



**PHASE I FINAL REPORT**  
June 25, 2019 – June 24, 2024

**FEED THE FUTURE INNOVATION LAB FOR FOOD SAFETY**

# Feed the Future Innovation Lab for Food Safety (FSIL)

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**June 25, 2019 – June 24, 2024**

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## MANAGEMENT ENTITY

The Feed the Future Innovation Lab for Food Safety (FSIL) is jointly managed by Purdue and Cornell Universities. In FSIL's first phase, the management entity provided technical leadership that guided the United States Agency for International Development (USAID) food safety research agenda while ensuring effective management and implementation of all activities within the FSIL portfolio. FSIL's management team and technical experts leveraged extensive experience in international food safety research, education, and extension to develop and manage a portfolio of food safety and capacity-strengthening activities.

## MANAGEMENT TEAM

### **Dr. Haley Oliver**

Director

Interim Vice Provost for Graduate Students and Postdoctoral Scholars

150<sup>th</sup> Anniversary Professor of Food Science

Senior Research Fellow, Krach Institute for Tech Diplomacy at Purdue

Purdue University

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Associate Director

Professor of Food Microbiology

Cornell University

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Managing Director (2023 – present)

Purdue University

### **Molly Webb**

Managing Director (2019 – 2022)

Purdue University

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Operations Specialist

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Cornell University

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Vice Provost for Graduate Education  
Cornell University

### **Dr. Amanda Deering**

Professor of Food Science  
Purdue University

### **Dr. Paul Ebner**

Interim Department Head  
Professor of Animal Sciences  
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Vice Provost for Graduate Education  
Dean of the Graduate School  
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Professor of Agricultural Economics  
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### **Dr. Gerald Shively**

Associate Dean and Director of International Programs in Agriculture  
Professor of Agricultural Economics  
Purdue University

### **Dr. Hui-Hui Wang**

Associate Professor  
Agricultural Sciences Education and Communication  
Purdue University

### **Dr. Martin Wiedmann**

Gellert Family Professor in Food Safety  
Cornell University

## ADVISORY COMMITTEE

In FSIL's first phase, the Advisory Committee was critical to developing a strategic research portfolio and building partnerships across academic, public, and private sectors. The management entity relied on Advisory Committee members to counsel FSIL on research priorities and serve as a resource to support FSIL research subaward processes and projects.

The Advisory Committee consisted of private sector food safety experts, government agency representatives, and experts in FSIL's cross-cutting themes.

**Bob Baker**

Senior Food Safety Advisor  
World Food Programme

**Betsy Baysinger**

Director, Trade and Scientific Capacity Building  
Division  
United States Department of Agriculture Foreign  
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Alliance of Bioversity International and the  
International Center for Tropical Agriculture

**Howard Popoola**

Vice President, Corporate Food Technology  
and Regulatory Compliance  
The Kroger Co.  
Board Member, Global Food Safety Initiative

## PHASE I GEOGRAPHIC SCOPE



In Phase I, FSIL targeted a select group of focus countries for core activities to maximize impact and limit overhead while maintaining a global focus. Phase I countries included Bangladesh, Cambodia, Kenya, Nepal, Nigeria, and Senegal. FSIL conducted additional activities through a buy-in award and a QuickStart project that covered East African Communities in Burundi, Rwanda, Tanzania, and Uganda.

## LIST OF PROGRAM PARTNERS

<b>U.S.</b>	Arizona State University Cornell University Kansas State University Purdue University Sathguru Management Consultants Tennessee State University Texas State University The Ohio State University The Pennsylvania State University Tuskegee University University of Alaska Fairbanks University of Connecticut University of Florida University of Georgia Utah State University
<b>Bangladesh</b>	Bangladesh Agricultural University University of Dhaka
<b>Burundi</b>	University of Burundi
<b>Cambodia</b>	Center of Excellence on Sustainable Agricultural Intensification and Nutrition (CE SAIN) Institut Pasteur du Cambodge Institute of Technology Cambodia Royal University of Agriculture World Vegetable Center
<b>Kenya</b>	International Livestock Research Institute Kenya Medical Research Institute University of Nairobi
<b>Nepal</b>	Nepal Development Research Institute Nepal Food Scientists and Technologists Association (NEFOSTA) Agriculture and Forestry University SAHAVAGI
<b>Nigeria</b>	Bowen University Obafemi Awolowo University University of Ibadan
<b>Rwanda</b>	University of Rwanda – Nyagatare campus
<b>Senegal</b>	Conseil National de Développement de la Nutrition Institut de Technologie Alimentaire Institut Sénégalais de Recherches Agricoles
<b>Tanzania</b>	Sokoine University of Agriculture
<b>Uganda</b>	Makerere University

## ACRONYMS

<b>ATP</b>	Adenosine Triphosphate
<b>CamGAP</b>	Cambodia's Good Agricultural Practices
<b>CE SAIN</b>	Center of Excellence on Sustainable Agricultural Intensification and Nutrition (Cambodia)
<b>Co-PI</b>	Co-Principal Investigator
<b>COVID-19</b>	Coronavirus Disease 2019
<b>FAO</b>	Food and Agriculture Organization of the United Nations
<b>FS</b>	Food Safety
<b>FSIL</b>	Feed the Future Innovation Lab for Food Safety
<b>FY</b>	Fiscal Year
<b>GAPs</b>	Good Agriculture Practices
<b>GAqPs</b>	Good Aquaculture Practices
<b>GFSS</b>	Global Food Security Strategy
<b>IAFP</b>	International Association for Food Protection
<b>ISRA</b>	Institut Sénégalais de Recherches Agricoles (Senegal)
<b>ITA</b>	Institut de Technologie Alimentaire (Senegal)
<b>M.S.</b>	Master of Science
<b>MSI</b>	Minority Serving Institution
<b>NGO</b>	Non-governmental Organization
<b>Ph.D.</b>	Doctor of Philosophy
<b>PI</b>	Principal Investigator
<b>RFA</b>	Request for Applications
<b>USAID</b>	United States Agency for International Development
<b>USDA</b>	United States Department of Agriculture
<b>WTP</b>	Willingness to Pay



# TABLE OF CONTENTS

Management Entity	i
Advisory Committee	iii
Phase I Geographic Scope	iv
List of Program Partners	v
Acronyms	vi
Table of Contents	vii
Executive Summary	1
Program Goals and Objectives	3
Overview of Activities	5
QuickStart Projects	5
Long-Term & Short-Term Subaward Design	5
Coronavirus Pandemic Rapid Response Project	7
Management Entity Activities	7
Accomplishments and Utilization of Research Outputs	9
Microbial Food Safety	10
Social and Behavior Change	14
Women in Food Safety Systems	16
Demand for Safe and Affordable Food	20
Food Safety Capacity Strengthening	23
Further Challenges and Opportunities	26
References	27
Appendix: Project Collaborators, Roles, and Institutions	31

## EXECUTIVE SUMMARY

This report presents progress over the first five-year phase of the Feed the Future Innovation Lab for Food Safety (June 25, 2019 – June 24, 2024). The Food Safety Innovation Lab (FSIL), managed by Purdue and Cornell Universities, has leveraged global food safety expertise in locally-led projects that address the root causes of foodborne illness. Phase I FSIL projects were designed to create systemic change to strengthen household and community nutrition, food security, and economic opportunity by identifying food safety knowledge gaps, supporting data-driven food safety practices and policies, and strengthening local food safety capacity.

Project activities focused on four objectives: 1) increasing awareness of food safety across value chains; 2) enhancing capacity to conduct food safety research; 3) developing policies that enable conditions for food safety research, translation, and practice; and 4) accelerating translational research technologies and practices for households, communities, and the food industry. FSIL's portfolio of capacity-building research projects included four commissioned projects, seven competitively funded short- and long-term projects, and a USAID buy-in to mitigate food industry disruptions during the coronavirus pandemic. Research focused on food safety across the value chains of nutrient-dense foods (produce, dairy, fish, and poultry) in Bangladesh, Cambodia, Kenya, Nepal, Nigeria, and Senegal. Phase I projects significantly advanced knowledge in four areas:

**Microbial Food Safety:** Across FSIL's focus countries and value chains, data showed that consumers were at risk of acquiring foodborne illnesses due to the presence of foodborne pathogens and lack of hygienic practices across food chains. Without further action to implement interventions to mitigate risks, such as training in Good Agricultural Practices and investments in safe water infrastructure, consumers will continue to be susceptible to disease and malnutrition.

