regulations and practices, and not always encouraging about what we try to do and achieve. There is not a one-size-fits-all approach, and local conditions may require different approaches. I think that working together at a global level is the first step, and then working locally in the different areas I mentioned, with local partners, is key. That is the only way that we can design systems and operations that make sense for everybody and are adapted to local situations.

Another aspect we focus on is food security and safety: aspects such as traceability, making sure that we know exactly where all the materials are coming from, what the materials are composed of and how they are sourced and produced, are key. I think it is very important that we continue informing consumers about all they may be concerned about, and give full transparency.

Professor Louise Fresco is President of the Executive Board of Wageningen University and Research Centre, one of the leading research institutes worldwide in the field of food, agriculture and life sciences. Louise has served as Assistant Director-General for Food and Agriculture at the UN FAO in Rome, and is a member of the Steering Committee of the FAO High Level Panel of Experts on Food Security and Nutrition. She has conducted field work in more than 50 developing countries, has served on the Supervisory Board of Rabobank, serves on the Board of Unilever, and is a published author and maker of documentaries. Louise Fresco's latest book is *Hamburgers in Paradise: The stories behind the food we eat*, published by Princeton University Press. It follows decades of research and explains how science has

enabled us to overcome past scarcities and why we have every reason to be optimistic about the future.

Dr Karen Brooks joined IFPRI in 2012 as Director, CGIAR Research Program on Policies, Institutions, and Markets. Prior to that she worked for the World Bank for more than twenty years in various capacities, including ten years as Sector Manager, Agricultural Operations, Africa Region, and during the 1990s as Lead Economist on agricultural issues of the transition from central planning in Eastern Europe and Central Asia. Prior to joining the World Bank, she was Associate Professor in the Department of Applied Economics at the University of Minnesota. Karen holds an undergraduate degree in Political Science from Stanford University, and a PhD in economics from The University of Chicago. She has published on issues related to agricultural policy in centrally planned economies, price and land policy in countries transitioning from planned to market economies, and the challenges of youth employment in Africa south of the Sahara.

Daniel Lagger has been in his role as Executive Director, Technical & Production (formerly Operations), since 1 March, 2016. In the preceding three and a half years he was Technical Manager at Nestlé Japan. Daniel began his Nestlé career in 1984 as a Project Engineer in Switzerland. Throughout his 32-year career, Daniel has held different positions in the group, in the Philippines, Thailand and Switzerland. He holds a Masters degree in Mechanical Engineering from the EPFL (École Polytechnique Fédérale de Lausanne) in Lausanne, Switzerland. Daniel believes that the most important part of any role is working as one team to deliver results. Outside of work, Daniel likes sailing, diving and skiing, and discovering new countries.

Conference overview

Dr Denis Blight AO FRSA

On the surface, the issue seems disarmingly simple: reduce food loss and waste, and the world will be a better place – more food to go around and less drag on the earth's finite resources. Right? Well, yes, no and maybe.

On average, food loss and waste are said to total about one-third of total production. Whilst estimates and the nature of losses and waste vary across locations and more precise measurements are still needed, it is generally accepted that food losses are greater in least developed and developing countries and food waste is more prevalent in the developed world.

Loss and waste occur across the whole food chain, from field to fork and from producer, processor and trader to consumer, and the costs of these losses and wastage are borne, unevenly some argue, across the same range of actors. Poor farmers in the developing world may lose crops to pests and diseases – both before harvest, and afterwards because of lack of reliable on-farm storage. The effects on their livelihoods can be devastating. For others in the value chain, long regional supply chains without adequate cold or chilled storage or safe means of transport contribute to further losses. Elsewhere, over-consumption and waste in developed countries may increase demand for food – to the delight of some farmers but to the detriment of health and global resources.

During this one-day conference we heard that to reduce losses in the food supply chain requires substantial investment in, for example, practical and policy innovations, and improvements in transport, in infrastructure, and in storage and packaging. We wondered to what extent will the cost of the investments outweigh the benefits of reduced waste? What form might the currently elusive but ultimately effective policies and practices take? The more we learnt, the more complex this matter seemed to become: everything seemed to depend on everything else.

Fortunately, as the conference progressed its pattern of overview presentations followed by practical case studies pointed to ways forward.

Want not, warm not

In her keynote presentation, Dr Karen Brooks of the International Food Policy Research Institute (IFPRI), argued that measuring food loss and waste, identifying where in the food system it occurs, and developing effective policies and affordable practices along the value chain are essential steps towards addressing the problem. Measurement and analysis help to determine who gains from a reduction in losses and who loses, and the answers are not straightforward.

