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Co-published by CABI and the International Livestock Research Institute 2020.

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ISBN-13: 978 1 78924 185 3 (hardback)  
ILRI ISBN: 92-9146-586-3 (hardback)

CABI Commissioning editor: Alexandra Lainsbury  
CABI Editorial assistant: Lauren Davies  
CABI Production editor: James Bishop

Typeset by SPi, Pondicherry, India  
Printed and bound in the UK by Bell and Bain Ltd, Glasgow

# 9 Food Safety and Nutrition

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## Executive Summary

### The problem

'Is our food safe?' is a fundamental concern of consumers. Moreover, as populations urbanize

and food systems develop, concerns about food safety grow. The emergence of food safety science responds to those concerns.

Food safety science – drawing on health, agriculture, technology, marketing and psychology – emerged as a separate discipline in the latter half

of the last century. Food safety is relevant to domestic and international markets and involves private and public sectors as well as civil society. Recent evidence suggests that the health burden of food-borne disease (FBD) is comparable to that of three major diseases – malaria, human immunodeficiency virus/acquired immune deficiency syndrome (HIV/AIDS) and tuberculosis. Most of the unsafe food health burden is due to contaminated fresh foods purchased from informal markets. Livestock products – milk, meat, offal and eggs – are especially risky. As our understanding of the importance of FBD, and its complicated links with livestock development, has increased, so too has research conducted by the International Livestock Research Institute (ILRI) and other research organizations in this area.

### **ILRI's role in the global context**

Food safety was historically a minor part of CGIAR research. This was partly due to a lack of awareness that FBD was a major development issue but also because FBD was conceptualized as an aggregation of specific diseases rather than as a systems problem. Donor investments in food safety were small compared with the scale of the problem, with investments in comparable diseases and with the potential return on investments (GFSP, 2019). Most investments have focused on trade rather than on ensuring the health of consumers in low- and middle-income countries. In the early 2000s, ILRI conducted some work on the health aspects of trade in livestock but did not have a major programme in food safety.

Rather, food safety was seen mainly as a potential barrier to market access by poor livestock keepers. It was addressed to some extent in dairy projects and initiatives such as the Debre Zeit Dairy Technology Centre. As such, ILRI and its predecessors, the International Livestock Centre for Africa (ILCA) and the International Laboratory for Research on Animal Diseases (ILRAD), were one of many research and development institutes seeking to increase the quality of agricultural products through research, training and capacity building. An evolving focus on food value chains in these institutions, however, helped shift the research agenda towards the food attributes desired by consumers, which often included food

safety, and towards consumer willingness to pay for food attributes, including safety.

In the early 2000s, ILRI began a programme on improving human health through livestock research in three areas: (i) animal-source foods for nutrition; (ii) zoonoses (diseases transmitted between animals and people); and (iii) FBD. This was the first CGIAR group with an explicit food safety mandate (rather than focusing on specific hazards) and with expertise in using research methods for food safety rather than diseases in general. ILRI was also one of the first groups to focus on food safety in the 'informal markets' of developing countries, and by the 2010s, had become the lead research institute globally in this emerging area.

### **Impacts of ILRI's research**

#### *Scientific impacts*

ILRI developed, contributed to, adapted and tested tools, methods and metrics, including participatory risk assessment, systematic literature reviews of food safety in informal markets, systems dynamics and food safety system performance assessment. Technology development and testing was a growing area with a focus on appropriate technologies such as disinfectants and pest control. Many publications were produced, often regarding tools and technologies. In addition, publications covered other aspects of evidence generation including reviews, reports of surveys, risk factor analyses, and interaction between food safety and other development issues, such as gender equity.

#### *Development impacts*

ILRI's initial work on food safety focused on adapting methodologies for developing countries, assessing the extent, nature and drivers of FBD, and piloting potential solutions. Only with the advent of the CGIAR Research Programmes (CRPs) (2012–2016) did the focus shift to achieving wide-scale development impacts. However, some development potential and realized impacts can be discerned. In summary, pilot projects identified various promising technologies. Moving to the intermediate scale, food safety research has been embedded in high-potential livestock value chains identified by the CRP on Livestock. These CRP initiatives reached hundreds of value chain

agents, thousands of farmers and tens of thousands of consumers, although the impact on food safety outcomes is more difficult to estimate. In Kenya and the Indian state of Assam, there is some evidence that food safety interventions went to scale and were sustained after the end of projects. We estimate that 6.5 million people benefited.

### *Policy impacts*

The first assessment of the global health burden of FBD found that the burden was unexpectedly high and borne mostly by low- and middle-income countries (Havelaar *et al.*, 2015). ILRI was one of the few research institutes with a substantial track record and publications in this area. As such, it was requested or commissioned to produce evidence syntheses for several intergovernmental organizations and donor agencies, substantially influencing their policies and activities. At a national level, ILRI has had a major impact on food safety policies in Kenya and Vietnam, as well as in India's Assam state, and has had a moderate impact in several other countries, including Cambodia, Uganda, Tanzania and Ethiopia.

### *Capacity building*

Given the previous neglect of food safety in the domestic markets of low- and middle-income countries, ILRI research had a strong emphasis on capacity building. Most food safety research projects included students at undergraduate, MSc and PhD levels. In several countries, such as Tanzania and Vietnam, all qualified risk analysis professionals have been trained by ILRI. In addition, ILRI developed and delivered a range of 1–2-week trainings aimed at policy makers and implementers. Many thousands of value chain agents were trained in individual projects. This was done to develop appropriate training and to test approaches because the role of CGIAR was seen to be that of developing material, approaches, delivery systems and incentives that could support the training of value chain agents rather than to conduct the training itself.

## **Introduction**

What is the role of international agriculture research in food safety? This chapter looks at ILRI's

work on food safety to draw conclusions about its actual and potential impacts. Unlike other aspects of agricultural research, food safety is a relatively new area for CGIAR, and we can easily trace the emergence and growth of its research agenda. The research agenda represents a departure from traditional CGIAR research in two main ways: (i) food consumers rather than food producers are the focus of food safety research; and (ii) the prime motivator of food safety research is improving human health rather than improving farm productivity, food security or natural resource management.

### **Why food safety matters**

Food-borne disease (FBD) includes any illness caused by ingesting contaminated or naturally hazardous food or drink. Food produced in developing countries often contains high levels of biological and chemical hazards and is prone to adulteration (Grace, 2015a,b), therefore creating conditions in which FBD thrives.

Only recently has good evidence on the burdens of FBD in developing countries started to emerge. The best assessment was published by the World Health Organization (WHO) in 2015, the culmination of nearly 10 years of work by dozens of experts (Havelaar *et al.*, 2015; Gibb *et al.*, 2015). A conservative estimate found that the health burden of unsafe foods (a combination of morbidity and mortality) was comparable to that of malaria, HIV/AIDS or tuberculosis, making FBD a major public health priority. The first part of the study, focusing on 31 hazards for which there was enough information to generate global estimates, found that around 98% of the FBD burden fell on developing countries, and 97% was due to microbes, parasites or viruses, with the remainder due to chemical hazards. FBD from these hazards caused 600 million illnesses and 420,000 deaths in 2010. The second part of the study, using a less conservative methodology, found four heavy metals resulted in an additional 1 million illnesses and 56,000 deaths in 2015. FBDs are estimated to cost the USA US\$15–80 billion a year (Scharff, 2012; Hoffmann *et al.*, 2015), which would be as high as 0.4% of estimated 2020 US gross domestic product (GDP). A recent World Bank/ILRI study estimated that FBD costs developing countries at least US\$100 billion a year (Jaffee *et al.*, 2019).

The WHO study on FBD identified the hazards responsible for most illness and death. In developed countries, most of the FBD burden is attributable to microbes, especially those of zoonotic origin; in developing countries, macroparasites are relatively important in addition to the microbes controlled in developed countries (such as those responsible for cholera and brucellosis) (Havelaar *et al.*, 2015). It is more difficult to ascertain which food is responsible. In developed countries, most of the burden is due to animal-source food and fresh produce, and this seems to be the case in developing countries (Hoffmann *et al.*, 2017; Grace, 2015a).