**Social and Behavior Change:** Social science research provided important insights into barriers to the adoption of food safety practices, which can inform target audiences and approaches for future trainings. Projects found that actors across the food system are motivated to strengthen food safety but often lack sufficient resources and knowledge to adopt food safety practices.

**Women in Food Safety Systems:** Surveys to understand gendered roles and food safety knowledge confirmed the crucial roles women play across value chains and revealed their lack of resources, opportunities, and monetary influence compared to their male counterparts. Going forward, prioritizing capacity building among women is key to increasing their access to food safety resources, training, and market opportunities and their impact on foodborne illness in their communities.

**Demand for Safe and Affordable Food:** Research demonstrated clear demand for food safety, evidenced by consumers' willingness to pay a price premium for safer food, and indicated that awareness of food safety risks and certification systems can increase consumers' willingness to pay a price premium. However, policy investments in food safety should carefully consider potential unintended consequences on lower-income consumers and focus on interventions that will improve food safety for all consumers.

Across projects, FSIL prioritized equipping local stakeholders with knowledge, skills, and networks to support sustainable improvement in food safety systems. Capacity strengthening occurred through graduate student programming, grower and producer training workshops, conferences, and policy consultation workshops that strengthened local and global food safety networks. Specific areas of knowledge included gender-sensitive research methods, general awareness of food safety risks, microbiology research techniques, experimental design and statistical analysis, social science research methodology, analysis of food pathogen transmission, risk assessment, and safe food production methods. In total, FSIL projects supported 33 graduate students and hosted 60 food safety workshops that trained 2,317 stakeholders.

In Phase II, FSIL will build on these findings through a focus on increasing consumer awareness of and demand for safer food, empowering governments to generate and use food safety data, and motivating the private sector to adopt safe food production practices. Research will identify data-driven behavioral levers that increase the demand for safer food and food safety regulations and support evidence-based policy formulation to strengthen food safety systems in Cambodia, Kenya, and Nepal.

# Feed the Future Innovation Lab for Food Safety

## Phase I

**60 TRAININGS & WORKSHOPS HELD**

to **strengthen** local research capacity, **support** producers and private sector stakeholders in adopting food safety practices, and **disseminate** research results to policymakers and local stakeholders

**2,317** participants

56% women

**190 RESOURCES DEVELOPED**

including 45 **fact sheets**, 6 food safety **country or regional reports**, a **policy brief**, and a Good Agriculture Practices (GAPs) **manual**



**78** Web stories

**31** Conference presentations

**18** Peer-reviewed publications

**10** Webinars



**33 GRADUATE STUDENTS SUPPORTED**

75% women

**38 GLOBAL PARTNERS ENGAGED**

**55% of research funds** committed to **local partners** in FSIL focus countries



**5 MINORITY SERVING INSTITUTIONS ENGAGED**

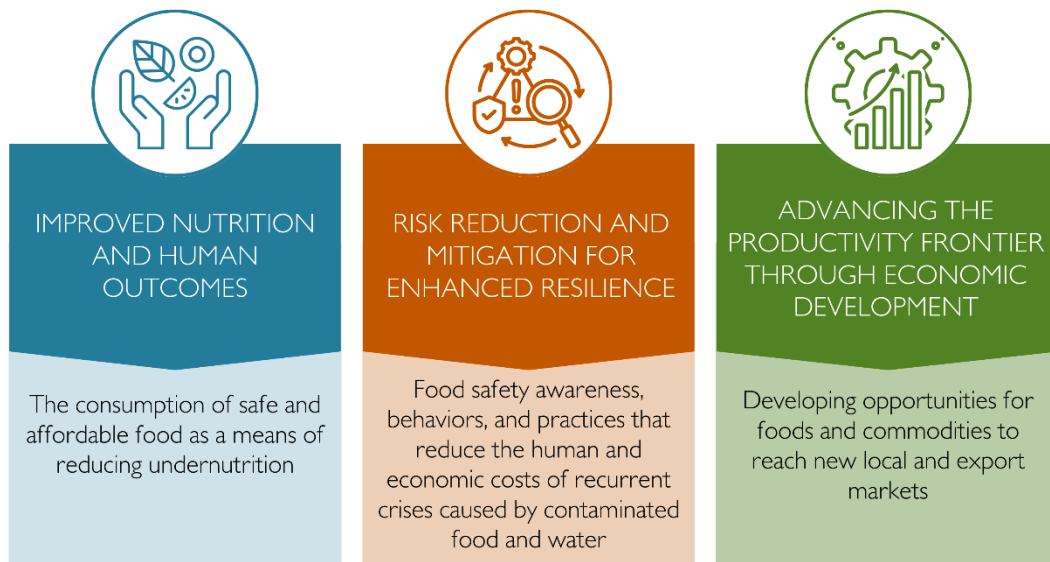
**2** MSI-led projects



## PROGRAM GOALS AND OBJECTIVES

In 2019, USAID selected Purdue University, in partnership with Cornell University, to lead the first Feed the Future Innovation Lab for Food Safety (FSIL). Globally, the burden of foodborne disease is comparable to major infectious diseases including malaria, tuberculosis, and HIV/AIDS, and children under age five bear 40% of the burden (Havelaar et al., 2015). Investments in food safety are strategic for meeting the U.S. Government's Global Food Security Strategy (GFSS) objectives of nutrition, resiliency, and economic growth, as foodborne disease contributes to malnutrition, carries public health and economic costs, and limits access to local and export markets. These objectives are reflected in FSIL's three Areas of Inquiry: Improved Nutrition and Human Outcomes, Risk Reduction and Mitigation for Enhanced Resilience, and Advancing the Productivity Frontier through Economic Development (Figure 1).

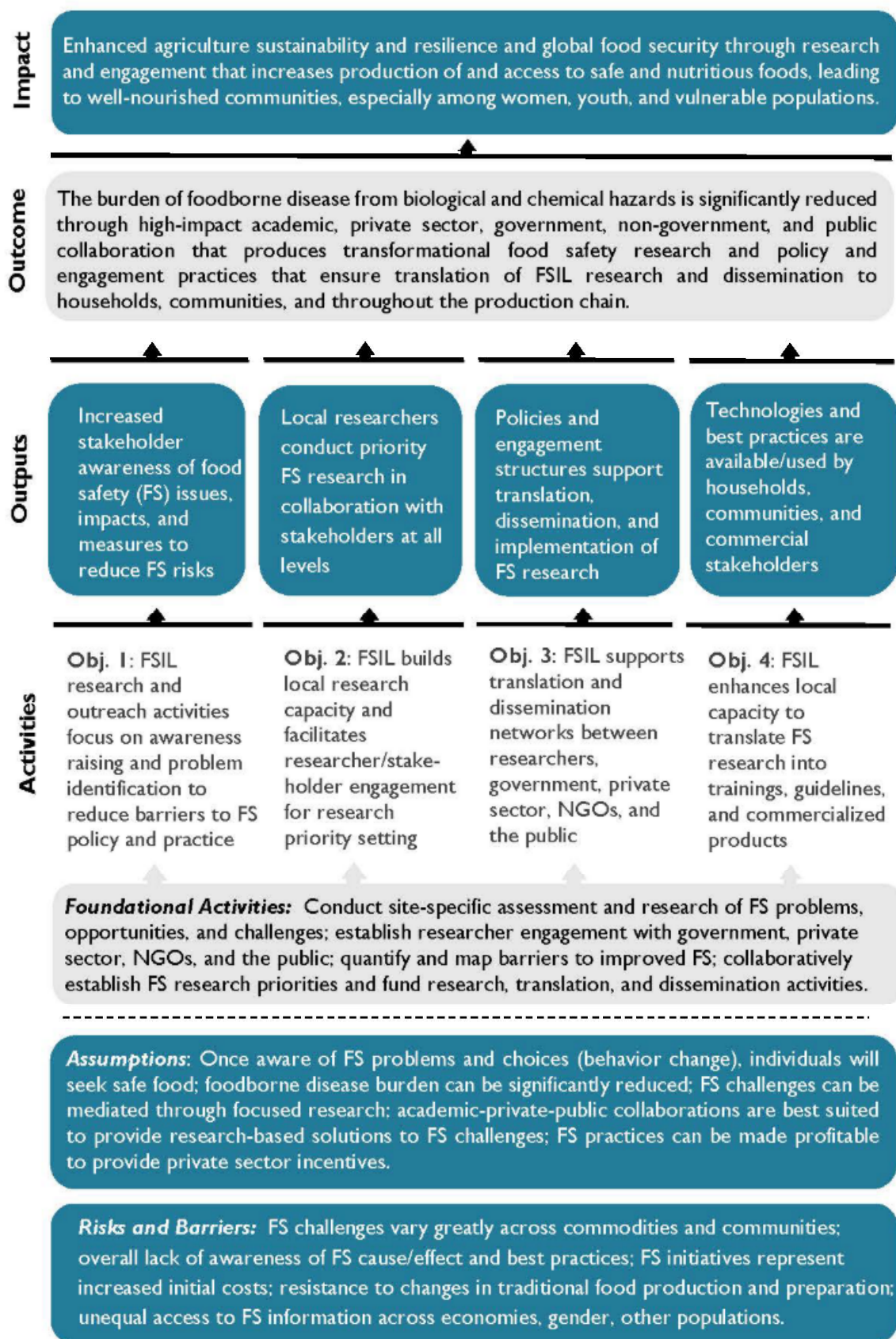
Figure 1. FSIL's Areas of Inquiry



In Phase 1, FSIL's research portfolio addressed four objectives that contribute to well-nourished communities through increased production of and access to safe and nutritious foods (Figure 2, Theory of Change):