Environmental impacts of waste and loss can re-balance the cost–benefit equation substantially: fewer resources are lost to wasted production; the

environmental footprint of disposal is reduced; and greenhouse gas emissions from production, marketing and disposal are lowered to global benefit. In this regard, Brooks combined the 'want not' and 'warm not' agendas and argued that food security and environmental management should underpin action. Brooks also discussed the important role of individual awareness and behaviour among consumers and as producers – a point that has also been raised in several of previous Crawford Fund conferences, such as by speakers Professor Jonathan Foley in 2012 (*The Scramble for Natural Resources*) and Dr Helen Szoke in 2014 (*Ethics, Efficiency and Food Security*) among others.

In a key conclusion for governments, donors and the private sector, Karen Brooks emphasised the importance of investment in agricultural research and increased trade to complement reduction of losses.

On-farm losses

The first overview presentation, by Brian Lipinski of the World Resources Institute's Food Program, was on on-farm losses. Having reminded us of estimated proportions of losses and waste by geographic region and stage of the entire value chain, Lipinski pointed out challenges of addressing on-farm losses at international scale. These include their extreme context-dependence, and the dispersed nature of farms and farm loss, and the underlying lack of good data and consistent definitions of food loss and waste. An important step forward that should help clarify matters, he told us, is the Food Loss and Waste Protocol and its *Food Loss and Waste Accounting and Reporting Standard* (FLW Protocol 2016) – a set of global definitions, practices and reporting requirements that enable companies and governments to define, measure and report on food loss and waste. This global standard has resulted from a multi-stakeholder effort with FAO, UNEP, The Consumer Goods Forum, the World Business Council, FUSIONS, WRAP and the World Resources Institute. Later in the day we heard that Nestlé had been one of the companies contributing. The Protocol and standard are online.

Among the case-study speakers, four people addressed innovative ways to tackle on-farm losses. Rodrigo Ortiz explained how AgResults is making good headway in Kenya, for example, with public funding of a prize mechanism to stimulate private sector investment in high-quality affordable storage systems. Farm livelihoods are being turned around thanks to storage solutions. This message was reinforced by Simon Costa later, as he described how he had personally succeeded in improving crop storage on African farms.

Reducing crop losses caused by pests and diseases during production is being achieved in Laos via an innovative program building diagnostic capacity in rural areas, as Madaline Healey (University of the Sunshine Coast) described. And in a similar but different way, CABI is combating plant pests and disease in Africa through its Plantwise programme. Washington Otieno outlined how CABI trains extension staff to recognise symptoms and recommend solutions to farmers coming to plant clinics, with online support from databases and advanced expertise.

Packaging, transport and processing: farm gate to fork

Losses don't stop at the farm-gate. Professor Ashok Gulati (of ICRIER[1]), in his overview confirming the broad loss and waste data presented by Brooks and Lipinski, asked 'Why bother?'. He answered his own question with clear views on benefits: a combined economic value of food lost and wasted close approaching US$1000 billion; if only a quarter of food is saved it would be enough to feed 870 million hungry people, and it would save precious resources of land, water and energy and the environment (and make for a cleaner atmosphere). Savings could, he said, deliver higher prices for farmers and lower prices for consumers. In developing countries such as India, losses occur in distribution channels and processing as well as in farm operations. Gulati outlined the potential for practical and policy innovations to improve farm equipment, packaging, storage infrastructure, transport and low levels of processing. Waste at the consumer level in the developing world is minimal, he pointed out, while summarising some causes of food waste in the developed world, including standards for the look of fresh products, and misunderstood date-marking systems. His proposals for Uber tractors and solar-powered cooling of market retailers' push carts were among practical innovations that grabbed the audience's attention, as did policy to support cooperatives aggregating small farmers' produce.

Two case studies in this session illustrated practical measures in the postharvest chain. Salesh Kumar's research, with colleagues from the University of the Sunshine Coast and elsewhere, has pinpointed physical risk factors along the tomato supply chain in Fiji, suggesting relatively easy ways to reduce the waste of damaged fruit. And in Timor-Leste, Dr Joanita Jong runs a program for the Ministry of Agriculture and Fisheries, vaccinating village chickens against Newcastle Disease, keeping them alive to scavenge protein and micronutrients to the benefit of local people who eat the chickens and eggs.

What can supermarkets do?

In a special-case presentation, the paper by Dr Arief Daryanto and Dr Sahara Sahara of Bogor Agricultural University asked what can supermarkets do to reduce food loss? They have particularly examined supermarkets in Indonesia, which are rapidly growing in number. Although food loss at the retail stage may be a relatively small share (a few per cent) of total food loss, the total loss volume remains significant in kilograms per person per year, according to FAO figures. Supermarkets are located close to the end of the food chain and are increasingly significant in developing countries.

