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# FOOD AND NUTRITION SECURITY

The biosecurity, health, trade nexus

## The Crawford Fund 2021 ANNUAL CONFERENCE

QT Hotel, Canberra ACT, Australia  
and Online

**13-14 December 2021**

Editor A. Milligan

## Threats to global food systems from biosecurity issues

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### ABSTRACT



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

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

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

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

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

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

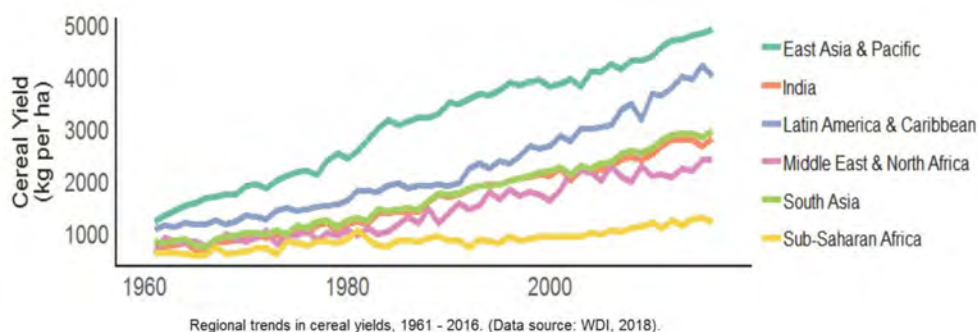


Figure 1. Global trends in cereal yields 1960–2016.  
*Data source:* World Development Indicators 2018.

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

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

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

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

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

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

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

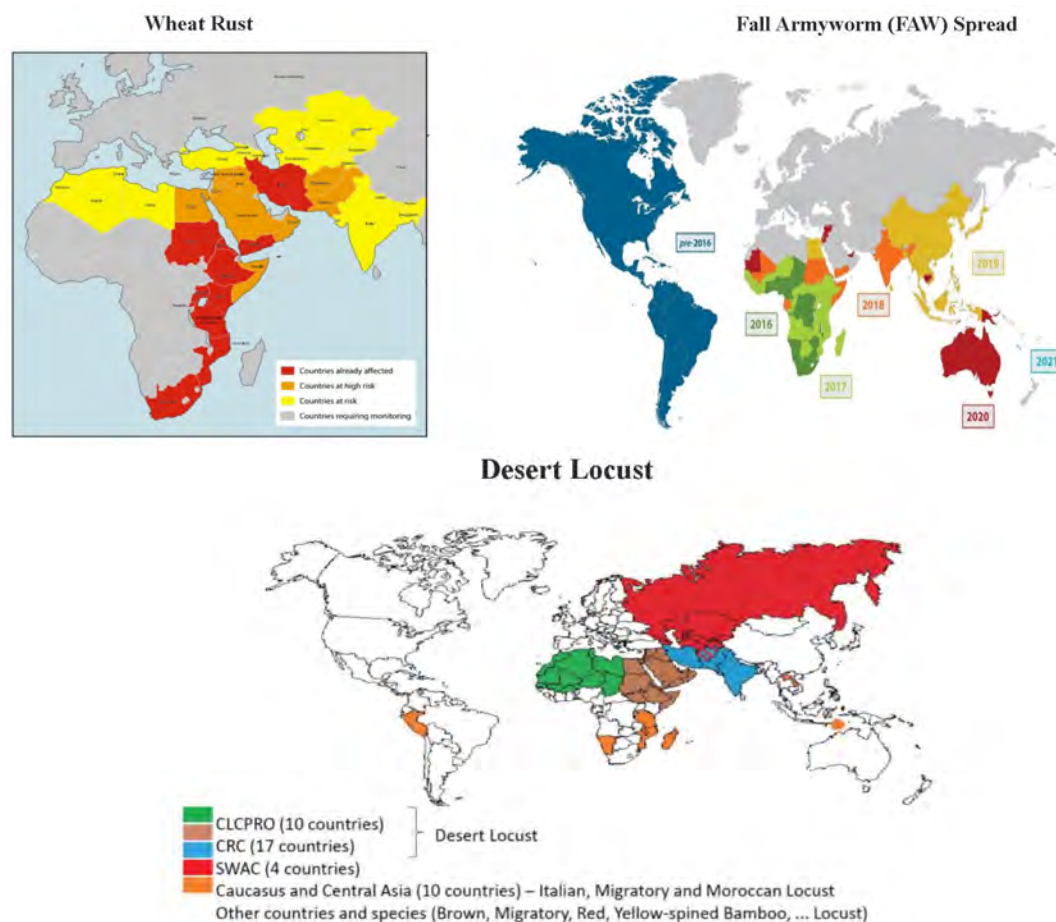


Figure 2. Geographical distribution of transboundary pest infestations. *Source:* FAO.

wheat rust Ug99 – <https://www.fao.org/3/i3730e/i3730e.pdf>

fall armyworm – <https://www.fao.org/fall-armyworm/monitoring-tools/faw-map/en/>

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

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



Table 1. Predicted economic losses.