Aside from its health burden and associated economic costs, FBD is important as a barrier to market access. Food export markets, formal markets and provisioning programmes already require food to meet certain sanitary and phytosanitary standards and, as a result, tend to exclude smallholder, women, less educated and more remote farmers, who have less ability than others to meet these standards (Unnevehr and Ronchi, 2014). As concern over FBD increases, meeting food safety standards is likely to become an ever more important constraint to smallholder production. These health, economic and equity concerns show how relevant food safety issues are to pro-poor agricultural research for development.

This chapter first summarizes the history of food safety research at ILRI and CGIAR, describing how the discipline grew, became a research agenda and evolved from an ad hoc and hazard-based agenda to one that was more systematic and risk based. The next section sets out the theory of change linking food safety research to economic and health benefits. It identifies two main pathways: evidence that counts and impact that scales. The following sections summarize ILRI progress along both pathways, and we end with conclusions and recommendations for new food safety research.

### **The History of Food Safety Research at ILRI and in CGIAR**

ILCA was established in 1974, and by 1977 had developed a research programme on smallholder production in the eastern African highlands. An ILCA Dairy Technology Unit was founded in

1986 at Debre Zeit, about 65 km south-east of Addis Ababa (ILCA, 1987), which aimed to develop milk-processing methods adapted for smallholders. This unit produced manuals that covered hygienic milk handling but did not focus on milk safety. The episodic production of dairy manuals and training material continued over the next decades: a major achievement was seen in 2006 when dairy boards in Kenya, Rwanda, Tanzania and Uganda endorsed generic training material for informal milk traders in the eastern and central Africa region. During this time, dairy research for development work continued in Botswana, Burundi, Ethiopia, Ghana, Kenya, Malawi, Mali, Nigeria, Senegal and Zimbabwe, among others; in the early 2000s, this was extended to Latin America and India.

Food safety, as opposed to food technology, research started at ILRI after the institute widened the focus of its predecessors to cover a broader range of livestock issues following the merger of ILRAD and ILCA in 1995. The first food safety research started in the late 1990s. It was conducted within a veterinary public health framework and focused on milk safety in Kenya (Aboye *et al.*, 2000; Kang'ethe *et al.*, 2000; Mwangi *et al.*, 2000; Omore *et al.*, 2000). This work was extended to Ghana, Tanzania and Uganda in the early 2000s. Food-borne zoonoses were specifically considered among other zoonotic diseases in a landmark ILRI volume prioritizing the livestock diseases whose control would most significantly reduce poverty (Perry *et al.*, 2002). Around the same time, another strand of research started on economic aspects of food safety, especially the trade-offs between safe food and other development objectives (Omore *et al.*, 2001). This led to the development of an ILRI programme on Animal Health and Food Safety for Trade, which had the objective of addressing food safety as a barrier to smallholder market access rather than as a constraint to human health. Congruent with the economic perspective, there was research on consumer demand for safety and quality. Ten studies from seven countries in Asia and Africa were brought together in an influential report (Jabbar *et al.*, 2010).

In 2003, for the first time, ILRI initiated a programme – Livestock Keeping and Human Health Impacts – with an explicit focus on improving human health through livestock. This marked the start of ILRI research employing a risk

analysis framework and focusing on improving food safety outcomes rather than subsuming food safety under market issues or veterinary public health. Following an external review (Science Council/CGIAR, 2008), food safety was again placed in an economic programme: in hindsight, this was a retrograde move given the broad trends of agricultural research towards greater emphasis on human health. Subsequently, the ILRI programme on Animal Health and Food Safety for Trade became Animal Health, Food Safety and Zoonoses, and finally Food Safety and Zoonoses, as it became clear that world export markets were less important to poor people and that FBD was more important than had been realized. In 2017, the wheel came full circle when research groups working on different aspects of human and animal health in four separate ILRI programmes across ILRI's two directorates (biosciences and integrated sciences) were brought together in a new Animal and Human Health Programme. Food safety was one of four major areas in this programme (the others were zoonoses and emerging infectious disease, herd health, and vaccines and diagnostics).

The ILRI food safety research agenda focuses its attention on traditional 'informal markets', where most smallholder and poor farmers sell their livestock products. Traditional processing, products and prices predominate in these informal or 'wet' markets, which tend to escape effective health and safety regulation, go untaxed and unlicensed, and sell food at lower prices than formal markets. Informal markets are also closer to and more accessible for poor consumers than formal markets.

An ILRI review of food safety and informal markets largely categorized the attitude of officials and donors towards informal markets as one of either neglect or unhelpful attention (Roesel and Grace, 2014). Much attention has been paid to the role of informal markets in maintaining and transmitting diseases but little to their role in supporting livelihoods (especially for women) and nutrition. Informal markets are often seen as outdated and unsafe, destined to be replaced by industrial production and modern retail. The ongoing COVID-19 pandemic has accentuated this belief among many stakeholders, especially those not familiar with wet markets.

Nevertheless, informal outlets are much more common and widely distributed than formal

sector alternatives and often offer services (such as immediate payment to farmers and provision of credit to consumers) that the formal sector does not provide. Food is perceived by consumers to be fresh, healthy, natural, convenient and less expensive (Roesel and Grace, 2014; Zhong *et al.*, 2020). With these advantages, it is not surprising that the formal sector share of animal-source food markets is less than 10% in most of sub-Saharan Africa and South Asia (Gomez and Ricketts, 2013). In southern and East Africa, informal markets currently supply 85–95% of market demand and are predicted to still supply 50–70% of market demand in 2040 (Tschirley *et al.*, 2015). In South Asia, traditional food retail occupies 95% of the market, in South-east Asia 71% and in South America 54% of the food retailed. In this context, informal markets are likely to remain important for at least several more decades.

The relative neglect of informal markets compared with other CGIAR research areas implies greater marginal utility of research investments. ILRI is almost unique in having a large research programme focused on food safety in informal markets, with a strong focus on generating actionable, high-quality evidence. As such, the group is responsible for much of the research information in this area. Importantly, the group produced the first book on food safety in informal markets (Roesel and Grace, 2014), in addition to dozens of journal papers, theses, posters, conference papers, research briefs, policy briefs, videos, infographics and blogs. ILRI also conducted numerous training courses for policy makers, researchers and value chain agents. The results of the various research and training activities are all available in open-access formats from the ILRI document repository (CGSpace: <https://cg-space.cgiar.org/>; accessed 19 February 2020) and other sites.

In parallel with the evolution of food safety at ILRI, there have been developments in the role of food safety in CGIAR, in which ILRI has been a major player. Food safety was not an initial focus of CGIAR research, with the first official mention of food safety in 2000 (Technical Advisory Committee, 2000). However, eight CGIAR centres had started small-scale research related to food safety in the following areas: breeding staple crops resistant to pests (so farmers can reduce pesticide use), breeding staple crops resistant



to aflatoxins, controlling aflatoxins using other organisms (biocontrol), breeding ergot (fungus) resistance in sorghum, reducing cyanide levels in cassava, and improving milk quality and safety (Kassam and Barat, 2003). Only research in the last area assessed health outcomes. In 2011, another survey of CGIAR food safety research was conducted, with more centres reporting food safety research. Aflatoxin research dominated, but there was an expansion of risk assessment and prioritization activities and substantial programmes on the safety of perishables (vegetables and animal-source foods), on zoonotic diseases, on occupational hazards and on water-associated diseases. As this list suggests, food safety research was almost entirely supply led, with centres looking at problems in the commodities they specialized in and with no overall alignment to health outcomes. The research effort and budget were very small compared with the overall CGIAR research portfolio.

Food safety research became more prominent with the development of the CRP on Agriculture for Nutrition and Health (A4NH), one of 15 CGIAR multicentre research programmes (Box 9.1). The Nutrition and Health programme was originally conceived as a joint venture between ILRI and the International Food Policy Research Institute (IFPRI). However, the CGIAR Consortium (now the CGIAR System Office) refused a jointly led CGIAR research programme, and, because most of the research in this programme focused on nutrition, it was agreed that IFPRI should lead the programme. A4NH had four main themes, or flagships, three focused on nutrition and one on the diseases associated with agriculture, including FBD. A4NH brought together portfolios on aflatoxin research led by the International Institute of Tropical Agriculture (IITA), the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), IFPRI and ILRI, and a portfolio of research on animal-source foods led by ILRI (A4NH, 2011). After two successful external evaluations (Sridharan *et al.*, 2015; Compton *et al.*, 2015), in which the research was deemed to be highly relevant, to have generated important evidence and to have generally met expectations, it was decided to make food safety a new, stand-alone flagship in the second phase of A4NH, starting in 2017.