Their study of the fresh product department of one leading supermarket chain in Indonesia has shown that fresh fruits and vegetables are most susceptible to loss, reducing supermarket profits, and they have recommended eight ways of reducing losses.

Management and re-use of waste

Professor Alice Woodhead (University of Southern Queensland) overviewed the exploding problem of food waste in Asia. She highlighted the global shift

[1] Indian Council for Research on International Relations

to an urbanised world of megacities with 10 million people or more: Tokyo 33 million people; Manila, Mumbai, Delhi and Jakarta 14 million and growing. Asian people now have busy urban lifestyles, and are increasingly middle-class, eating western-type diets that are protein-rich, chilled and packaged, and sold through supermarkets and, increasingly, e-commerce. Megacities have grown too fast to develop waste-management systems at scales needed for the population density, leading to mega waste. Delivery of fresh produce – whether over the 'last mile' into city centre supermarkets or across regional areas and national borders in rural areas – is challenged by a lack of understanding of chilling needs and cold chain infrastructure. Food waste is a common consequence.

Problems of produce management in Australia and Asia are different, Professor Woodhead said, and Australia needs to understand the Asian situation if we are to export fresh produce there successfully. From the policy point of view, there needs to be a focus on cold chain logistics and infrastructure. Education is important – about food quality and management; the requirements of chilled food; why chilled food is different; and about waste management. There is a huge role here for R&D.

The final four case-study speakers showed us how much we can gain by reuse of food waste. First Dr Steven Lapidge (SARDI[2]) reminded delegates that 'every nutrient is sacred'. He said the world needs a nutrient retention paradigm. That thought was then amplified by Dr Cedric Simon (CSIRO), Dr Bernadette McCabe (University of Southern Queensland) and Dr Dana Cordell (University of Technology Sydney).

CSIRO, we heard, has found a way to add nutrients to crop wastes and create a commercial 'wonder food' called Novacq™ for raising fish in aquaculture, replacing the need to feed them on fishmeal made from real fish. Dr McCabe focused on biogas which can be produced from abattoir wastes and household food scraps, for example, as a community resource for cooking, light and heating in developing countries. And Dr Cordell explained how phosphate can be recycled from all organic sources in the food system, including human sewage.

Nestlé's war on waste: a journey through the supply chain

The final keynote was delivered by a representative from the private sector, Daniel Lagger, Executive Director, Technical and Production, Nestlé Oceania.

Nestlé claims it has been 'providing safe and nutritious food for 150 years', and now has around 335,000 employees and 436 factories in 85 countries producing around 2000 brands for sale in around 189 countries. Corporately Nestlé has set a long-term goal of zero waste for disposal. Lagger gave us some encouraging examples to show how the company is working towards that goal by avoiding food waste and improving resource efficiency along the value chain: for instance, in water usage for growing coffee in Vietnam; in harvesting of cocoa and composting of cocoa waste in Ivory Coast; in reducing milk loss and lifting quality and sustainability on dairy farms in China; in tailoring trucks to the products

[2] South Australian Research & Development Institute

they carry for maximum efficiency; and in visualising and aiming for 'dream' packaging. Where possible, he said, they try to reuse materials and create value from them, at any and all points along their supply chains. His concluding words, while spoken in relation to Nestlé, are globally applicable:

> 'There is no single silver bullet for waste. Good waste-reduction starts with drive from the top, plus extensive external collaboration, plus an eye for opportunities that can enable thousands of small and large projects to eliminate, reduce, reuse and recycle. ... Those who measure waste can better manage it; those who commit to a path can effect true change. That is good news for people, business and the planet.'

Overall

From the Sir John Crawford Memorial Address by Professor Louise Fresco (of Wageningen University) on Monday evening 29 August, to its conclusion in the evening of Tuesday 30 August, this conference succeeded in putting forward practical and potential ways in which food loss and waste should be conquerable, globally. It attracted over 280 delegates from across Australia and the world (pp. 150–57), and gained considerable media attention (pp. 158–68).

Professor Fresco's address, titled 'The Future of our Food', while not recorded for publication in this Proceedings, resonated strongly with the dinner guests and was often referred to during the presentations during the main conference. Professor Fresco also joined keynote speakers Dr Karen Brooks and Mr Daniel Lagger in the closing Panel Discussion (pages 135–44) – a session that maintained and rounded out the upbeat messages of the day.

I join our Board in sincerely thanking all who have been involved in this conference, and particularly our sponsors (pp. iv–v) for their support.

Reference

FLW Protocol (2016). *Food Loss and Waste Accounting and Reporting Standard*. World Resources Institute, Washington, D.C., USA. 160 pages. www.flwprotocol.org.