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

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

### Losses

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

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

### 1980–2000: rising incomes and food diversity

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

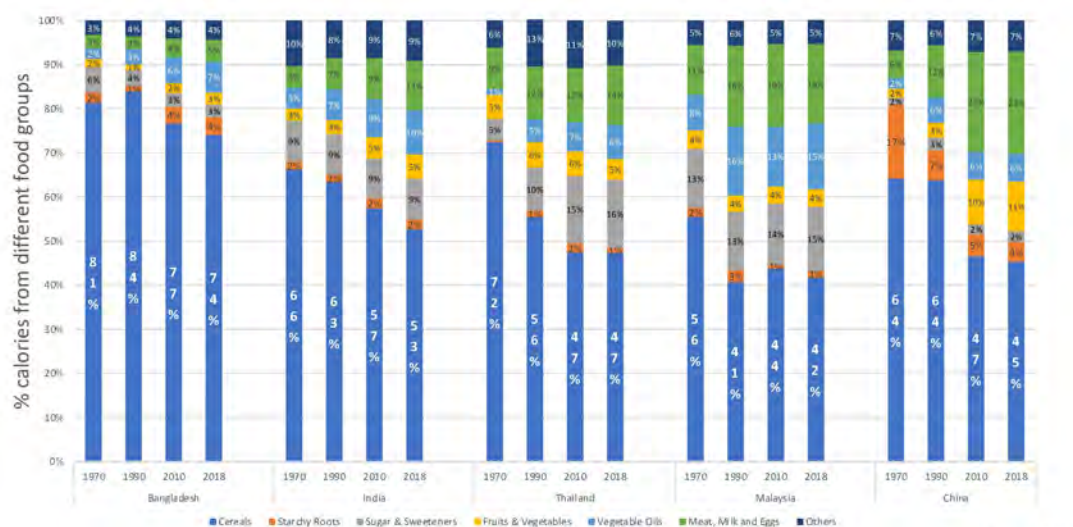


Figure 3. Diversifying of calorie sources: less reliance on cereals over time; increase in consumption of meat and fruits and vegetables. *Source:* FAOSTAT.

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

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

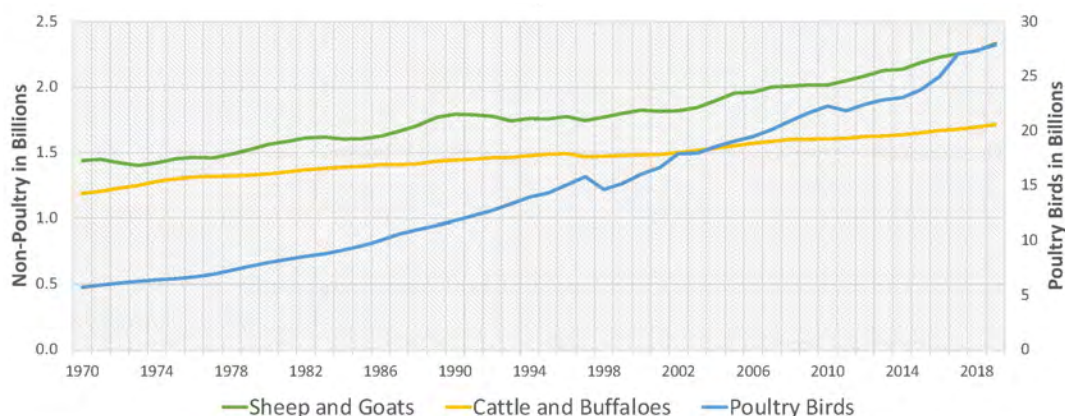


Figure 4. Phenomenal increase in the total number of livestock over the past 5 decades: global livestock populations over time. *Source:* FAOSTAT

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

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

#### **2000–2020: globalisation of trade and consumer tastes**

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

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

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





Figure 5. Countries affected by avian influenza H5N1 between 2003 and 2008.

Source: FAO and WHO.