- 1. Increasing awareness of food safety across value chains.** Awareness of foodborne illness often lags behind other public health risks. Raising awareness of food safety among food system actors is a foundation for motivating farmers, processors, distributors, vendors, and consumers to adopt practices to prevent contamination.
- 2. Enhancing capacity to conduct food safety research.** Strengthened capacity to identify the root causes of foodborne illness within food systems, develop and evaluate mitigation strategies, and facilitate the adoption of food safety interventions is a foundation for sustained progress.
- 3. Developing policies that enable conditions for food safety research, translation, and practice.** With the support of outreach efforts, access to resources, economically viable market-based approaches, and monitoring, food safety policies and regulations that meet international standards can drive systemic change in food safety.
- 4. Accelerating translational research technologies and practices for households, communities, and the food industry.** New research technologies, such as rapid tests and whole genome sequencing, as well as data-driven practices that prioritize high-risk activities and pathogens in a value chain, are essential tools to increase the pace and impact of food safety investments.

Figure 2. FSIL's Theory of Change and Impact Pathway for Food Safety (FS)



## OVERVIEW OF ACTIVITIES

FSIL developed a portfolio of capacity-building research projects to meet its four objectives. Activities included four commissioned research projects (QuickStarts), four competitively funded four-year projects (long-term subawards), and two competitively funded two-year projects (short-term subawards). In addition, a USAID buy-in funded a one-year project to mitigate food industry disruptions in Africa and Asia during the coronavirus pandemic.

### QuickStart Projects

In FY2020, FSIL launched four foundational one-year research projects (QuickStarts; Table 1) which conducted country-wide food safety assessments to map key stakeholders; catalog food safety programs, players, and policies; and initiate discussions of food safety research priorities. The resulting landscape analyses for Bangladesh, Cambodia, Kenya and East Africa, and Senegal were informed by scientific literature reviews and stakeholder interviews. The reports characterized the current state of food safety systems, including regulatory structure and oversight, recent food safety research projects, institutional food safety capacity, and food safety challenges and priorities (Mutua et al., 2021a; Kang’ethe et al., 2021; Mutua et al., 2021b; Suman et al., 2021; Arias-Granada et al., 2020; Ebner et al., 2020; Thompson et al., 2021). Common themes across countries and regions included:

- Limited evidence on the incidence of, prevalence of, and risks posed by microbial foodborne pathogens
- A need to assess the impact and efficacy of innovative food safety interventions, including research on consumers’ willingness to pay for safer food and the economic impacts of food safety practices
- Challenges associated with preventing contamination in traditional markets
- Regulatory challenges, including overlapping oversight and lack of adoption of international standards
- Gaps in food safety training, laboratory resources, and surveillance mechanisms

Table 1. QuickStart projects and researchers

Project	Project Researchers
Bangladesh QuickStart	PI: Kannan Vijayaraghavan
Cambodia QuickStart	PI: Jessie Vipham Co-PIs: Lyda Hok and Valentina Trinetta
Kenya QuickStart	PIs: Delia Grace and Florence Mutua
Senegal QuickStart	PI: Jonathan Bauchet Co-PI: Ibrahima Sarr

Two of the QuickStart projects also included initial assessments to gauge the current risk of microbial contamination in specific value chains. In Cambodia, the data demonstrated a high frequency and level of foodborne pathogen contamination on vegetables collected from distribution centers (Schwan et al., 2022). In Senegal, the preliminary data indicated that peanuts produced in the Senegalese peanut basin were heavily contaminated by indicators of fecal contamination and fungi (yeasts and molds) (Britton et al., 2021).

By identifying key gaps in data and local food safety research capacity, the QuickStart projects informed research priorities and approaches in the Requests for Application (RFAs) for long-term and short-term subawards.

### Long-Term & Short-Term Subaward Design

The subsequent long-term and short-term subawards focused on reducing microbial foodborne pathogen contamination in nutritious, perishable foods and aligned with individual GFSS Country Plans. Projects were selected through two competitive RFAs for multidisciplinary research that leveraged expertise in microbiology, toxicology,

social and behavioral science, and local capacity strengthening. Projects were led by U.S.-based principal investigators (PIs) who partnered with in-country and other U.S.-based co-principal investigators (Co-PIs) at one or more institutions (Appendix). The first RFA (May 2020) targeted Bangladesh, Cambodia, Senegal, and Kenya. The second RFA (April 2021) focused on Minority Serving Institution (MSI)-led partnerships for global food safety research with eligible focus countries of Bangladesh, Cambodia, Ghana, Haiti, Kenya, Nepal, Niger, Nigeria, Rwanda, Senegal, Tanzania, and Uganda. In projects funded through both RFAs, the cross-cutting themes of gender equity, youth engagement, human and institutional capacity development, and food safety enabling environments were incorporated. The seven subaward projects resulting from the two RFAs are summarized below, with two distinct phases described for the Kenya poultry project.

### **Bangladesh: Food Safety Economics in Aquaculture**

Recent increases in the production of farmed fish in Bangladesh have been accompanied by a strengthening of the country's food safety regulatory structure. This project, led by Madan Dey at Texas State University, used food safety economics and microbiology research to support data-driven food safety policies and practices in aquaculture. The team assessed food safety knowledge, attitudes, and practices among consumers and value chain actors; evaluated consumer demand for safer fish and the potential economic impact of food safety practices on production costs for small-scale fish farms; developed training materials to support the adoption of Good Aquacultural Practices; and engaged government stakeholders on the development of additional training resources and certification programs.

Co-PIs: Mohammad Saidur Rahman (in-country lead), Md. Akhtaruzzaman, Md. Abdul Alim, Samina Luthfa, K.H.M. Nazmul Hussain Nazir, and Pratheesh Sudhakaran

### **Cambodia: Food Safety Across the Vegetable Value Chain**

Cambodia's commitment to reducing malnutrition has led to the increased promotion of high-value, nutritionally rich foods, including raw vegetables which carry a risk of foodborne disease unless consistently protected from cross-contamination with foodborne pathogens. This project, co-led by Paul Ebner at Purdue University and Jessie Vipham at Kansas State University, integrated microbiology, social behavior change science, and economics to identify strategies to reduce foodborne illness from the consumption of vegetables. Researchers mapped and characterized the prominent pathogens and contamination points; assessed value chain actors' food safety awareness and perceived barriers to adopting food safety interventions; and quantified consumers' willingness to pay for safety-certified produce.

Co-PIs: Lyda Hok (in-country lead), Nora Bello, Rithy Chrun, Edward Dudley, Jasna Kovac, Chanthol Peng, and Navin Sreng

### **Kenya Phase I: Safer Poultry Production Practices**

Poultry is an important dietary component for poor and middle-class Kenyan households and a key source of revenue for women and youth. In this project led by Barbara Kowalczyk at the Ohio State University, the team focused on systems-based, risk-informed approaches to food safety on small-scale poultry farms. Researchers collaborated with stakeholders using risk ranking to identify food safety priorities for the poultry value chain and conducted a review of gender roles in poultry production and the food safety hazards faced by men, women, and youth.