Dr Denis Blight AO FRSA, the Chief Executive of the Crawford Fund, has had a career including positions as an Australian diplomat, public servant and chief executive. His association with international agricultural research began in earnest some 25 years ago. Prior to working for the Crawford Fund, he was Director-General of CAB International, an intergovernmental body in research, training and publishing in the life sciences, and had 15 years with IDP Education Australia, the international development program of Australian universities and colleges, including the position of Chief Executive.

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Conference delegates 2016

*Asterisks identify the recipients of the 2016 Crawford Fund Conference Scholarships

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ANDREW AO, Neil	Murray-Darling Basin Authority
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*BENYAM, Addisalem	Central Queensland University
BERRY, Sarah	James Cook University / CSIRO
*BEST, Talitha	Central Queensland University
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*TAYLOR, Thomas	The University of Western Australia
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WALLACE, Leonie	Inns of Court
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*WEST, Elisha	Appleton Institute, Central Queensland University, South Australia

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WYNN, Peter	Charles Sturt University
*YARGOP, Rohan	The Centre For Global Food & Resources, The University of Adelaide
ZALCMAN, Emma	AAPARI – Asia Pacific Association of Agricultural Research Insitutions
*ZHANG, Jianping	CSIRO
*ZHANG, Yu	The University of Queensland

Media coverage of the 2016 conference

Social media: Twitter

See **#cfconf16** at Twitter.com to read the hundreds of tweets and photos sent out during the conference, and during the Sir John Crawford Memorial Address on 29 August and the Crawford Fund Scholars day that preceded it.

Media in attendance:

Sue Neales, *The Australian* national rural affairs reporter

Sarina Locke, *ABC Rural* national reporter

Elizabeth Finkel, *Cosmos Science Magazine* editor-in-chief

Press materials:

All media materials developed for the event are available online at https://www.crawfordfund.org/wp-content/uploads/2016/09/MEDIA-REPORT.pdf.

A media alert was distributed nationally.

Nine media releases (titles listed on p.168) were developed for the strategy involving targeted distribution and personal approaches related to addresses by:

- Karen Brooks
- Louise Fresco
- Ashok Gulati
- Arief Daryanto
- Daniel Lagger
- Bernadette McCabe
- Dana Cordell
- Steve Lapidge
- Brian Lipinski.

Interviews arranged:

The following speakers were involved in interviews:

- Karen Brooks
- Louise Fresco
- Ashok Gulati
- Rodrigo Ortiz
- Simon Costa
- Daniel Lagger
- Salesh Kumar
- Arief Daryanto
- Bernadette McCabe
- Dana Cordell
- Washington Otieno
- Madaline Healey
- Steve Lapidge
- Brian Lipinski
- Alice Woodhead.

Coverage achieved:

TV:

ABC TV News 24 'The World'

Gulati

http://iview.abc.net.au/programs/world/NU1640H173S00

PRINT/ONLINE:

The Australian

Brooks, Lagger (with photo shoot completed)

http://www.theaustralian.com.au/business/calls-to-cut-food-waste-grow-louder-at- canberra-conference/news-story/0dee06ac59c96d994eedecefadde7b59

The Conversation

McCabe

http://theconversation.com/australian-communities-are-fighting-food-waste-with-circular- economies-64424

Fairfax Regional Press

Healey

Queensland Country Life – http://www.queenslandcountrylife.com.au/story/4145087/lao-farmers- improve-pest-management/

North Queensland Register – http://www.northqueenslandregister.com.au/story/4145087/lao- farmers-improve-pest-management/?cs=4750

The Land – http://www.theland.com.au/story/4145087/lao-farmers-improve-pest- management/?cs=4937

Stock Journal – http://www.stockjournal.com.au/story/4145087/lao-farmers-improve-pest- management/?cs=4879

Stock and Land – http://www.stockandland.com.au/story/4145087/lao-farmers-improve- pest-management/?cs=4598

Food and Beverage Magazine

Woodhead, McCabe

https://foodmag.com.au/world-food-waste-issues-on-the-agenda-at-crawford-fund-forum/

My Sunshine Coast

Healey

http://mysunshinecoast.com.au/news/news-display/academic-to-present-food-security- plan-in-canberra,45309

RADIO/ONLINE:

Radio National 'Breakfast'

Fresco

http://www.abc.net.au/radionational/programs/breakfast/eliminating-massive-food-waste- could-help-food/7797088

RADIO/ONLINE continued:

Radio Australia 'Pacific Beat'

Kumar

http://www.abc.net.au/news/2016-08-30/project-looks-to-reduce-tomato-damage-in- fiji/7797218

National Community and Indigenous Radio 'The Wire'