**Box 9.1.** Justification for incorporation of food safety research at ILRI.

Food safety research is a relatively new area for CGIAR and ILRI. It can be seen as a response to changing agri-food systems and as evidence of the ability of CGIAR to take on new challenges. Like most organizations, ILRI periodically revisits its priorities and strategies, but this is typically done based on donor interest, popular wisdom, consultation and expertise rather than by using a systematic framework. Important exceptions at ILRI were: (i) an institutional prioritization in 1998 based on *ex ante* returns to research, which tightened ILRI's focus but led to a reduction of work in Latin America and with pastoralists; (ii) a geographic information system (GIS)-based mapping of poor livestock keepers, suggesting that Asian poor livestock keepers were neglected clients (Thornton *et al.*, 2002); (iii) an accompanying identification of research priorities based on expert opinion of pro-poor impacts, which showed the importance of zoonoses (Perry *et al.*, 2002); (iv) a non-systematic identification of priority countries for CRPs, which for the first time focused on consumers as well as producers; and (v) a mapping of zoonoses and poverty, which suggested that FBDs were among the most important zoonoses (Grace *et al.*, 2012c). These exercises in general provided justification for increased focus on FBD. In particular, compared with other animal health issues, FBD is relatively important, neglected and tractable, characteristics suggesting that it is a relatively promising area for research investment.

### Food safety pathways to impact

The 2017–2021 strategy for food safety research in A4NH identified two impact paths: evidence that counts and impact that scales (A4NH, 2016). The first pathway, evidence that counts, posits that ILRI evidence, published in peer-reviewed journals and actively communicated to users in ways that are clear, compelling and actionable, will lead to better decisions and these will lead to positive impacts. The second pathway, impact that scales, is based on ILRI discovering, developing or contributing to novel technologies or institutions that improve food safety for millions of people. Our big-idea impact pathway is the triple path to improving food safety in mass domestic markets by working with informal traders through a combination of



increasing their capacity to sell safe food through training and technologies, providing motivation for behaviour change (e.g. by improving business and marketing skills) and providing a more enabling operating environment, so that authorities, instead of ignoring or punishing informal traders, encourage them to professionalize their work.

### Empirical evidence

The first pathway – evidence that counts – is well within the traditional research sphere. Our theory of change is that, for ‘evidence to count’, the right information must be conveyed to the relevant people through appropriate channels. Research efforts can also build capacity of the relevant people so that they can make good use of the evidence generated and better align their incentives with action to improve food safety.

Recent decades have seen an increasingly systematic and systemic approach to using evidence across a broad range of fields; ILRI seeks to apply this to the issue of food safety in informal markets. Much of the interest can be traced back to the evidence-based medicine movement, which started in the 1990s in Canada. Evidence-based medicine was defined as ‘a systemic approach to analyse published research as the basis of clinical decision making’ (Claridge and Fabian, 2005). The approach quickly spread to allied health fields, such as dentistry, and then to areas such as education and housing.

Evidence-based approaches explicitly weight different types of evidence. In the evidence hierarchy, scientific evidence trumps anecdote or opinion, and scientific evidence itself is considered weaker or stronger depending on defined characteristics. For example, evidence from a multi-centre randomized controlled trial is stronger than evidence from a cohort study, which in turn is stronger than evidence from a cross-sectional study. While the best research evidence is intended to be the major factor in medical decisions, it is acknowledged that research evidence is only one factor, often a minor one, in development decision making. However, there is a consensus in the literature that, especially in developing countries, a more evidence-based, or at least evidence-informed, approach to policy

and practice is desirable, and that research can also tackle the process problem of insufficient reliance on evidence in decision making. As a result, important research-for-development donors rely increasingly on evidence. The food safety work at ILRI, which strongly drew on epidemiology, was and is well placed to meet this demand.

CGIAR is an important generator of agricultural research evidence in developing countries. Surveys have found that CGIAR science outputs compare well with advanced research institutes in production of evidence (Elsevier, 2014). However, there is less information on how this evidence is used or linked to development impact. In general, the implementation of research evidence is not straightforward. A review of the use of public health evidence in developed countries found that there was no reliable evidence on the extent of its use and that its impact was often indirect, competing with other influences (Orton *et al.*, 2011). The same review suggested that barriers to the use of research evidence included: decision makers’ perceptions of research evidence, the gulf between researchers and decision makers, the culture of decision making, competing influences on decision making and practical constraints.

Food safety research is more likely to have an impact if the following are true:

- *The research is of objectively high quality.* Our food safety research seeks to drive up quality by publication in high-impact-factor journals, shifting from less to more rigorous protocols and following best practice guidelines for conducting and reporting studies.
- *Stakeholders are involved.* For example, they may take part in the design of the research, serve as advisory members or visit research sites. ILRI’s food safety research has often involved national ‘champions’ who were identified as key promoters and disseminators of the research findings.
- *The research is produced by scientists in whom decisions makers have confidence.* For example, Kenyan policy makers want to see studies on aflatoxins in feed from Kenya, even if studies from Tanzania are likely to be almost as relevant. ILRI’s food safety research has taken place in 27 countries as of 2020.

- *The research is important but non-obvious.* For example, our finding in Vietnam that pork in supermarkets was less safe than pork sold in wet markets contradicted policy makers' preconceptions. They initially resisted the information, but when they saw the reasons for this finding, it made more of an impression on them than research findings that matched their preconceptions.
- *The evidence is timely, coming when decision makers need to do something.* For example, research on training dairy traders in north-east India provided a solution for decision makers dealing with public concern over milk safety.

We have found that food safety evidence leading to impacts generally occurs as one of three kinds: (i) developing the methods and tools needed to generate evidence of food safety in informal markets; (ii) developing and testing innovations with potential for widespread use; and (iii) influencing policy.

### Developing research methods and tools

Faced with the challenge of informal food hazards but little understanding of their risks to human health, ILRI identified the need for new tools and methods for conducting food safety research in a development context. The overarching framework for food safety work was an approach that ILRI called 'Participatory Risk Analysis'. Over the past several decades, risk analysis has been accepted as the 'gold standard' for assuring food safety. It has been adopted by the international community and underpins trade in foods and livestock. However, risk analysis has not had much success in the informal markets of developing countries, where most of the poor buy and sell their food. Conventional risk analysis is often expensive and time consuming, requires considerable amounts of data and quantitative analysis, and is typically led by technocrats. By taking the core concepts of risk analysis and combining them with proven development analytic methods such as participatory rural appraisal and gender analysis, an approach emerged that could be applied successfully to the food safety challenges in developing

countries. Applying this food safety approach was an important innovation of the programme (Grace *et al.*, 2008, 2010, 2011, 2012a,b; Grace and Randolph, 2009). The approach was subsequently used in Tanzania, Uganda, Vietnam and elsewhere, and its strengths and weaknesses, as well as the recommendations generated, were captured in peer-reviewed publications (Häsler *et al.*, 2018; Nguyen-Viet *et al.*, 2019; Roesel *et al.*, 2019).

Within this risk analysis framework, other methods and innovations were developed, including a global mapping of zoonotic diseases and poverty. This involved an updating of the global maps of poor livestock keepers, a systematic prioritization of zoonotic diseases likely to be relevant to the poor, a systematic literature review of the prevalence of these zoonoses in people, livestock and food products, and combining these in global maps (Grace *et al.*, 2012c). This was subsequently used to inform a major call for research on zoonotic diseases funded by the UK Department for International Development (DFID) and British research councils, which subsequently generated important research findings across a range of projects.

Economic assessment is another key tool to improving food safety. Collaborative research by ILRI over a number of years on the demand for livestock products in Ethiopia, Kenya and Tunisia in Africa, in Bangladesh and India in South Asia, and in Cambodia and Vietnam in South-east Asia provided strong empirical evidence on food safety (Jabbar *et al.*, 2010). The study identified 'wet markets' as the typical point of purchase of animal products. The quality and safety of livestock food products were mostly defined according to how these attributes were perceived by consumers: by their taste, colour, flavour and smell. Developing-country consumers also judge quality and safety by what they perceive to be the nutritional attributes of the foods, such as freshness, absence of adulteration, fat content (milk) and fat cover (meat), and various aspects of appearance, packaging, geographic origins, indicators of expired shelf life, a government inspection stamp and the cleanliness of the premises selling the products. The same consumers are aware of microbial, chemical and physical hazards in animal-source foods. In general, quality and safety issues were not always clearly demarcated: consumers tended to

associate some attributes with both while in other cases the differences were clearer.