Co-PIs: Robert Onsare (in-country lead), Kathleen Colverson, Arie Havelaar, Sanja Ilic, Catherine Kunyanga, Kara Morgan, Robert Scharff, and Ahmed Yousef

### **Kenya Phase II: Microbial Food Safety in the Poultry Value Chain**

For Kenya's rapidly growing population, chicken is of increasing importance in food security and nutrition. This ongoing project, co-led by Robert Onsare of the Kenya Medical Research Institute and Catherine Kunyanga of the University of Nairobi, is collecting fundamental data on microbial food safety in the poultry value chain. The team is evaluating gender and youth roles related to food safety, assessing the prevalence of *Salmonella* and *Campylobacter* bacteria at the points of production and sale, characterizing the bacterial isolates using whole genome sequencing, and developing and implementing training in Best Management Practices for poultry production to improve food safety.

### **Nepal: Market-Led Produce Safety**

Consumption of fresh produce contributes to well-nourished individuals, households, and communities, but when produce is consumed raw, prior contamination with foodborne pathogens can undermine its contributions to reaching nutritional targets. This project, led by Aditya Khanal of Tennessee State University, used food safety economics and microbiology to provide evidence and recommendations to strengthen food safety in Nepal's produce value chain. Researchers assessed the risk of fresh produce contamination from household and on-farm water sources; quantified consumer demand for safer produce; conducted surveys to understand current food safety knowledge, attitudes, and practices; provided food safety training to extension agents and vegetable farmers; and convened government and private sector stakeholders to discuss future produce safety policies and investments.

Co-PIs: Ram Hari Timilsina (in-country lead), Rita Gurung, Agnes Kilonzo-Nthenge, Ashok K. Mishra, Saroj Poudel, and Sramika Rijal

### **Nigeria: Household Food Safety and Nutrition**

Household-level food safety is a significant economic and public health concern in Nigeria, which has a childhood stunting rate of 33%. This project, led by Andrea Bersamin of the University of Alaska Fairbanks, identified strategic, feasible activities to mitigate and prevent household foodborne illnesses in Nigeria. Researchers assessed food safety risks from household surfaces; measured levels of childhood stunting; identified the challenges faced by mothers in providing safe and nutritious foods for their children; and convened stakeholders to discuss critical policy needs to support the implementation of Nigeria's national food safety plan.

Co-PIs: Bolanle Otegbayo (in-country lead) and Abiodun Atoloye

Collaborators: Folake Olukemi Samuel, Olufemi Oludare Aluko, Abiodun Ayooluwa Areola, and Nkem Torimiro

### **Senegal: Safer Milk Production and Processing**

Senegal's diverse and fragmented supply chain of small farms, aggregation sites, artisanal processing facilities, and transport from rural areas to urban centers creates challenges for protecting food safety in dairy products. This ongoing project, led by Manpreet Singh of the University of Georgia, is advancing data-driven food safety practices among dairy producers and processors. Researchers are collecting baseline pathogen data from farms and small dairy processors; strengthening food safety laboratory research capacity; assessing current food safety knowledge, attitudes, and practices in the dairy value chain; and conducting food safety trainings for dairy producers and small-scale processors.

Co-PIs: Cheikh Ndiaye (in-country lead), Woubit Abebe, Victoria Collins McMaken, Younoussa Diallo, Rawah Faraj, Jessica Marter-Kenyon, and Harshavardhan Thippareddi

## **Coronavirus Pandemic Rapid Response Project**

The coronavirus pandemic began to impact research activities in Spring 2020. FSIL was awarded a one-year buy-in project to develop a task force to support the international food industry, which faced unprecedented challenges associated with the pandemic. In this project, experts from the Institute for Food Safety at Cornell University, led by PI Martin Wiedmann, partnered with technical experts in Bangladesh, Cambodia, Kenya, Nepal, and Senegal to provide science-based information to prevent food supply chain disruption. They developed practical resources, such as checklists, mitigation strategies for food businesses, and videos in several languages with frequently asked questions, and they held country-specific and regional Food Industry Virtual Office Hours that reached more than 1,000 participants.

## **Management Entity Activities**

The management team directed and managed FSIL's research portfolio and capacity-strengthening efforts through routine engagement with internal and external stakeholders, effective communication and management structures, and dissemination of FSIL results and learnings. Virtual monthly meetings between the management team and all



subawards provided opportunities to monitor and advise on activities, address challenges proactively, and develop a culture of collaboration and open communication.

Annual meetings with the FSIL management team, subaward teams, USAID representatives, Advisory Committee members, and FSIL technical experts provided opportunities to share project progress and learnings, collaborate across and within subaward teams, and support engagement between subawards and FSIL’s Advisory Committee and technical experts. Annual meetings were held in Indianapolis (2021), Texas State University (2022), and Cambodia (2023). Additional opportunities to transfer knowledge across projects were provided through annual virtual project exchanges and quarterly meetings of the gender working group. The gender working group, consisting of gender specialists from each subaward and any FSIL researchers or students engaged in gender research, was facilitated by FSIL’s gender technical expert Hui-Hui Wang with support from Kathleen Colverson and Jan Henderson, experts in gender research and group facilitation.

FSIL results and learning were shared broadly through online engagement with Twitter/X and LinkedIn, routine submission of blog posts and updates to Agrilinks, and regular e-newsletters. The management team also hosted ten webinars on key food safety topics: a five-part webinar series in 2020 that explored the intersection of food safety with other key development areas, which attracted 1,426 registrants from 72 countries; a webinar in 2022 on the lessons learned from the global coronavirus food safety task force (298 registrants); a two-part webinar series on risk-based food safety approaches in 2023 (450 registrants); and a two-part webinar series in 2024 that shared results from FSIL research projects on the themes of social behavior change and gender (384 registrants). Finally, the management team is currently developing policy briefs to share key findings from each subaward project.



FSIL’s November 2023 annual meeting in Phnom Penh, Cambodia, brought together project researchers, Cambodian stakeholders, USAID staff, technical experts, advisory council members, and the FSIL management team.  
Photo credit: CE SAIN

# ACCOMPLISHMENTS AND UTILIZATION OF RESEARCH OUTPUTS

FSIL's long- and short-term subawards advanced knowledge in four key research areas: **microbial food safety, social and behavior change, women in food safety systems, and demand for safe and affordable food**. In these areas, FSIL projects built locally-relevant and context-specific evidence and translated it into key findings and recommendations that were shared through peer-reviewed publications, webinars, conference presentations, stakeholder meetings, and training workshops that informed food safety practices, priorities, interventions, and policies. Across value chains and regions, key themes emerged:

1. Consumers are at risk of acquiring foodborne illnesses due to the presence of foodborne pathogens and lack of hygienic production practices, water, food processing environments, and households.
2. Actors across the food system are motivated to strengthen food safety but often lack sufficient resources and knowledge to adopt food safety practices.
3. Because women play a significant role in food and agricultural systems and have tremendous opportunities to influence food safety, future trainings and interventions to strengthen food safety must be designed for and engage women.
4. Demand for safe foods exists in the marketplace, as evidenced by the willingness of consumers to pay a price premium for foods with safety certifications.

FSIL's projects also took a broad approach to **local capacity strengthening**, including supporting graduate students in relevant fields, strengthening research skills, training producers and processors in food safety practices, and sharing findings and recommendations with government stakeholders.

The sections that follow highlight research approaches, findings, and recommendations in microbial food safety, social and behavior change, women in food safety systems, demand for safe and affordable food, and local capacity strengthening. Overarching findings supported by examples from selected projects are provided to inform future research, policy, and capacity-building efforts.



Photo credit: Sina Nov/CE SAIN

## Microbial Food Safety

Microbial food safety was a cornerstone theme of FSIL’s Phase I long-term and short-term projects in Bangladesh, Cambodia, Kenya, Nepal, Nigeria, and Senegal. In QuickStart projects, stakeholder consultations, and discussions with FSIL’s Advisory Committee, microbial food safety was identified as an under-prioritized food safety hazard requiring targeted research to establish its importance in public health. Because microbial food safety data was lacking in FSIL focus countries, projects collected baseline microbiology data in their selected value chains to understand the extent of microbial risk.