Brooks

http://thewire.org.au/story/real-cost-food-waste/

National Commercial Rural News

McCabe, Cordell

http://www.2gb.com/article/close-professor-bernadette-mccabe

ABC National Rural News

and various State 'Country Hour' programs

Fresco, Brooks, Costa, Cordell, Otieno, McCabe

http://www.abc.net.au/news/2016-08-30/future-of-food-putting-consumers-in-touch-with- farming/7797134

http://mobile.abc.net.au/news/2016-09-01/clean-energy-project-as-risk-as-government- plans-to-cut-funding/7804922?pfmredir=sm

http://www.abc.net.au/news/2016-09-02/former-horticulturalist-volunteers with-un- world-food-program/7809040

NSW Statewide 'Drive'

Lapidge

3.50 pm live with Fiona Wyllie

ABC 666 'Afternoons'

Karen Brooks and Brian Lipinski

Extended interview

https://soundcloud.com/666abccanberra/crawford-fund-conference http://pim.cgiar.org/2016/08/29/as-heard-on-radio-karen-brooks/

Australian Rural Communication Network

Lapidge, McCabe

Both interviews distributed nationally through syndicated service to 150 stations.

SBS Bahasa

Daryanto

National Radio Release – Lapidge

DOWNLOAD SOURCE	BROADCAST STATIONS & SYNDICATES
North Queensland – Rural Report 30/08/2016, 14:26	Innisfail (Qld) - 4AY Innisfail (Qld) - 4KZ Innisfail (Qld) - Kool FM Mareeba (Qld) - 4AM Mareeba (Qld) - Kik FM
North Queensland – Rural Report 30/08/2016, 14:25	Innisfail (Qld) - 4AY Innisfail (Qld) - 4KZ Innisfail (Qld) - Kool FM Mareeba (Qld) - 4AM Mareeba (Qld) - Kik FM
Hamilton – 3HA/Mixx FM 30/08/2016, 13:20	Hamilton (Vic) - 3HA Hamilton (Vic) - Mixx FM Regional Victoria - Ace Radio Affiliates*
Gippsland – 1242/TR FM 30/08/2016, 13:17	Gippsland (Vic) - 1242 Gippsland (Vic) - TR FM
National – AIR National News 30/08/2016, 13:15	Adelaide (SA) - PBA FM Adelaide (SA) - Wow FM 100.5 Albany (WA) - Gold MX Albury/Wodonga (NSW/Vic) - 2REM FM 107.3 Armidale (NSW) - Tune FM 106.9 Augusta (WA) - 2 Oceans FM Ayr (Qld) - Sweet FM 97.1 Bacchus Marsh (Vic) - Apple FM Bathurst (NSW) - Life FM Beaudesert (Qld) - Beau FM 101.5 Bendigo (Vic) - Phoenix FM 106.7 Boonah (Qld) - Rim FM Bordertown (SA) - 5TCB Bribie Island (Qld) - 88.0 FM Brisbane (Qld) - Bay FM 100.3 Bunbury (WA) - 103.7 FM Byron Bay (NSW) - Bay FM Cairns (Qld) - Cairns FM 89.1 Canberra & Tuggeranong (ACT) - Artsound FM Carnarvon & Geraldton (WA) - Radio Mama Castlemaine (Vic) - 94.9 Main FM Cessnock (NSW) - 2CHR FM Collie (WA) - 1089 AM

National – AIR National News

30/08/2016, 13:15 (*continued*)

Coraki (NSW) - Richmond Valley Radio
Darwin (NT) - 97 Seven
Derwent Valley (TAS) - Tyga FM
Devonport (Tas) - 7RPH 96.1 FM
Dungog (NSW) - FM 107.9
Echuca/Moama (Vic/NSW) - EM FM 104.7
Esperance (WA) - Hope FM
Fraser Coast (Qld) - Fraser Coast FM 107.5
Gippsland & Phillip Island (Vic) - 3MFM
Gloucester (NSW) - Bucketts Radio
Gold Coast (Qld) - 94.1 FM
Gold Coast (Qld) - Heartland FM
Gold Coast (Qld) - Station X 1692 AM
Goolwa (SA) - Alex FM 96.3
Gosford (NSW) - 94ONE
Goulburn (NSW) - FM 103.3
Grafton (NSW) - Big Rig Radio
Healesville (Vic) - Flow FM
Hepburn Springs (Vic) - Hepburn Community Radio
Hobart (Tas) - 7RPH 864 AM
Hobart (Tas) - 99.3 Edge FM
Hobart (Tas) - Hobart FM 96.1
Holbrook (NSW) - 2GHR FM
Inverell (NSW) - STA FM
Kangaroo Island (SA) - Kix FM 90.7
Katherine (NT) - 8KTR
Kilmore (Vic) - OKR FM
Kingaroy & Lower Burnett (Qld) - Crow FM
Lake Macquarie (NSW) - Radio Yesteryear 97.3 FM
Lameroo (SA) - 3MBR FM 107.5
Launceston (Tas) - 7RPH 106.9 FM
Launceston (Tas) - Way FM
Lightning Ridge (NSW) - Opal FM
Loxton & Riverland (SA) - Life FM
Mackay (Qld) - 4CRM 107.5 FM
Mackay, Sarina & Whitsundays (Qld) - My 105.9 FM
Mansfield (Vic) - Radio Mansfield 99.7
Maryborough (Vic) - Goldfields FM
Marysville (Vic) - Flow FM
Melbourne (Vic) - 3SER 97.7 FM
Melbourne (Vic) - 3WBC 94.1 FM
Melbourne (Vic) - Plenty Valley FM 88.6
Moranbah (Qld) - 4RFM 96.9
Morwell (Vic) - Gippsland FM
Mount Beauty (Vic) - Alpine FM 96.5
Mt Gambier (SA) - Lime FM
Mt Isa (Qld) - Rhema FM 107.5