One ILRI innovation was an adaptation of system dynamics – a model that maps resource flows and management processes within a complex system – to informal food systems (see Chapter 6, this volume, for an adaptation to East Coast fever). This was used to investigate interventions in the pork chain in Vietnam. Desk studies have combined information on the health burden of FBD, the foods responsible and macro-economic models to predict future trends in FBD in terms of health burden and economic cost (Kristkova *et al.*, 2017). In India, the number of FBD cases is expected to rise from 100 million to 150–177 million in 2030 compared with 2011, and an economy-wide model predicted that this would incur costs equivalent to 0.5% of the GDP.

CGIAR identified gender as a cross-cutting issue that should be mainstreamed in research. However, most food safety research does not have a gender perspective. We adapted and applied gender analysis tools to understanding food safety and documented this in several papers (Kimani *et al.*, 2012; Grace *et al.*, 2015d; Kiama *et al.*, 2016).

Similarly, although food safety and nutrition are biologically coupled, they are not often well integrated in agricultural development. This can be problematic because interventions intended to improve food safety can work against nutrition and vice versa. We developed a framework for a rapid assessment of food safety and nutrition and applied it to several of the livestock value chains where the CRP on Livestock and Fish was working (Eltholth *et al.*, 2014; Hoa *et al.*, 2014; Häsler *et al.*, 2019) and, along with the lead UK think tank at Chatham House, developed a widely disseminated evidence synthesis on animal-source foods in the first 1000 days of life, covering nutrition and food safety (Grace *et al.*, 2018a).

What cannot be measured cannot be managed. When ILRI started work on food safety, there was little understanding of suitable metrics and indicators for food safety in low- and middle-income countries. ILRI led a working group with broad expert inclusion to develop the first synthesis and analysis of food safety metrics for these countries (Grace *et al.*, 2018b). It also developed a tool to measure ‘food safety system performance’, inspired by a similar tool developed

and applied to the countries belonging to the Organization for Economic Cooperation and Development (OECD). Currently, ILRI is providing technical support to develop the world’s first ‘Food Safety Index’, which the African Union intends to include in the Malabo Declaration process. This means that all African Union countries will have an obligation to report on food safety and be mutually accountable, driving up food safety in Africa. ILRI is also a partner in the international Global Burden of Animal Diseases initiative.

### Developing and testing innovations for application

Another suite of ILRI research focuses on generating outputs or products intended for use by value chain agents and implementers, including technologies, approaches and surveillance.

- *Technologies.* Food safety technologies are technical approaches to improving food safety. Nearly all of the technologies researched by ILRI food safety scientists are adaptations of products developed by others. For example, we adapted the insecticide-treated bed nets widely used in the control of malaria to reduce flies in informal markets. In other cases, ILRI had no role in the development of the technology but tested it in order to assess its suitability and/or to suggest improvements to make it more useful (e.g. use of ozone in disinfection). None of the technologies developed, tested or adapted is being delivered at scale but several are considered to have potential for widespread use.
- *Approaches.* These comprise processes or different ways of doing things. Many are oriented around capacity building in new practices or providing information. We can consider that one approach is having impact at scale: this is the triple-path approach to informal traders comprising capacity building, enabling environment and motivation.
- *Surveillance.* The third category of innovations is concerned with disease detection, reporting and response, such as the use of information technology for reporting from slaughterhouses.

**Table 9.1.** Food safety product lines. Green shading indicates that the development is on track, yellow indicates that there are some delays or problems, orange indicates that there are significant delays or problems, and red indicates that it has been cancelled. (Constructed by authors).

Category	Product	Stages of development			
		Research	Proof of concept	Evaluate to development	Delivery
Technologies	Aflatoxin binders for animal feed				
	Aflatoxin probiotics for food and feed				
	Insecticide-treated netting for food safety in wet markets				
	Ozone disinfection for wet markets				
	Chlorine disinfection for wet markets				
	Filter paper tests for bacterial load in food				
	Mazzican for less mastitis and safer milk				
	Boiling milk to improve safety				
	Fermenting milk to improve safety				
	Off-ground slaughter using a metal grid				
Approaches	Training slaughterhouse workers				
	Training and certification of traders				
	GAP light – simplified Good Agricultural Practice				
	SMS messages for changing farmer behaviour				
	Biosecurity				
Surveillance	Bidirectional e-surveillance system for slaughterhouses				
	Participatory epidemiology for outbreak investigation				
	e-Surveillance for disease reporting				
	Participatory disease surveillance for managing large-scale outbreaks				

The most important ILRI food safety products in these categories are summarized in [Table 9.1](#). This summary of product lines gives an overview of ILRI evidence generation. More insight into potential impact can be gained by looking at specific research projects and topics. To give a concrete example, we analysed research outputs on aflatoxins posted on the CG-Space document repository. Over a period of 6 years and with the input of one or two full-time-equivalent ILRI scientists per year working with students and partners, we produced 29 journal articles accompanied by 50 science outreach items (conference presentations, reports), 14 policy outreach items (briefs, technical packages) and 50 public outreach items (videos, infographics, press conference, blog articles). In addition, we communicated the research results to all the farmers and value chain agents participating in this research. This

suggests that these projects are indeed producing outputs that go beyond research papers and that plausibly will help to ensure that 'evidence counts'.

Outcome and impact assessments carried out by specific projects can also illustrate the potential use and benefits of evidence generated on food safety projects ([Box 9.2](#)).

### Capacity building activities by ILRI

Capacity building was integral to all of ILRI's food safety research and is an important dimension of CGIAR research. Between 2012 and 2015, the following training activities were carried out by ILRI's food safety research programme ([Table 9.2](#)): (i) training of value chain agents for the purpose of developing and testing models and approaches; (ii) training

**Box 9.2.** Evaluation of a multi-country food safety project.

Safe Food, Fair Food was the first major ILRI research project to focus on food safety. It conducted a peer-to-peer project assessment whereby teams from participating countries visited another country to conduct a structured evaluation. This was generally positive. For example, the project had five major components, the first being a situational analysis of food safety. The main impacts of this situational analysis work were: (i) raised awareness on food safety in informal markets among food safety stakeholders; and (ii) a coming together of different sectors (especially medical and veterinary) to discuss the common issue of food safety. A semi-quantitative analysis of the situational analysis identified four success criteria, and a peer evaluation was conducted when each of the seven country teams evaluated another country against these criteria (maximum score of 5). The average across seven countries was 16.4 out of 20, equivalent to 82 out of 100, suggesting good overall impact.

Assessment points (maximum score of 5 for each category)	Average score
1. Did the participants of situational analysis represent stakeholders of food safety in the country well?	4.7
2. What information does the situational analysis provide?	4.1
3. Was there any delay in conducting situational analysis?	3.6
4. Were there measurable impacts from the situational analysis?	4.0
Subtotal	16.4
Percentage	82.1

**Table 9.2.** ILRI capacity development in food safety, 2012–2015. (Compiled by authors from ILRI archives). (unpublished data, ILRI).

Year	Value chain agents	Officials and policy makers	Researchers and students	Graduate fellows
2012	70	110	52	26
2013	524	77	42	69
2014	304	146	161	101
2015	1460	37	192	42

government officials and policy makers to increase their capacity to understand and make good decisions, creating an enabling policy environment; and (iii) training researchers to build their capacity but also to influence future implementers and decision makers. Although we do not have denominator data, we believe this represents a majority of the food safety graduate fellows and researchers in the countries in which ILRI worked, a substantial proportion (around half) of relevant government officials and policy makers, and a much smaller proportion (much less than 1%) of value chain agents.

The benefits of training have been documented to some extent by projects that conducted outcome studies, including Safe Food, Fair Food (Box 9.2), which worked in multiple countries in sub-Saharan Africa, and PigRisk, a project working in Vietnam.