Across FSIL’s focus countries, results revealed that **consumers are at risk of acquiring foodborne illnesses** due to the presence of foodborne pathogens (e.g., *Salmonella*) and lack of hygienic production practices, water, food processing environments, and households. **Without further action to understand the sources of foodborne pathogens and interventions to prevent their entry and proliferation in value chains, consumers will continue to be susceptible to disease and malnutrition.**

### Bangladesh

In aquaculture, production practices can reduce the risk of contamination with foodborne pathogens. The project investigated the impact of improved fish stocking and pond management practices on the safety of farmed fish. To determine whether any safety improvements were observed, the prevalence of *Salmonella* and coliforms were measured in fish sampled from three test ponds and three control ponds. *Salmonella* is a bacterial foodborne pathogen; its presence in food puts consumers at risk of acquiring salmonellosis, which can cause severe illness and death. Likewise, the presence of coliforms in food, water, or environmental samples indicates that fecal contamination from people, animals, or wastewater has occurred. Fecal material can carry foodborne pathogens, so the presence of coliforms in samples indicates that consumers are at risk of exposure to foodborne pathogens. Coliforms are ‘indicator organisms,’ which are frequently tested in food production environments to determine their hygienic status.

Good Aquaculture Practices (GAQPs) implemented in the three test ponds included draining the pond and applying lime; site management to prevent birds and other animals from accessing the pond; maintenance of appropriate fish stocking density; water quality monitoring; and the use of feed formulations without antibiotics, growth hormones,



Photo credit: Allison Joyce/Far on Foot

or harmful chemical additives. In data currently being prepared for publication, *Salmonella* was detected less frequently in fish from test ponds (6.3%, n=48) than control ponds (31%, n=48). Similarly, coliforms were detected less frequently in fish from test ponds (52%, n=144) than control ponds (97%, n=144). Although cooking fish reduces consumers' direct risk of acquiring foodborne illness, the presence of foodborne pathogens on fish increases the risk of exposure from cross-contamination with uncooked fish on surfaces and other foods in markets, processing facilities, and households. The results indicate that consumers are at risk regardless of production practice, as both a pathogen and indicator organism for fecal contamination were found in fish farmed under both types of production practices. Intentional changes to production practices can potentially improve food safety, although the impact of specific production practices on the safety of fish requires further research.

A literature review examining the food safety risks of fish in Bangladesh was published in *Reviews in Aquaculture* (Khan et al., 2023), and the experimental results were shared with approximately 150 stakeholders, including government officials, farmers, researchers, and representatives from the feed industry, at a dissemination event in May 2024. Recommendations based on this research included expanded training and implementation of GAQPs and the development of certification and labeling programs for farms following GAQPs. To begin implementing these recommendations, the team is developing a GAQPs manual to increase the accessibility of guidelines for Bangladeshi extension agents and farmers, and they are engaging with the Department of Fisheries, Bangladesh Food Safety Authority, and National Planning Commission to institutionalize GAQPs in Bangladesh's national policies.

### Cambodia

To understand the risk posed by raw vegetable consumption and identify key points along the value chain to mitigate that risk, the project collected baseline *Salmonella* and *E. coli* prevalence data throughout fresh produce value chains. *E. coli* is a coliform that is frequently tested in food production environments as an indicator organism for potential fecal contamination and unhygienic conditions. Every step along a food value chain presents an opportunity for pathogens to contaminate food. For foods consumed raw, such as fruits and vegetables for salads, preventing contamination is especially important because food pathogens are not killed during food preparation by cooking or preservation methods. Understanding the major sources of contamination (e.g., specific foods, value chain locations, surfaces, and/or production practices) can more effectively focus food safety interventions and training efforts.



“Food systems are complex, and it is difficult to control foodborne pathogens at all levels, so you need to identify the locations that contribute the most to cross-contamination and transmission to human beings. Our data, including whole genome sequencing of pathogens, has identified areas where changes in practices can lead to a measurable reduction in the risk of contamination of vegetables that reach consumers.”

-Jessie Vipham, Cambodia long-term subaward PI

Photo credits: CE SAIN & Andrew Ball



Foods and surfaces from fresh produce farms, distribution centers, and markets located in Battambang and Siem Reap provinces were sampled for microbial contamination. *Salmonella enterica* and *E. coli* were detected on vegetables, including cucumbers (*Salmonella*: 0.54%; *E. coli*: 31%; n=372), lettuce (*Salmonella*: 2.7%; *E. coli*: 54%; n=372), and tomatoes (*Salmonella*: 0.0%; *E. coli*: 22%; n=248). They were also common on food-contact surfaces (*Salmonella*: 13%; *E. coli*: 41%; n=249) and non-food-contact surfaces (*Salmonella*: 11%; *E. coli*: 33%; n=248). The cucumbers and lettuce sampled presented a direct risk of *Salmonella* exposure to consumers, with prevalence rates in lettuce approximately 50-fold higher than in the United States (Reddy et al., 2016), and all produce types were commonly contaminated with *E. coli*. **Both *Salmonella* and *E. coli* were highly prevalent on food-contact and non-food-contact surfaces, indicating additional risk of pathogen transmission to food products and food handlers.** Because *Salmonella* and *E. coli* prevalence rates did not significantly differ between farms, distribution centers, and markets in either province, food safety improvements are needed across the value chain. *Salmonella* isolated from positive samples were subjected to whole genome sequencing to gain further insights on pathogen transmission and diversity. **The data showed that highly similar *Salmonella* isolates were identified over time and value chain location, suggesting persistence and recurring transmission and contamination throughout the value chain. Specific recommendations to reduce pathogen transmission risk included investing in safe water infrastructure and displaying vegetables in markets on tables instead of the ground, particularly during the rainy season.**

These data and recommendations were shared by four graduate students via poster presentations delivered at the annual meeting of the International Association for Food Protection in 2024 (Chhoeun et al., 2024; Salazar et al., 2024; Sokhom et al., 2024; Tep et al., 2024). Manuscripts are being prepared and reviewed for publication in academic journals in FY2025.

## Nepal

The project collected baseline safety data on the water sources used by growers and consumers to wash fresh produce. Water safety is critically important to food production, especially for foods that do not undergo cooking or other preservation methods, such as fruits and vegetables that are consumed raw. Fresh produce can become contaminated with foodborne pathogens if unsafe water is used for irrigation or washing at the producer, vendor, or household level to remove dirt and other debris from the surface. Water safety is a primary element of Good Agriculture Practices (GAPs), which aim to protect fresh fruits and vegetables from becoming contaminated with foodborne pathogens while they are being grown, harvested, and transported to market.



Photo credit: Kathacharya Productions

This study focused specifically on water used for washing produce and found that water contamination in Nepal was high across the food value chain and across geographies. **Of 156 consumer water samples from five metropolitan areas in Nepal, 63% tested positive for *E. coli*. Of 238 grower and vendor wash water samples from ten districts in Nepal, 55% were contaminated.** An important finding from this research was that well water used by growers to wash produce was less contaminated with *E. coli* (29%, n=100) than municipal tap water (73%, n=52) or irrigation streams (88%, n=43), but contamination rates were still very high overall. **This data shows that consumers and producers frequently use unhygienic water in the preparation and production of fresh fruits and vegetables, which indicates an opportunity for exposure to and spread of foodborne pathogens.**

This study was published in the *Journal of Food Protection* (Khanal et al., 2024b), shared at the 9<sup>th</sup> National Conference in Food Science and Technology (Timilsina et al., 2023), and presented to 120 stakeholders at a national policy consultation, with recommendations to increase investment in safe water infrastructure and improve food safety training for producers (i.e., GAPs) and consumers (Nepal Food Scientists and Technologists Association et al., 2024). This research was also used to provide water source recommendations in a Nepal-specific grower manual (Kilonzo-Nthenge et al., 2024).

## Nigeria

To understand the risk of contamination of food with microbial pathogens during meal preparation, the project collected baseline consumer hygiene data from households raising children under five. Children under five bear a disproportionate burden of foodborne disease. Although the burden of maintaining a safe food supply cannot be placed solely on consumers, consumer practices can reduce the risk of illness. Microorganisms can thrive in food production environments, including household kitchens. Cleaning, sanitation, proper food storage, and the prevention of cross-contamination are some of the key practices that consumers should follow to maintain safe meal preparation environments in their homes and protect children from cycles of disease and malnutrition.