National – AIR National News
30/08/2016, 13:15 (*continued*)
Murrayville (Vic) - 3MBR FM 103.5
Murrindindi/Marysville (Vic) - UGFM
Narrandera (NSW) - Spirit FM
Newcastle (NSW) - Radio 1629 AM
Newman (WA) - 6NEW
Nhulunbuy (NT) - Gove FM 106.9
Online - Business Success Radio
Orange (NSW) - FM 107.5
Perth (WA) - UKWA Radio
Port Hedland (WA) - 101.3 FM
Port Pirie (SA) - Trax FM 105.1
Port Stephens (NSW) - Port Stephens FM
Qld/NT/SA/Tas - RadioTAB (87 locations)
Regional SA - Flow FM (15 locations)
Roxby Downs (SA) - Rox FM
Seymour (Vic) - Seymour FM
Southern Highlands (NSW) - Sounds of the Mountains
Stanthorpe (Qld) - Ten FM
Sunshine Coast (Qld) - 106 Five
Sunshine Coast (Qld) - Sunshine FM
Sydney (NSW) - Sky Sports Radio
Taree (NSW) - 2TLP 103.3 FM
Tasmania - Coast FM (4 Locations)
Tasmania - Star FM (3 Locations)
Temora (NSW) - Tem FM
Tennant Creek (NT) - Flow FM
Tenterfield/Stanthorpe (NSW/Qld) - Ten FM
Toodyay (WA) - FM 105.3
Townsville (Qld) - Triple T
Tumbarumba (NSW) - Radio Upper Murray
Wagga Wagga (NSW) - Life FM
Walwa (Vic) - Radio Upper Murray
Warwick (Qld) - Rainbow FM
Whyalla (SA) - 5YYY
Woodend (Vic) - Highlands FM
Yarra Junction (Vic) - 99.1 Yarra Valley FM
Yarraman (Qld) - 4WHO 99.7 FM

Gympie & Noosa – 4GY 30/08/2016, 13:13
Gympie/Noosa (Qld) - 4GY

New England – Local 30/08/2016, 13:10
Armidale (NSW) - 2AD
Armidale (NSW) - FM 100.3
Gunnedah (NSW) - 2MO
Gunnedah (NSW) - Triple G
Tamworth (NSW) - 2TM
Tamworth (NSW) - FM 92.9

New England – Local 30/08/2016, 13:07	Armidale (NSW) - 2AD Armidale (NSW) - FM 100.3 Gunnedah (NSW) - 2MO Gunnedah (NSW) - Triple G Tamworth (NSW) - 2TM Tamworth (NSW) - FM 92.9
New England – Local 30/08/2016, 13:07	Armidale (NSW) - 2AD Armidale (NSW) - FM 100.3 Gunnedah (NSW) - 2MO Gunnedah (NSW) - Triple G Tamworth (NSW) - 2TM Tamworth (NSW) - FM 92.9
New England – Local 30/08/2016, 12:39	Armidale (NSW) - 2AD Armidale (NSW) - FM 100.3 Gunnedah (NSW) - 2MO Gunnedah (NSW) - Triple G Tamworth (NSW) - 2TM Tamworth (NSW) - FM 92.9
Gippsland – 1242/TR FM 30/08/2016, 12:03	Gippsland (Vic) - 1242 Gippsland (Vic) - TR FM
Cooma (Gippsland) – Capital Radio 30/08/2016, 10:23	Cooma (NSW) - 2XL Cooma (NSW) - Snow FM Warragul & Gippsland (Vic) - 3GG
New England – Local 30/08/2016, 10:16	Armidale (NSW) - 2AD Armidale (NSW) - FM 100.3 Gunnedah (NSW) - 2MO Gunnedah (NSW) - Triple G Tamworth (NSW) - 2TM Tamworth (NSW) - FM 92.9
National – Rural Comm Network 30/08/2016, 10:13	National - ARCN Affiliates (Multiple Locations)
National – Rural Comm Network 30/08/2016, 10:13	National - ARCN Affiliates (Multiple Locations)
National – Rural Comm Network 30/08/2016, 10:13	National - ARCN Affiliates (Multiple Locations)