### Influence on international, regional and national policies

International and regional agriculture and health organizations are considered crucial to development and this implies that ILRI engagement with them can have far-reaching impacts. Some ILRI inputs were specific to food safety high-level processes (e.g. its participation in WHO, 2013), while others incorporated food safety dimensions into broader livestock or development initiatives (e.g. food safety as an aspect of sustainable livestock development). Another distinction is between initiatives led by ILRI and initiatives where ILRI scientists were part of a broad range of scientists. Some of the most notable contributions are shown in Tables 9.3 and 9.4.

The following summary gives examples of where ILRI food safety research has contributed

**Table 9.3.** Food safety research led by ILRI.

Commissioner	Food safety aspect	Outcomes from the report	Source
DFID	FBD in low- and middle-income countries	Contributed to a funding call on food safety	Grace (2015b)
OIE	FBD as neglected livestock diseases	OIE communiqué issued	Grace <i>et al.</i> (2015a)
UNEP	Aflatoxins	Featured in UNEP annual report	Harvey <i>et al.</i> (2016)
EAC	Aflatoxins in feed and livestock products	Developed technical briefs used for setting policy at East African Community level	Grace <i>et al.</i> (2015b,c)
World Bank	Food safety in Vietnam	Contributed to a major funding initiative and to national policy	World Bank (2017)
USAID	Food safety in developing countries	Contributed to initiation of first food safety Innovation Laboratory	Grace (2017)
LCIRAH	Food safety metrics	Contributed to food safety tracking by African Union	Grace <i>et al.</i> (2018a)
DFID/BMGF	Food safety	Investment report influenced major funding call	Grace <i>et al.</i> (2018b)

OIE, Office International des Epizooties (World Organisation for Animal Health); UNEP, United Nations Environment Programme; EAC, East African Community; USAID, US Agency for International Development; LCIRAH, Leverhulme Centre for Integrative Research on Agriculture and Health; BMGF, Bill & Melinda Gates Foundation.

**Table 9.4.** Food safety initiatives to which ILRI contributed.

Commissioner	Food safety aspect	Outcomes from the report	Source
IFPRI	Aflatoxins	2020 briefs – an influential series of communications	Unnevehr and Grace (2013)
WHO	Food safety burden	Co-author on the FERG report	Havelaar <i>et al.</i> (2015)
WHO	Trade and human health	Chapter in WHO book	Hawkes <i>et al.</i> (2015)
IFPRI	Emerging economies	Paper in Global Food Policy Report	Grace and McDermott (2015)
HLPE	Food safety as an element of sustainable livestock systems	Co-author in 'Sustainable Livestock' report	HLPE (2016)
FAO	Food safety as an element of a healthy food environment	Included in International Conference of Nutrition agenda	Grace (2017)
World Bank	Food safety	Contributions to two major reports	Jaffee <i>et al.</i> (2019); GFSP (2019)
FAO/WHO	Food safety	First FAO/WHO/AU conference on food safety issued a communiqué	<a href="http://www.fao.org/3/CA3225EN/ca3225en.pdf">http://www.fao.org/3/CA3225EN/ca3225en.pdf</a>
WTO	Food safety economics	Speaker at pre-panel event	<a href="https://www.wto.org/english/tratop_e/sps_e/faowhowtoapril19prog_e.htm">https://www.wto.org/english/tratop_e/sps_e/faowhowtoapril19prog_e.htm</a>

HLPE, High-Level Panel of Experts; FAO, Food and Agriculture Organization of the United Nations; FERG, Foodborne Disease Burden Epidemiology Reference Group.



to policy. A more detailed explication can help illustrate the specific contributions.

WHO undertook the first global assessment of FBDs through its Foodborne Disease Burden Epidemiology Reference Group (FERG). This showed the high burden of FBD and is likely to lead to increased funding in this neglected area. The WHO's burden of disease studies were highly influential in determining the global health agenda and especially in directing billions of dollars in funding to the 'big three' diseases (Maudlin *et al.*, 2009). It is therefore plausible that the FERG study will also have widespread impacts.

A High-Level Panel of Experts (HLPE) is the science-policy interface of the Committee on World Food Security (CFS), the foremost international platform for food security. In October 2014, the CFS requested the HLPE to prepare a report on sustainable agricultural development for food security and nutrition, including the role of livestock (HLPE, 2016). An important planning meeting was held at ILRI, where ILRI's Delia Grace served as one of ten members of the HLPE livestock project team. HLPE reports are widely used as reference documents within and beyond CFS and the United Nations system, by the scientific community as well as by political decision makers and stakeholders, and at international, regional and national levels.

A World Bank-supported task force on risk assessment for food safety comprising researchers and policy makers was formed in 2013 to build capacity for food safety management in Vietnam. ILRI scientists were involved in the task force and A4NH provided funding (Nguyen-Viet, 2012). The task force consisted of researchers in Vietnam working on risk assessment and food safety with representatives of the Vietnamese Ministry of Health and Ministry of Agriculture and Rural Development. The task force first analysed the situation of food safety policy in Vietnam. Key constraints and areas where research and development interventions could assist policy were identified. Stakeholder workshops were conducted to determine the scope of activities and to prioritize food safety issues. Training sessions with a focus on case studies of risk assessment for food safety were organized to strengthen the risk assessment capacity of task force members and of policy makers. Case studies were conducted to: (i) assess the health risks of vegetables

and fish grown/caught in wastewater; (ii) assess the health risks related to antibiotic residues in pork; and (iii) disseminate research results and advocate for risk assessment as a tool for food safety management. The health risks from these case studies were assessed quantitatively, and risk communication and management strategies were developed. Achievements of the task force included the training of policy makers, managers and researchers; the publication of case studies of risk assessment in a special edition of a Vietnamese journal; and the publication of policy briefs. The task force was also requested to run training courses for veterinary professionals of ministries. The process, outcomes, challenges and potential impacts of the task force have been documented by Nguyen-Viet *et al.* (2018).

IITA coordinated the development of technical packages for the East African Community comprising technical papers on aflatoxin situational analysis, the scientific basis for aflatoxin control and policy recommendations for aflatoxin control. These technical packages aimed to assemble the best scientific thinking on the topic as the basis for policy recommendations. Through A4NH, ILRI scientists drafted two of these packages, which were submitted to the East African Community (Grace *et al.*, 2015b,c) and officially launched in 2018.

ILRI was commissioned by the US Agency for International Development (USAID) to develop a white paper on the potential need and role of a new Feed the Future Innovation Lab on Food Safety (Grace, 2017). The report recommended this, which contributed to the initiation of the laboratory in 2019.

ILRI was asked by the Global Food Safety Partnership (GFSP; a World Bank hosted public-private initiative for supporting food safety capacity building) to participate in a study on previous food safety investment in Africa and to make recommendations for future directions (GFSP, 2019). This led to engagement with the East African Community (EAC) and three-way collaboration between the EAC, GFSP and ILRI to support EAC in developing food safety strategy.

ILRI was asked by the World Bank to be a partner and co-author of the Eat Safe Initiative, which sets out global strategy for improving food safety and developed the first estimate of the cost of foodborne disease in low- and middle-income countries (Jaffee *et al.*, 2019).

In 2015, the African Union (AU) launched the Comprehensive Africa Agriculture Development Programme (CAADP) Biannual Review (BR) to monitor progress on agricultural development in the continent. The CAADP BR encompassed 43 indicators, seven of which tracked nutrition, but none captured food safety. In discussion with the AU, ILRI partnered to help develop the first African Food Safety Index (AFSI). The AFSI was launched as part of the 2019 CAADP BR, and 50 out of 55 AU Member States reported in at least one of its three elements.

### Impact that scales

International agricultural research has always aimed for widespread impact, first by improving food production in developing countries and later by widening its focus on livelihoods and on the health and environmental externalities of agriculture. Impact assessments show large and well-documented benefits to CGIAR research on crop genetic improvement, most notably rice, maize and wheat, and especially in Asia. There is much less evidence, however, for large-scale benefits from global agricultural research in the fields of policy, natural resource management and livestock (Renkow and Byerlee, 2010; Jutzi and Rich, 2016).

There are different models for understanding how innovations in agri-food systems, whether technologies or institutions, could have widespread, sustained impact. In developing countries, agricultural extension services and development initiatives are important but often have limited reach. In recent years, interest has grown in other dissemination actors, especially the private sector and collective action and in novel dissemination pathways such as social media. The food safety research agenda explores the potential of different partnerships to achieve impact at scale.