Environmental hygiene was assessed through *E. coli* detection tests. The team collected 1,000 swab samples of kitchen items and surfaces from 250 households. **Food-contact surfaces were more frequently contaminated with *E. coli* (31%, n=500) than were non-food-contact surfaces (20%, n=500). Of the food-contact surfaces, some of the more frequently contaminated items were blenders (48%, n=27), knives (41%, n=32), pots (38%, n=124), grinding stones (37%, n=27), and soup bowls (36%, n=14). Of the non-food-contact surfaces, the more frequently contaminated items were sponges (59%, n=41) and sinks (44%, n=16). The high *E. coli* prevalence on kitchen food-contact surfaces highlights the challenges that households currently face in reducing the risk of cross-contamination with potential foodborne pathogens during meal preparation.**

These data are being prepared for review and publication in an academic journal in FY2025. Although important as standalone results, these data become more actionable when combined with the results of the *Our Voice* study described in the Women in Food Safety Systems section below, which used qualitative data shared by Nigerian mothers to identify facilitators of and barriers to improving food safety for their families. Recommended interventions resulting from that work are described below, and the findings on *E. coli* prevalence in households provide powerful motivation for their implementation.

## Senegal

This project is collecting baseline pathogen and indicator organism data for milk samples collected from small-scale milk producers and mini-dairy processors. To date, the project has completed sampling in the Saint Louis region; efforts are ongoing in Louga and Matam. **Preliminary data indicates that animal and milking environments are unsanitary, resulting in high levels of aerobic bacteria and coliforms in many raw milk samples. Several raw milk samples also contained human pathogens including *Listeria monocytogenes* and *Staphylococcus* spp., which indicates a direct risk of pathogen transmission to people if not controlled through processing methods such as pasteurization or fermentation.** With proper pasteurization or fermentation, processors can eliminate foodborne pathogens from products, but they must maintain sanitary processing environments to ensure milk and other products do not become contaminated during or after processing. In addition, raw milk must conform to minimum quality standards for pasteurization or fermentation to effectively kill pathogens, indicating the necessity for interventions across the supply chain. With complementary dairy processor survey data and stakeholder input, the project will determine points of intervention to focus future training and intervention efforts.

## Social and Behavior Change

Strengthening food safety is ultimately about behavior change, which requires an understanding of existing knowledge, attitudes, and practices and extrinsic barriers to adopting new practices, such as lack of infrastructure, resources, and government regulation. Social and behavior change research in FSIL projects included surveys, focus group discussions, and interviews with actors across value chains to understand the factors that influence behavior change. **Projects found that actors across the food system are concerned about food safety issues and motivated to strengthen food safety. However, behavior change was limited by knowledge gaps about microbial food safety risks and effective practices to mitigate them as well as access to resources, such as sufficient access to clean water.** All FSIL subawards were interdisciplinary, tying together evidence from microbiology and social science research to understand the existing risk of microbial contamination, factors that contributed to risk, and opportunities and priorities for intervention. With this full context, projects were able to prioritize recommendations for interventions to strengthen food safety.

### Cambodia

Because improving food safety often involves adopting new behaviors, understanding the food safety perceptions of and potential barriers to change faced by food system actors can inform recommendations for interventions and training. Researchers surveyed 69 vegetable growers in Battambang and Siem Reap provinces and 31 vendors in Phnom Penh to assess their perceptions of the importance of vegetable safety, frequency of vegetable contamination, health impacts of consuming contaminated vegetables, the value chain location of contamination, and who is most responsible for preventing contamination (Mosimann et al., 2023b). **Based on the data, food safety programs for growers and vendors should include efforts to increase participants' understanding of the health impacts of consuming contaminated vegetables, particularly the impact of microbial contamination, as there was greater awareness and concern about chemical contamination. Growers and vendors most frequently perceived vegetable contamination to occur at the farm. Programs for vegetable growers could leverage this sense of responsibility to encourage behavior change to prevent contamination, while programs for vendors may need to emphasize their role in ensuring vegetable safety at markets.**

Complimentary research used the Capability, Opportunity, Motivation-Behavior model to understand the major obstacles to behavior change for food system actors and identify low-barrier areas where intervention could have a greater



“In Cambodia, the produce sold in informal vegetable markets comes from farms via distributors, and preventing contamination with foodborne pathogens is important at every step. If you want to encourage someone to adopt a food safety practice, whether or not they know how to do it is one thing. Our goal was to figure out whether or not people thought they could do it, whether they felt they had the opportunity to do it and whether they felt like, ‘Oh, this would motivate me to do it.’”

-Sabrina Mosimann, Cambodia long-term subaward graduate student

Photo credit: Andrew Ball

immediate impact (Mosimann et al., 2023a). Surveys captured 181 produce farmer, vendor, and distributor perceptions about their capability, opportunity, and motivation to implement daily food-contact surface cleaning with soap and water. Across all groups, motivation to change behavior was relatively high. However, their perceived opportunity was lower relative to their motivation, indicating that they lacked sufficient resources, such as time to perform the washing step or money to buy soap. The groups differed in their perceived capability to change behavior; farmers had relatively low perceived capability, whereas vendors and distributors had relatively high perceived capability. **The results of this study suggest that all stakeholders may be limited in changing food safety behaviors because of their access to resources or other external factors (opportunities), and increasing stakeholders' access to soap and clean water may support behavior change. Additionally, the results suggest farmers may be limited in their knowledge or skills related to food safety behaviors (capabilities), and focused training for farmers may support behavior change.**

The research was published in *Frontiers in Sustainable Food Systems* (Mosimann et al., 2023a; Mosimann et al., 2023b) and shared during FSIL's 2024 webinar on social behavior change in food safety (Ebner, 2024).

## Senegal

Due to the dominance of imported powdered milk in the Senegal dairy market, the domestic dairy sector primarily consists of small-scale milk producers and mini-dairy processors. To better understand food safety practices and risks in the domestic dairy value chain, the project conducted focus group discussions and surveys with owner-operators of nine mini-dairies and the households that supplied them with milk (428 individuals in 162 households) in the Saint Louis, Louga, and Matam regions of Senegal. **At the mini-dairies, the team found that owner-operators were generally aware of food safety issues and practices, and a majority reported receiving training and employing food safety practices such as washing hands and equipment and rejecting milk that does not meet quality standards.** The results showed that although additional safety criteria likely should be added to the milk quality testing and rejection regimen, the existing acceptance of food safety practices may provide a strong foundation for future improvements. **Food safety challenges cited by mini-dairy owner-operators were transportation and energy infrastructure (e.g., refrigeration and cold chain) and limited access to training and financing to implement safe practices across the dairy value chain, including for milk producers.** In addition, many dairies are owned and operated by women, but one-third reported constraints such as limited control over dairy income and decision-making to invest in improved practices.

Findings from producer surveys supported the assessment by the mini-dairies that producers faced significant challenges in employing safe practices. **A large majority of producers reported having no access to information or training related to dairy production, and concern about illness from unsafe milk was low, with only 5% of respondents reporting that they had observed a family member becoming sick from consumption of unsafe milk. In addition, 23% of respondents reported that their household consumed milk that was rejected by the mini-dairy.** Also in alignment with reports from the mini-dairies, producers faced significant resource constraints in adopting improved practices, such as access to finance and cold chain and transport infrastructure.

The project has highlighted that there are significant safety concerns in the Senegalese domestic dairy value chain and a lack of resources among producers and processors to address them. This work was shared in FSIL's 2024 webinar on social behavior change in food safety (Marter-Kenyon, 2024).

### Project recommendations include:

- **Increased government support for financing and training**
- **Pressuring the heavily subsidized powdered milk sector to use a portion of profits to support capacity strengthening in the domestic dairy sector**
- **Collective organizing of mini-dairies to pool influence and resources**
- **Leveraging media such as television, phone, and radio to share food safety messaging rather than relying on formal extension training.**



## Women in Food Safety Systems

Since its inception, FSIL sought to engage and empower women in projects to increase access to safe, nutritious diets. Globally, women are significant contributors to food production, processing, and preparation, and are thus integral to preventing the spread and growth of food pathogens in value chains. They compose 50% of the agrifood system workforce in sub-Saharan Africa and 43% in Southeast Asia (FAO, 2023) yet have less access than men to land, technology, financial services, training opportunities, and markets. To address this, FSIL's projects centered women in the design of research, capacity building, and policy activities to reflect their position as key stakeholders among producers and consumers. Projects conducted surveys to understand gendered food production roles, attitudes, and knowledge of food safety and provide tailored, science-based food safety training to women. Many projects employed a dedicated gender specialist to lead these efforts.