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

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

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

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

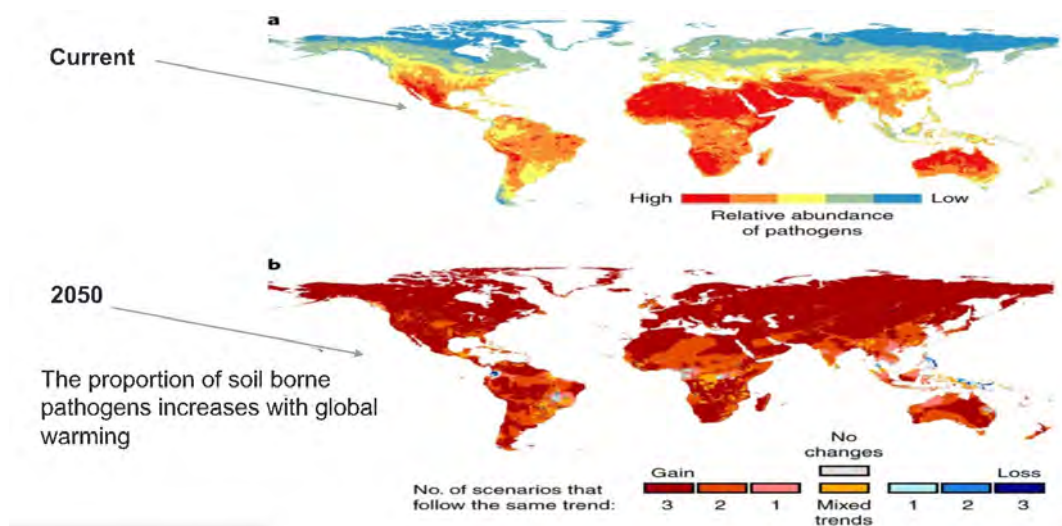


Figure 6. Current relative abundance and temporal projections (to 2050) of potential plant pathogens across the globe. *Source:* Delgado-Bacuerizo *et al.* 2020.

### Climate change

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

### COVID-19

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

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

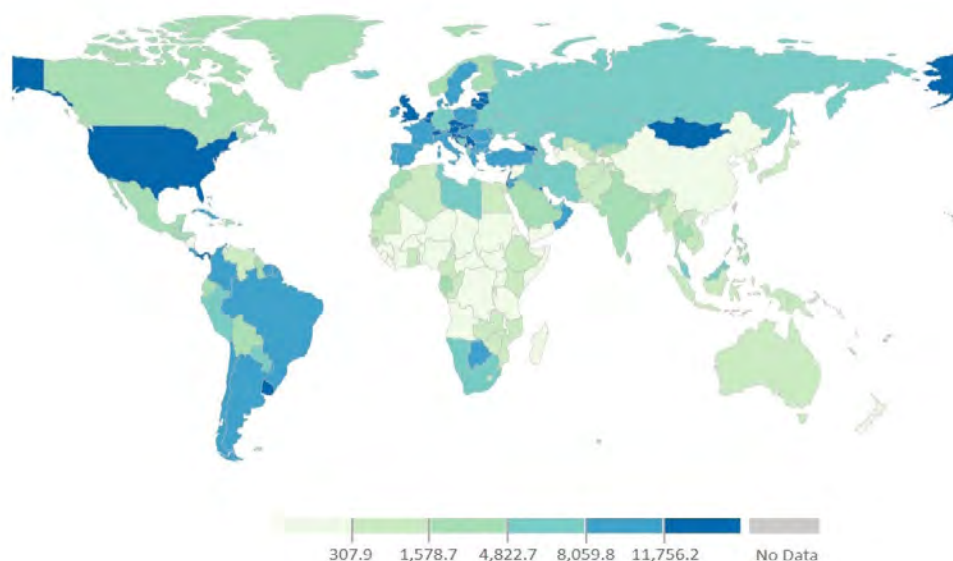


Figure 7. Global cumulative cases of COVID-19 reported per 100,000 population as at 2 December 2021. *Source:* CDC (Centers for Disease Control and Prevention, [cdc.gov](https://www.cdc.gov)).

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

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

### Building resilience in food systems

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

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

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



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

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

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

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

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

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

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

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

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

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

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

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



## References

- Delgado-Baquerizo M., Guerra C.A., Cano-Diaz C. *et al.* (2020) The proportion of soil-borne pathogens increases with warming at the global scale. *Nature Climate Change* **10**(6). DOI 10.1038/s41558-020-0759-3
- Knight-Jones T.J.D., Rushton J. (2013) The economic impacts of foot and mouth disease: What are they, how big are they and where do they occur? *Preventive Veterinary Medicine* **112**(3–4): 161–173. doi: 10.1016/j.prevetmed.2013.07.013r

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