ILRI food safety research partnered with four broad categories of individuals or organizations: researchers, agents in value chains, development programme implementers and enablers. The relative level of involvement of these groups varies – it will grow, reduce or stay the same – based on the particular stage of given research.

Specifically, ILRI's food safety research partners include the following:

- *Researchers.* Important research partners in ILRI food safety are the veterinary, agriculture and, to a lesser extent, medical universities, national agriculture and medical research systems and centres of excellence in the countries in which we work. Advanced research institutes are important partners, especially Free University Berlin, Liverpool University, Uppsala Agricultural University, the University of Florida and the University of Sydney. The CGIAR centres IFPRI, IITA and World Fish have been major partners.
- *Value chain agents.* Most of ILRI's food safety research engagements have been with small-scale value chain agents, often via intermediaries such as trader associations, but there has been increased interest in medium-sized formal businesses. We have also worked with public–private partnerships such as the Global Alliance for Livestock Veterinary Medicines (GALVmed).
- *Development programme implementers.* Development-implementing partners of ILRI include non-governmental organizations such as Veterinarians without Borders and large-scale development projects funded by the World Bank, USAID and others.
- *Enablers.* The international and regional enablers include: the Africa Union–Interafrican Bureau for Animal Resources (AU-IBAR), Association of Southeast Asian Nations (ASEAN), EAC, Economic Community of West African States, Food and Agriculture Organization of the United Nations (FAO), Intergovernmental Authority on Development, United Nations Environment Programme (UNEP), World Bank, WHO and the Office International des Epizooties (OIE, World Organisation for Animal Health). We also work with policy makers and implementers at the country level, including national ministries, state veterinary services and municipal authorities.

### Training and enabling informal sector agents

Demand for fresh foods is growing rapidly in developing countries and most of this demand

must be met by markets. A study in southern and East Africa found that most food is already obtained from markets (54% in 2010, predicted to reach 70% in 2040) and that the informal sector currently supplies 85–95% of market demand and 51–57% of total demand (Tschirley *et al.*, 2015).

ILRI pioneered a 'triple-pathway' approach to improving food safety in informal markets by professionalizing rather than penalizing the informal sector, with the aims of supporting smallholder market access, safeguarding the supply of cheap nutritious food to the poor and reducing the burden of FBD. In the early 2000s, a training and certification scheme was designed and launched in Kenya to improve the quality and safety of informal dairy markets by improving the practices of traders, while also supporting the livelihoods of the dairy value chain agents. The scheme was taken up by a large proportion of eligible traders (with project support).

The traders were trained in hygienic milk handling and business practices and at the end of their training could apply for a certificate from the Kenya Dairy Board that entitled them to legally sell milk (Box 9.3).

Participant tests before and after the training showed that trader knowledge and practices improved, and microbiological tests showed that there was a substantial and significant decrease in unsafe milk. A later economic evaluation found an important reduction in transaction costs attributable to less harassment by authorities, less confiscated equipment and fewer bribes paid but also fewer losses of milk to spoilage. There was anecdotal evidence of improved business performance. A more recent evaluation found that, although the scheme had encountered some challenges, it was still operational. Eight years after the project officially ended, many traders have continued in the scheme; we estimated that up to 5 million consumers are benefiting from

**Box 9.3.** Smallholder dairy training and certification initiative.

In Kenya, dairy products are a significant expenditure in poor households. The informal, small-scale milk sector dominates the milk marketing chain, with some 60 - 70 % of the raw milk market. Milk sold informally from door to door or in milk bars reaches poor consumers who pay a lower price for it than for factory-packaged milk; it also generally provides farmers with higher prices than they can get in the formal sector.

However, prior to policy change in 2004, informal vendors, including mobile milk traders and bar vendors, milk transporters and small-scale milk producers (many of them women), were not officially recognized. They were unable to obtain a licence and were frequently harassed by powerful dairy market players, who sought to protect their own interests while professing concern over the safety and quality of milk sold in the informal sector.

Efforts to revise the dairy policy were spearheaded by ILRI's Smallholder Dairy Project. Implemented along with the Kenya Agricultural Research Institute (KARI) and the Kenya Ministry of Livestock and Fisheries Development, the project generated research-based evidence to reveal the economic significance of the informal milk sector and highlight the potential for improved handling and hygiene practices to ensure milk quality.

As part of the ongoing development of pro-poor strategies for small-scale milk market development, the Dairy Traders Association of Kenya was officially launched in September 2009. Its aims and activities include self-regulation based on the training and certification concept originally developed by the Smallholder Dairy Project and further scaled up by other projects. Around 4000 milk traders, offering employment to over 10,000 people, have been trained and certified by the Kenya Dairy Board through the association. Field regulators also ensure that licensed outlets and premises operated by milk traders meet conditions for milk hygiene, testing requirements and sanitation, and that operators know how to comply with these conditions.

A key supporting aspect of the Smallholder Dairy Project was the development of modules for training (milk handling, processing and marketing) and certification of vendors to improve milk quality. This training, along with simple innovations such as wide-necked milk cans, were shown to improve the safety of milk significantly. The proportion of milk with high levels of contamination fell from 71% to 55% among traders using plastic containers and from 48% to 42% among those using metal containers. Without the intervention, policy change would have been unlikely (WRENmedia, 2010).

milk provided by trained traders and tens of thousands of dairy farmers from market access through trained traders.

An evaluation of the Kenya-ILRI collaborative Smallholder Dairy Project was conducted in 2008 (Kaitibie *et al.*, 2010a,b; see Chapter 17, this volume). This showed significant economic benefits derived from changes in dairy policy resulting in lower transaction costs. Some 73% of national benefits accrued to producers and consumers with the balance going to traders and input suppliers. Related evidence showed improvements in milk quality (Omore and Baker, 2011), although it was not possible to link such improvements to changes in market prices.

Key lessons from the Smallholder Dairy Project were as follows:

- The scheme was successful in improving the quality and safety of milk, at least in the short term, and the focus on quality seems to have improved business performance.
- The scheme reduced milk marketing costs and was appreciated by both traders and consumers.
- The traders provided information to consumers and can be a practical node for dissemination of nutritional change and promotion of milk consumption to consumers as part of a marketing intervention.
- Training in business skills, including a greater consumer orientation, can improve business performance.

Key policy lessons were the following:

- Policies seeking to exclude the informal sector are unlikely to improve food safety or nutritional quality and may paradoxically decrease food safety and reduce the accessibility of food.
- Food safety and nutrition programmes should also help to reform anti-informal sector policies. Merely reducing inappropriate regulatory pressure on small businesses has the potential to increase small business capacities and to create incentives for them to improve the quality of their product.
- 'Light-touch' interventions centred around training can deliver substantial improvements in product quality, even in the absence of major technological or infrastructure upgrades.

There was, however, a lack of systematic support to this initially successful project. The original assumption that vendors would pay private business development services to provide training was not valid. However, other development actors did use the modules to provide one-off trainings. More critically, changes in the institutional and political context were not favourable to the informal sector and a subsequent follow up found that, while traders expressed a very favourable opinion to training, there was no systematic training programme in place and moreover milk sold by trained traders was no safer (Alonso *et al.*, 2018).

Moreover, the approach used in the Smallholder Dairy Project was never evaluated to see whether health benefits were obtained from safer milk. Although marketing skills were taught, there was no emphasis on teaching vendors how to promote the nutritional benefits of milk. The capacity-building initiative did not benefit from a gender perspective in design or implementation, notwithstanding the importance of women as milk producers, traders and consumers. Sustainability and scalability challenges had not been fully overcome. These deficits are being addressed in a project under way in 2020 ([www.ilri.org/research/projects/moremilk-making-most-milk](http://www.ilri.org/research/projects/moremilk-making-most-milk)); accessed 1 August 2020.