**Across projects, survey results demonstrated the crucial roles women play in value chains including fish, dairy, chicken, and produce as well as in household food purchase decision-making and meal preparation.** In alignment with previous research, projects found that women often lacked the resources, opportunities, and monetary influence of their male counterparts. Women were receptive to food safety training and are well positioned to improve food safety through private sector and household roles. **Based on FSIL project results, prioritizing women's participation in food safety discussions and activities through strategic capacity strengthening is key to increasing their access to food safety resources, training, and market opportunities.**

### Bangladesh

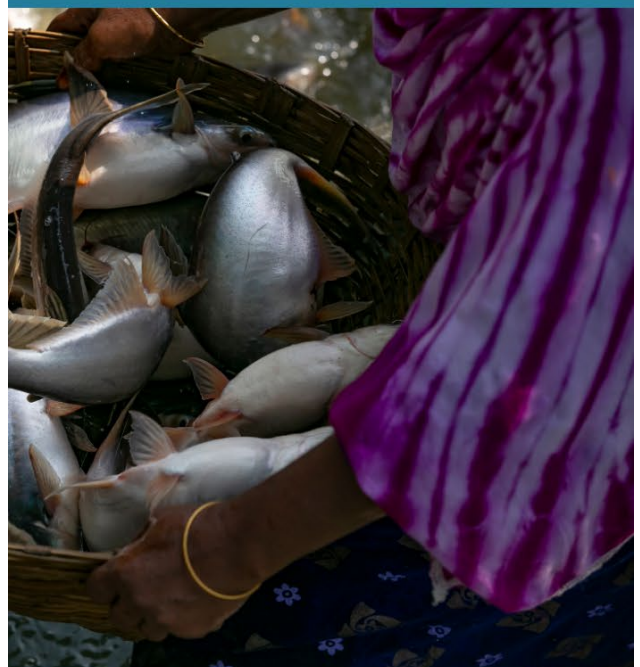
Fish is among the most important and affordable animal-based protein sources in the Bangladeshi diet, with women impacting the supply of and demand for safe fish both as producers and through their purchasing decisions at market. The project integrated two gender-focused research components to address the intersection of women and fish safety through surveys and focus groups to understand women's food safety knowledge, attitudes, and practices; gender norms; unpaid working hours; and willingness to pay (WTP) for safer fish. Previous research showed that women in Bangladesh faced challenges due to gender norms that imposed a double burden of agricultural and domestic work while having inadequate access to resources and assets (Ferrant et al., 2014; Rahman et al., 2019). To build upon this work, the project surveyed 110 female fish producers in Mymensingh Division. **The results showed that although 86% of women had favorable attitudes towards food safety and safe fish production, 85% had not received any aquaculture training.** Unsurprisingly, due to lack of training, 30-40% of women were unaware of GAqPs. The survey also investigated unpaid working hours, finding that female fish



“Women have a role in all activities of fish farming, but they have no decision-making power. Women have a great opportunity to contribute more to safe fisheries, but they must be given that opportunity.”

-Samina Luthfa, Bangladesh long-term subaward  
gender specialist

Photo credits: Rahat Mahfuz & Allison  
Joyce/Far on Foot



producers work an average of 2.4 unpaid hours per day. **These results confirmed that despite their contributions, women rarely or never contributed to decision-making related to management of the fish farm, such as buying land for fish production.**

In addition to surveying female producers, the project hosted eight focus group discussions in seven towns to capture qualitative data and interact face-to-face with female consumers. The focus group discussions further elucidated household gender roles, showing that women were often tasked with buying fish and other foods, cleaning, and cooking, but they almost never made decisions about land purchases or household expenditures. **Women indicated in discussions that they would be willing to pay more for safer fish to ensure the health of their family members, but they had difficulty identifying safe fish in the marketplace and may need additional money to afford it. Female consumers' understanding of food safety was limited to visible qualities of fish, and they were unfamiliar with foodborne pathogens and chemical hazards, such as heavy metals and antibiotic residues.** Based on these results, the project recommended that government agencies actively engage women in future aquaculture and food safety training and that the government improve communication and dissemination of GAQPs. **Female consumers also stated that they did not trust local retailers to provide safe fish or accurate information about safety, indicating an opportunity for the government to enforce regulations that improve safety and to certify products that meet safety standards.** Anecdotally, the project hired and trained a female fish producer to raise fish using GAQP to meet the microbiology and food safety economics project objectives; after receiving GAQPs training, she informally and enthusiastically taught other local women, who were very receptive to the training. The research findings on gender and food safety in the aquaculture sector were presented at FSIL's 2024 webinar on engaging and empowering women to strengthen food safety (Luthfa, 2024) and at the Aquaculture America conference (Mandal et al., 2024). They will be more widely disseminated through peer-reviewed publications which are in preparation for submission in FY2025.

## **Cambodia**

The project engaged women in Cambodia's vegetable value chain through leadership training and research to better understand the demands on female vegetable producers' time, which would impact their ability to attend food safety trainings and implement food safety practices. The team piloted a leadership and food safety workshop designed to empower female farmers to collaborate and take collective action to strengthen food safety in their communities in Battambang and Siem Reap provinces. Prior to the workshops, a month-long virtual "train the trainer" course was used to mentor in-country co-trainers, comprised of Cambodian university students majoring in food science and technology at the Royal University of Agriculture and the Institute of Technology of Cambodia. During the day-long workshops, 27 female vegetable farmers and staff members from Banteay Srei, a local nonprofit focused on women's self-empowerment, worked together to identify their personal strengths and conduct risk assessments of the vegetable value chain, learning how their leadership and collective action can improve food safety in their communities. The workshop revealed that although the women felt a great responsibility for producing safe vegetables, this was their first experience with interactive training where self-discovery and leadership were used to empower them to take action to improve vegetable safety for their communities. Workshop organizers noted that the participants came away with a better understanding of the vital role they play in collaborating with downstream value chain actors to ensure consumers receive a safe end product.

Researchers also sought to better understand how female vegetable producers' labor responsibilities and time were distributed, as adopting food safety practices can present an additional time burden. **Results from semi-structured interviews illustrated that women spent more time on hiring labor, managing money, harvesting, cooking, and childcare and less time on land preparation and equipment maintenance. One factor that impacted women's distribution of time and labor was the type and level of familial support, particularly the contributions of husbands and extended family, which can influence women's access to professional and social spaces.** In addition, their individual perceptions about opportunity impacted their participation in agricultural education programs. **For example, women did not believe they had opportunities to join agriculture training programs unless they individually received an invitation, so posting a callout flyer in a public spot about a food safety workshop would likely have little success in encouraging women's participation. The findings suggest that future food safety projects should consider the gendered distribution of farm tasks when identifying the best audiences for training programs, i.e., projects that focus more on safe harvesting practices are more likely to engage women. They should also extend personal invitations to women for**

**training opportunities and reduce barriers to engagement, for example by offering the same workshop at multiple times to accommodate diverse schedules.** These findings and recommendations align with conclusions from previous USAID projects and were shared at FSIL's 2024 webinar on engaging and empowering women to strengthen food safety (Thompson, 2024) and will also be further shared through peer-reviewed publications that are in preparation for submission in FY2025.

## Nepal

The project sought to understand women's decision-making roles and food safety knowledge as consumers, and training needs as producers of fresh fruits and vegetables. The team conducted 604 surveys among households from five metropolitan areas. **In households, women were the dominant decision-makers for what and where to buy fresh produce (83%), and they decided what to prepare, cook, or eat in 73% of households. In addition, women are increasingly responsible for managing farms, particularly as more men in Nepal move abroad or to cities for off-farm employment opportunities. Despite their significant role across the food system, women were found to be less aware of some food safety issues than men and to have fewer opportunities for food safety training.** The team shared these results through a publication in the *Nepal Public Policy Review* (Khanal et al., 2023a); conference presentations at the 2023 annual CGIAR gender research conference (Khanal et al., 2023c; McGuire et al., 2023) and *Agricultural Policies and Practices in Nepal: Pathways for Transformation* (Khanal et al., 2023b); and a national policy consultation on fresh produce safety (Nepal Food Scientists and Technologists Association et al., 2024). The team's primary recommendation from the research was to prioritize women's access to food safety training programs. They implemented the recommendation through five trainings on food safety practices for growing fresh fruits and vegetables, which they conducted for producers and extension agents in four provinces of Nepal. Of the 341 total participants, 53% were women.

## Nigeria

To document the lived experiences of mothers in providing safe, nutritious foods for their families, the project used a citizen science approach: the *Our Voice* Discovery Tool mobile application (Buman et al., 2013). Participants included 55 mothers of children under the age of five living in five municipal Local Government Areas in Ibadan Metropolis, Nigeria, including both low and high wealth index categories of mothers. After initial training in food safety awareness and use of the app, they received daily prompts for five days to provide photos and notes on facilitators and barriers to safe food.