National –
Rural Comm Network 30/08/2016, 10:13 National - ARCN Affiliates (Multiple Locations)

National –
Rural Comm Network 30/08/2016, 10:13 National - ARCN Affiliates (Multiple Locations)

National –
Rural Comm Network 30/08/2016, 10:13 National - ARCN Affiliates (Multiple Locations)

Bendigo & Castlemaine –
KLFM 30/08/2016, 08:43 Bendigo & Castlemaine (Vic) - KLFM

Bathurst –
2MCE 30/08/2016, 07:15 Bathurst & Orange (NSW) - 2MCE

National – AIR National News
30/08/2016, 07:10 Adelaide (SA) - PBA FM
Adelaide (SA) - Wow FM 100.5
Albany (WA) - Gold MX
Albury/Wodonga (NSW/Vic) - 2REM FM 107.3
Armidale (NSW) - Tune FM 106.9
Augusta (WA) - 2 Oceans FM
Ayr (Qld) - Sweet FM 97.1
Bacchus Marsh (Vic) - Apple FM
Bathurst (NSW) - Life FM
Beaudesert (Qld) - Beau FM 101.5
Bendigo (Vic) - Phoenix FM 106.7
Boonah (Qld) - Rim FM
Bordertown (SA) - 5TCB
Bribie Island (Qld) - 88.0 FM
Brisbane (Qld) - Bay FM 100.3
Bunbury (WA) - 103.7 FM
Byron Bay (NSW) - Bay FM
Cairns (Qld) - Cairns FM 89.1
Canberra & Tuggeranong (ACT) - Artsound FM
Carnarvon & Geraldton (WA) - Radio Mama
Castlemaine (Vic) - 94.9 Main FM
Cessnock (NSW) - 2CHR FM
Collie (WA) - 1089 AM
Coraki (NSW) - Richmond Valley Radio
Darwin (NT) - 97 Seven
Derwent Valley (TAS) - Tyga FM
Devonport (Tas) - 7RPH 96.1 FM
Dungog (NSW) - FM 107.9
Echuca/Moama (Vic/NSW) - EM FM 104.7
Esperance (WA) - Hope FM
Fraser Coast (Qld) - Fraser Coast FM 107.5
Gippsland & Phillip Island (Vic) - 3MFM

National – AIR National News
30/08/2016, 07:10 (*continued*)
Gloucester (NSW) - Bucketts Radio
Gold Coast (Qld) - 94.1 FM
Gold Coast (Qld) - Heartland FM
Gold Coast (Qld) - Station X 1692 AM
Goolwa (SA) - Alex FM 96.3
Gosford (NSW) - 94ONE
Goulburn (NSW) - FM 103.3
Grafton (NSW) - Big Rig Radio
Healesville (Vic) - Flow FM
Hepburn Springs (Vic) - Hepburn Community Radio
Hobart (Tas) - 7RPH 864 AM
Hobart (Tas) - 99.3 Edge FM
Hobart (Tas) - Hobart FM 96.1
Holbrook (NSW) - 2GHR FM
Inverell (NSW) - STA FM
Kangaroo Island (SA) - Kix FM 90.7
Katherine (NT) - 8KTR
Kilmore (Vic) - OKR FM
Kingaroy & Lower Burnett (Qld) - Crow FM
Lake Macquarie (NSW) - Radio Yesteryear 97.3 FM
Lameroo (SA) - 3MBR FM 107.5
Launceston (Tas) - 7RPH 106.9 FM
Launceston (Tas) - Way FM
Lightning Ridge (NSW) - Opal FM
Loxton & Riverland (SA) - Life FM
Mackay (Qld) - 4CRM 107.5 FM
Mackay, Sarina & Whitsundays (Qld) - My 105.9 FM
Mansfield (Vic) - Radio Mansfield 99.7
Maryborough (Vic) - Goldfields FM
Marysville (Vic) - Flow FM
Melbourne (Vic) - 3SER 97.7 FM
Melbourne (Vic) - 3WBC 94.1 FM
Melbourne (Vic) - Plenty Valley FM 88.6
Moranbah (Qld) - 4RFM 96.9
Morwell (Vic) - Gippsland FM
Mount Beauty (Vic) - Alpine FM 96.5
Mt Gambier (SA) - Lime FM
Mt Isa (Qld) - Rhema FM 107.5
Murrayville (Vic) - 3MBR FM 103.5
Murrindindi/Marysville (Vic) - UGFM
Narrandera (NSW) - Spirit FM
Newcastle (NSW) - Radio 1629 AM
Newman (WA) - 6NEW
Nhulunbuy (NT) - Gove FM 106.9
Online - Business Success Radio