The trader intervention is a model for improving food safety when approaches based on regulation do not work (Johnson *et al.*, 2015). The model has been adapted and tested in other contexts, including dairy (India and Tanzania) and meat (Ethiopia, Nigeria and Senegal). In two of the three cases, evaluations documented that participating value chain agents increased their knowledge and skills and improved their food-handling practices. In some cases, better milk quality and higher incomes were found (Lapar *et al.*, 2014) and significant economic benefits were generated (Kaitibie *et al.*, 2010a,b). In the case of Nigeria, the intervention could plausibly be linked with a reduction in diarrhoea and savings in reduced healthcare expenditure worth many times the cost of training butchers (Grace *et al.*, 2012a). However, follow-up research 9 years later revealed a marked deterioration in meat quality as the result of lack of follow-on training and, more importantly, a shift from enabling to disabling environment (Grace *et al.*, 2019).

Based on results from early studies, a formal theory of change was developed by Johnson *et al.* (2015). This identified three components that they considered essential for success. The so-called 'triple-path' model included the following:

- *Training and technologies.* Informal sector agents needed tools to deliver safe food. This usually meant training, awareness raising and simple technologies such as disinfectants. Training in business skills was often included.
- *Enabling environment.* Regulatory authorities had to be on board with the intervention and there had to be some mechanism for institutionalization (e.g. a locally or nationally recognized certificate) and a means of quality assurance.
- *Motivation and incentives.* Incentives were essential for behaviour change but were very context specific. In one case, certificates protected traders against harassment from authorities; in another, the training enabled traders to improve their bargaining power with the public sector. It was originally hypothesized that trained traders would be able to charge a premium for safer food, but in no project were they able to charge more for food, although some may have increased their market share.

This triple-path approach is sometimes called 'Training, Certification and Marketing', or TCM, where 'training' refers to the capacity building aspect, 'certification' to the enabling environment and 'marketing' to the provision of incentives for behaviour change.

Table 9.5 presents evidence for the outcomes and impacts of food safety interventions, based on five relatively well-evaluated projects.

## Human Nutrition Research at ILRI

Many rural poor people worldwide subsist on substandard diets consisting largely of the same cheap cereal and tuber staples day in and day out. When they move to cities, their intake of cheap, highly processed foods high in sugar, salt and fats increases. Nutritional deficiencies in such diets are common and are associated with a range of poor health and development outcomes. The first 1000 days of life, from conception to

around 2 years of age, are considered an especially crucial nutritional period: setbacks during this period are hard to recover from by later attempts to 'catch up'. Undernutrition, while declining, remains at high levels in vulnerable communities, while diseases associated with too much food consumption trend upwards.

An initiative in 1984 brought together 12 CGIAR centres at ILCA, in Ethiopia, to discuss how the centres were addressing human nutrition. At that time, ILCA was including nutritional status in its field research, while ILRAD viewed its contribution to better nutrition as an indirect one made by tackling serious livestock diseases (Doyle, 1984).

During the 1960s and 1970s, insufficient energy was thought to be the most serious dietary constraint to improved human nutrition. As a result of research during the 1980s and 1990s and improving levels of energy consumption, attention shifted to micronutrient deficiencies in the diets of the poor. Because milk, eggs and meat are among the richest dietary sources of vitamins and minerals, in addition to protein, this created a new appreciation for the contribution that livestock products can make to ensuring nutritious and diverse diets.

In the late 1990s, ILRI conducted its first empirical studies investigating links between livestock keeping and human nutrition. A study from Ethiopia (using data from 1989 to 1998) found that introducing cross-bred cows could improve human health and nutritional status (Thornton and Otero, 1998); similar findings were reported from coastal Kenya (Nicholson *et al.*, 1999). Another Ethiopian study, in 1997 and 1999, indicated that market-oriented livestock activities moderately reduced poverty and improved food security and nutrition of smallholder households (Ahmed *et al.*, 2003). Econometric models applied to data from coastal and highland Kenya in the late 1990s found positive impacts of dairy cattle ownership on chronic malnutrition in coastal Kenya (Nicholson *et al.*, 2003).

A major event to bring together nutrition researchers and stimulate nutrition research in CGIAR was held in 2000 in the Philippines (Pinstrup-Andersen, 2000). Discussions at this meeting explicitly addressed the role of highly nutritious foods, including livestock products. The meeting concluded that ILRI efforts to increase the supply of livestock products to the poor could

**Table 9.5.** ILRI food safety interventions in informal markets.

Particulars	Kenya	Senegal	Ibadan, Nigeria	Assam state, India	Kampala, Uganda
Value chain	Informal milk sector	Goat restaurants	Butchers	Informal milk sector	Butchers
Year range	1997–2006	2010–2011	2009–2011	2009–2013	
Number of traders	25,000–30,000	Several hundred in three slaughterhouses	Around 900 in the market	Around 300 traders and 600 producers in the main milkshed	
Number of market agents trained	In 2010, 4200 traders registered nationally; in pilot areas, 85% of traders had been trained	Around 100 trained	80 directly by the project and around 420 by peer-to-peer training	265 traders and 480 producers have been trained	50% of butchers
Consumers reached	Around 0.5–5 million	Nearly 1 million	Around 360,000	Around 1.5 million	Around 0.5 million
Gender aspects	Not explicit; women made up about one-third of the traders	Not included: all workers were men	Targets for women participation and gender dimensions researched	Not explicit; nearly all traders and farmers were men	
Intervention	Training in hygiene and business practices, provision of hygienic dairy cans, with a certificate given to successful trainees, reducing their harassment by officials	Training in hygiene, raising awareness on food safety	Peer-to-peer training on basic hygiene; provision of equipment, banners and promotional material; use of butchers' associations to monitor performance and ensure compliance	In-depth training needs analysis; training of trainers; training covering hygiene and business skills; traders motivated by better relations with officials and positive publicity and farmers by visible reduction in mastitis	Training in hygiene, equipment, posters, certificates
Documented impact	Improved KAP after training; improved milk safety after training with reduction in unacceptable coliforms from 71% to 42%; This project gave training and certification programs for informal milk traders, enabling thousands to be licensed and resulting in national economic benefits having a net present value of US\$230 million.	No change in KAP after training; management provided no soap or other necessities and were rather indifferent to practices, and there was no obvious incentive for behaviour change	Reduction of unacceptable meat from 97.5% to 78.5% ( $p < 0.001$ ); significant improvements in KAP after training; cost of training was US\$9 per butcher and estimated gains through diarrhoea averted was US\$780 per butcher	Improved KAP after training; significantly higher milk production after training and tendency for reduced mastitis; significant sector benefits in several sites	Improved KAP after training; satisfaction with training

*Continued*



**Table 9.5.** Continued.

Particulars	Kenya	Senegal	Ibadan, Nigeria	Assam state, India	Kampala, Uganda
Policy influence	High: legislation changed and new institutions	None	Low: only engagement with market authorities	High: new institutions but no change to legislation	Some: linked to broader ILRI policy processes
Current status of the initiative	Training and certification are episodic and project-led, but trained vendors have an important share of the market	None: one-off training	The pilot was intended to investigate efficacy and acceptability and did not have a strategy for sustainability	Training and monitoring are ongoing and supported by the government	Training is being supported by donors
Reference(s)	Kaitibie <i>et al.</i> (2010a,b); Omore and Baker (2011); Alonso <i>et al.</i> (2018)	Submitted	Grace <i>et al.</i> (2012a)	Lapar <i>et al.</i> (2014); Lindahl <i>et al.</i> (2018)	Ongoing

KAP, knowledge, attitudes and practices.

be presumed to have nutritional benefits while acknowledging that there had been insignificant efforts to measure these benefits (Bouis, 2000).

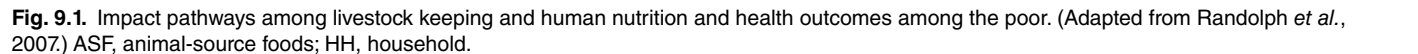
Delgado *et al.* (2001) examined the effects of income growth on diets using Chinese panel data. As incomes improved, Chinese consumers shifted from high-carbohydrate foods towards high-fat, energy-dense foods, with these changes varying by income levels. These income effects suggested that increased incomes could affect diet and body composition in ways detrimental to health; moreover, the biggest harm would fall on low-income groups due to their increasing incomes. The study argued that higher incomes might reverse health gains achieved in the preceding two decades if diet-related non-communicable diseases could not be controlled (Delgado *et al.*, 2001).