National – AIR National News

30/08/2016, 07:10 (*continued*)	Orange (NSW) - FM 107.5 Perth (WA) - UKWA Radio Port Hedland (WA) - 101.3 FM Port Pirie (SA) - Trax FM 105.1 Port Stephens (NSW) - Port Stephens FM Qld/NT/SA/Tas - RadioTAB (87 locations) Regional SA - Flow FM (15 locations) Roxby Downs (SA) - Rox FM Seymour (Vic) - Seymour FM Southern Highlands (NSW) - Sounds of the Mountains Stanthorpe (Qld) - Ten FM Sunshine Coast (Qld) - 106 Five Sunshine Coast (Qld) - Sunshine FM Sydney (NSW) - Sky Sports Radio Taree (NSW) - 2TLP 103.3 FM Tasmania - Coast FM (4 Locations) Tasmania - Star FM (3 Locations) Temora (NSW) - Tem FM Tennant Creek (NT) - Flow FM Tenterfield/Stanthorpe (NSW/Qld) - Ten FM Toodyay (WA) - FM 105.3 Townsville (Qld) - Triple T Tumbarumba (NSW) - Radio Upper Murray Wagga Wagga (NSW) - Life FM Walwa (Vic) - Radio Upper Murray Warwick (Qld) - Rainbow FM Whyalla (SA) - 5YYY Woodend (Vic) - Highlands FM Yarra Junction (Vic) - 99.1 Yarra Valley FM Yarraman (Qld) - 4WHO 99.7 FM

Nowra –	
2ST/Power 30/08/2016, 06:18	Nowra, Bowral & Ulladulla (NSW) - 2ST Nowra, Bowral & Ulladulla (NSW) - Power FM
Muswellbrook –	
2NM/Power 30/08/2016, 06:16	Muswellbrook & Hunter Valley (NSW) - 2NM Muswellbrook & Hunter Valley (NSW) - Power FM
Ballarat –	
Voice FM 30/08/2016, 05:54	Ballarat (Vic) - Voice FM
Albury/Wodonga –	
2AY 30/08/2016, 05:12	Albury/Wodonga (NSW/Vic) - 2AY Regional Victoria - Ace Radio Affiliates*

Media releases

Dr Karen Brooks, Director of the CGIAR Research Program on Policies, Institutions and Markets

'WASTE NOT, WARM NOT: Both required in the complexity of food waste and climate change', 29 August 2016

Dr Dana Cordell, Co-founder of the Global Phosphorus Research Initiative and Research Director of the Institute for Sustainable Futures at the University of Technology Sydney

'PHOSPHORUS SCARCITY ALREADY CRITICAL: Selling Nutrient Security Service Could be a Game Changer', 29 August 2016

Dr Arief Daryanto, Director of the Graduate Program of Management and Business and Senior Lecturer in the Faculty of Economics and Management, Bogor Agricultural University

'FOOD LOSS IN SUPERMARKETS: Are there lessons from developing countries?', 29 August 2016

Professor Louise Fresco, President of Wageningen University and Research Centre

'HAMBURGERS IN PARADISE: THE FUTURE OF OUR FOOD?', 29 August 2016

Professor Ashok Gulati, Infosys Chair Professor for Agriculture at the Indian Council for Research on International Economic Relations

'SAVING FOOD FROM THE FARM TO THE FORK: Wastage in rich and poor countries alike', 29 August 2016

Mr Daniel Lagger, Executive Director, Technical and Production, Nestlé Oceania

'NESTLÉ'S WAR ON WASTE: What can the private sector do to address food waste?', 29 August 2016.

Dr Steve Lapidge, Director, Science Partnerships, South Australian Research and Development Institute

'RETAINING NUTRIENTS FOR GLOBAL FOOD SECURITY: Everyone has a role to play in establishing the circular food economy', 29 August 2016

Mr Brian Lipinski, Research Associate, Food Program, World Resources Institute

'ADDRESSING THE COMPLEXITIES OF ON-FARM FOOD LOSSES', 29 August 2016

Dr Bernadette McCabe, Associate Professor and Principal Scientist in the National Centre for Engineering in Agriculture at The University of Southern Queensland

'FIGHTING FOOD WASTE TO HELP FOOD AND ENERGY SECURITY', 29 August 2016.

The text of these media releases is online at:
https://www.crawfordfund.org/wp-content/uploads/2016/09/MEDIA-REPORT.pdf

THE CRAWFORD FUND
For a Food Secure World

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