In 2003, for the first time, an ILRI programme was initiated with an explicit focus on improving human health through livestock by considering both the associated benefits and risks of livestock to people's health. The new ILRI Livestock Keeping and Human Health Impacts programme focused on nutrition, zoonoses and food safety. This programme sought to leverage expertise through partnerships, and commissioned some important evidence syntheses. These concluded that the available evidence suggested that interventions to promote livestock were generally positive for nutrition, although few high-quality studies took into account the complex links between livestock and nutrition, and most had substantial methodological weaknesses (Leroy *et al.*, 2006). The project also developed an influential conceptual framework (Fig. 9.1) articulating the links among livestock, nutrition and human health (Randolph *et al.*, 2007). These links are context specific. To begin teasing out the roles of different species, a study conducted in Ethiopia demonstrated that ownership of small stock did not contribute to improved child nutrition within the household, whereas poultry might provide direct benefits through egg consumption (Good, 2009).

An external review (Science Council/CGIAR, 2008) recommended that human nutrition not be a focus for ILRI. This led to fragmentation of ILRI's first human health programme, and for several years little research was done at ILRI relevant to human nutrition. However, the launch of A4NH in 2012 provided an opportunity to revive this important area of research.

ILRI leveraged external expertise to re-establish nutrition work. This included collaborations with senior nutritionists at Emory University in Georgia, IFPRI, the London School of Hygiene and Tropical Medicine, UK, and Washington State University. Exploratory work and pilots were conducted in several field sites. Highlights include the following:

- An ILRI study conducted with households representing low, medium and high levels of dairy intensification in rural Kenya indicated that women's increased labour demands as households intensified their dairy production were associated with poorer nutritional outcomes for their young children; in contrast, children in households of high dairy intensity received more milk than children in lower-intensity households (Njuki *et al.*, 2015).
- ILRI produced the first reported study showing a link between aflatoxin in milk and child stunting (children who are too small for their age) in two low-income areas in Nairobi (Kiarie *et al.*, 2016).
- ILRI conducted a project to develop tools for rapid, integrated assessment of food safety in value chains. Studies in five countries documented the potential importance of livestock products to nutrition and how these were being eroded by poor food safety (El-Tholth *et al.*, 2018; Häslar *et al.*, 2018, 2019; Roesel *et al.*, 2019; Nguyen-Viet *et al.*, 2019).
- ILRI conducted an analysis of the demand for livestock products, the drivers of this demand and the barriers to consuming livestock products among poor households in Nairobi. Price was found to be the most important barrier to consumption, while taste was reported as the main driver for consumption. Estimated demand elasticities indicated that increases in total food expenditure would lead to the greatest increase in demand for beef meat. Price reductions would increase the demand relatively more for fish, other meats and dairy products (Cornelsen *et al.*, 2016).
- A systematic review suggested that food scares linked to livestock disease outbreaks and FBD could harm nutrition due to consumers avoiding the implicated foods (Green *et al.*, 2017).



**Fig. 9.1.** Impact pathways among livestock keeping and human nutrition and health outcomes among the poor. (Adapted from Randolph *et al.*, 2007.) ASF, animal-source foods; HH, household.

- A study in Tanzania suggested that participation in a pro-poor agricultural intervention to improve milk production may improve women's milk consumption (Mishkin *et al.*, 2018).
- A Women Empowerment in Livestock Index, based on a widely used index to measure empowerment of women in agriculture and adapted to livestock keepers, incorporated nutrition and was used to identify dimensions of empowerment associated with dietary diversity and food security (Galiè *et al.*, 2018).
- Work with FAO on the challenges of ensuring livestock interventions in the Sahel had positive nutritional benefits and led to a reformulation of relevant FAO guidelines (Dominguez-Salas *et al.*, 2019).

As ILRI also endeavoured to engage with the Millennium Development Goals and the subsequent Sustainable Development Goals, there were increasing efforts to understand the appropriate contributions of livestock products to human diets, especially given the wide and sometimes conflicting concerns about undernutrition, overnutrition, the environmental externalities of livestock systems, livestock-associated human diseases and animal welfare. A series of papers looked at some of the synergies and trade-offs among these societal goals (Enahoro *et al.*, 2018; Salmon *et al.*, 2018; Sirma *et al.*, 2018). ILRI increasingly engaged in broad platforms that addressed all these issues. These included livestock initiatives taking on greater nutritional focus, such as the multi-stakeholder Global Agenda for Sustainable Livestock partnership, the Livestock Data for Decisions project, the Global Livestock Agenda to 2020 initiative and the Global Livestock Advocacy for Development project. The links among livestock, livestock-associated disease and human nutrition were also set out in several influential publications that ILRI authored or co-authored (Grace, 2015a, 2016, 2017; ILRI, 2019). ILRI's collaboration with Chatham House produced a widely cited and evidenced-based synthesis of livestock-enhanced diets in the first 1000 days of life (Grace *et al.*, 2018a).

A few ILRI projects have aimed to improve nutrition through consumption of livestock products as opposed to better understanding this issue or advocating for it. ILRI participated in an mNutrition initiative that involved mobile phone

companies providing mobile phone-based health, nutrition and agriculturally based information services to the poor. ILRI helped to build the capacity of local partners to develop appropriate nutrition messages and to ensure the quality of the messages (CABI, 2017). More than 5 million people were reached with these nutrition messages. There was evidence of some behaviour change due to implementing this service, but it proved difficult to develop business models to keep the service going because people were generally unwilling to pay for mobile phone-based health information. A rigorous external evaluation of this project is under way. Preliminary results indicate that aspects of the approach are attractive to mothers, but considerable technological and sociological barriers challenge access and uptake (<https://perma.cc/7QSA-Z9DF>; accessed 19 August 2020).

Another large ILRI-led project focused on behavioural communication change messages to promote dietary diversity, including livestock products, in Kenya. This project gave more than 5000 women training in nutritional issues and reached over 50,000 infants via nutritional messages to their mothers (Kiome *et al.*, 2019). This was not a research project and the impact is not clear. Another project in Rwanda aimed to evaluate the nutritional impacts of a social and behavioural change communication intervention combined with a government initiative dubbed 'One Cow per Poor Family' (Flax *et al.*, 2017). The final results of this project are not yet available, but initial results confirm that families who are given a free cow had lower stunting prevalence than families who were eligible but had not yet received a free cow (Flax *et al.*, 2019).

ILRI projects have also been the entry point for other nutrition projects. The ILRI-led African Chicken Genetic Gains (ACGG) project in Ethiopia has partnered with a Food, Agriculture and Natural Resources Policy Analysis Network (FANRPAN) project which will promote chicken and egg consumption in the ACGG households benefiting from ACGG provision of 25 imported tropically adapted chicken strains and locally developed indigenous strains. Again, work is ongoing and findings are yet to emerge.

In conclusion, the contribution that livestock make to human nutrition has evolved at ILRI from an assumed but unexamined premise,

to an active area of research, to relegation outside of ILRI and finally back to renewed recognition that this should be an important focus of ILRI's agenda. The very small investments in this area to date have necessarily constrained its impacts. Research studies did produce useful information on links among livestock keeping, livestock product consumption and nutrition. There were also methodological advances in tools for assessing nutrition in value chains, for formulating diets and for measuring women's empowerment. ILRI advice has also been incorporated in many guidelines. While recent decades have seen livestock production coming under increasing criticism in high-income countries because of environmental, health and animal welfare concerns, the increasing numbers of high-level reports and global engagements on nutrition and livestock issues are likely to draw attention to the importance of livestock and livestock-derived products for nutritionally vulnerable populations

### The Future

ILRI and partners have been studying food safety in informal markets for more than a decade. This work has helped confirm the

hypothesis that food safety is an important and probably growing constraint to smallholder value chains because of its multiple burdens on human health, livestock production and product marketing. Over the same period, our understanding of the global burden of FBD in developing countries has greatly increased, validating ILRI's emphasis in this area, especially the importance of zoonotic disease and animal-source foods, areas where ILRI is mandated to research.

ILRI research on FBD has resulted in many science outputs, including some genuinely innovative tools and approaches, and has already demonstrated outcomes at community, national and regional levels. These include substantial inputs into global, regional and national strategies and national training programmes. The major development-oriented approach – the triple-path for training, motivating and enabling of informal market agents – has been shown to be both scalable and sustainable. While questions remain about its lasting effects on food safety and its application outside those few countries where its success has been demonstrated, the next few years should bring further evidence about this, with benefits lasting for many decades to come.

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