The data showed that facilitators of food safety practices included access to resources, equipment, and basic amenities, such as covered plastic containers and freezers with a reliable power supply; access to hygienic markets and food vendors; personal values, practices, and strategies such as handwashing before meal preparation; close proximity between food preparation and consumption areas; and non-shared food preparation areas, i.e., non-communal living. Barriers included lack of access to resources, equipment, and basic amenities, such as intermittent power supplies and dedicated cooking and eating areas; infestations of rodents, insects, and other pests; communal living spaces; lack of food safety practices among vendors of ready-to-eat foods and in markets; lack of convenient access to water for handwashing; and environmental factors such as nearby household municipal waste sites.

**In subsequent focus group discussions, the mothers identified five priorities for intervention:**

- **Provision of essential community amenities and routine building inspection**
- **Public sensitization on safe food and hygienic practices**
- **Food safety education for vendors of raw and cooked food**
- **Enforcement of regular environmental sanitation practices**
- **Multifaceted stakeholder involvement in promoting safe food practices**

These recommendations were shared with public health and food system stakeholders in a July 2024 meeting to inform future efforts to improve food safety and mitigate foodborne illness among families with young children. The methods and findings were also shared at FSIL's 2024 webinar on engaging and empowering women to strengthen food safety (Samuel, 2024). Overall, the use of the *Our Voice* Discovery Tool was effective in engaging women in documenting their lived experiences and empowered them to identify food safety risks and provide context-specific information that could be overlooked by researchers. It also facilitated peer-to-peer learning as participants shared their values, strategies, practices, and experiences related to food storage, preservation, and hygiene.

## Kenya

Small-scale poultry farming is a significant source of income for many rural and peri-urban households in Kenya and contributes to household food security and nutrition. However, when poultry products are contaminated with foodborne pathogens, they pose a risk to producers, processors, and consumers. FSIL's Kenya Phase I project evaluated gender roles in poultry production to better understand the different food safety risks faced by men, women, and youth and to develop strategic trainings and interventions to mitigate risk. **A literature review conducted by the project determined that women were the primary owners of poultry in Kenya and were most often responsible for poultry-rearing activities, even when men were considered the landowners of a farm (Garsow et al., 2022).**

The project built on the knowledge gained from the literature review by conducting surveys with 246 women and youth smallholder poultry farmers in Kiambu County, Kenya. **The surveys found that key activities performed by women included purchasing chicks, watering and feeding chicks, cleaning the poultry houses, and veterinary care.** On-farm poultry processing (slaughter) prior to sale was typical. Young men (18-35 years) were primarily responsible for slaughtering activities, followed by older women (greater than 35 years) and older men (greater than 35 years). **Women also were often responsible for financial decisions regarding poultry, such as when to purchase chicks, when to sell the chickens, and how to spend the income generated by sales.**

While women were found to dominate poultry production activities and decision-making, men had greater roles in transportation, trading, and brokering, which gave them more influence over price and market access. The results of this research are currently being prepared for publication in peer-reviewed journals. In addition, the findings will be used to inform ongoing Kenya Phase II work to assess the prevalence of *Salmonella* and *Campylobacter* in the poultry value chain and future trainings on safer poultry production and processing practices. The knowledge gained from the gender analysis will be used to adapt trainings for the appropriate audiences, with particular attention to the inclusion of women in training about on-farm activities.



“Poultry production in Kenya is more than a livelihood; it empowers women and youth, driving income, food security, and community development. Women, often at the forefront of poultry farming, manage critical tasks from chick purchasing to financial decisions, playing a transformative role in rural economies. Their leadership ensures that households thrive, fostering resilience and growth within the poultry value chain.”

-Abdiiaziz Beinah, Kenya long-term phase I and phase II subawards doctoral student  
Photo credit: Far on Foot/Davina Leonard



## Demand for Safe and Affordable Food

Producers can be motivated to adopt safe food production practices by sufficient consumer demand for safe food, the economic viability of food safety practices, and government support through the enforcement of food safety policies and regulations. FSIL's projects in Bangladesh, Cambodia, and Nepal assessed consumer demand for safe food by conducting consumer willingness-to-pay (WTP) studies. The economic viability of safer production practices was addressed through studies of producers' willingness to accept higher costs of production and by tracking the cost of implementing safe food production practices versus standard practices.

Research in these three countries demonstrated the **demand for food safety**, as evidenced by consumers' willingness to pay a price premium for safer food and producers' willingness to adopt safer production practices. **These results also suggested that increased consumer awareness of food safety could create demand, spurring the supply side to offer products with higher levels of food safety.** However, many stakeholders expressed that government intervention would be required to ensure all people have access to safe food regardless of their ability to pay for it. Policy investments in food safety should carefully consider potential unintended consequences on lower-income consumers and focus on improving food safety across the food system to benefit all consumers.

### Bangladesh

A key driver for private sector adoption of Good Aquaculture Practices (GAQPs) is consumer demand, indicated by their WTP higher prices to offset the costs of interventions such as water quality monitoring, hygiene, temperature control after harvest, and documentation. An experimental auction method was used to estimate consumer WTP for safer tilapia, pangasius, and rohu fish. **Without information on specific safety attributes or production practices, participants were on average willing to pay 29% more for tilapia, 21% more for rohu, and 10% more for pangasius produced using GAQPs compared to traditional methods, which reflects the benefit of GAQPs on quality characteristics observed by consumers.**

**After receiving information about the production practices used and product contamination levels, participants' WTP for fish produced using GAQPs increased to 52% for tilapia, 39% for pangasius, and 34% for rohu.** Consumers of all income categories were willing to pay a significantly higher price for safer fish. Among low-income consumers, women exhibited a higher WTP for safer fish compared to their male counterparts and were more sensitive to information about contamination levels. **The data show that product safety information influences consumers' WTP and suggest that food safety certification and labeling could drive demand for safer fish.**

**In pond trials to determine how the adoption of GAQPs would affect production costs, the per unit cost of production did not increase with the adoption of GAQPs, yet the per unit selling price was higher for fish produced using GAQPs, resulting in higher profit.** Fish feed is one of the most expensive inputs for fish farmers, but the use of fewer feed additives dictated by GAQPs can reduce the cost of commercial feed production, resulting in lower feed expenses for farmers. GAQPs also resulted in larger fish yields, which reduced the per-unit production costs.

This research was published in *Aquaculture Economics & Management* (Dey et al., 2024a) and shared at the 3<sup>rd</sup> Biennial International Conference of the Fisheries Society of Bangladesh (Dey et al., 2024b); the 6<sup>th</sup> National Scientific Conference on Food Safety and Health (Rahman et al., 2024b); the 68<sup>th</sup> Annual Conference of the Australasian Agricultural and Resource Economics Society (Rahman et al., 2024a); Aquaculture America (Dey et al., 2023; Khushi et al., 2024; Rahman et al., 2024c); and FSIL's 2024 webinar on social behavior change in food safety (Dey, 2024). **Two key recommendations resulting from the research were for the private sector fish feed industry to increase production of feed that is free from harmful additives, more affordable for farmers, and more profitable for the feed company and for government agencies to develop GAQPs certification programs and trainings for farmers.** The research team has encouraged uptake of these recommendations through engagement with the feed industry, including partnering with a feed company to produce the feed used in the pond trial; developing a training manual for farmers to increase awareness and adoption of GAQPs; and engaging the Department of Fisheries and Bangladesh Food Safety Authority on development of additional training resources and certification programs to better meet consumer demand for safer fish.

## Cambodia

Over the past decade, the Cambodian government and international organizations have introduced certification mechanisms to assure food safety and quality, including USDA Organic certification and CamGAP certification, Cambodia's Good Agricultural Practices standard offered by the Government Directorate of Agriculture. CamGAP adoption among vegetable producers has been slow, and consumers' WTP for certified products and valuation of different certification mechanisms was unknown. An experiment was conducted with 585 shoppers at ten traditional markets and eight supermarkets in Phnom Penh to estimate consumers' WTP for certified products and the effect of providing information about the certification process. **On average, consumers were willing to pay a premium of 100% for USDA organic-certified cucumbers and of 55% for CamGAP-certified cucumbers compared to the traditional, non-labeled cucumbers. The findings indicate that there is a market for certified foods in Cambodia, but there is higher trust in or awareness of the USDA Organic certification mechanism compared to CamGAP certification. The research suggests that consumer trust in local certification processes may increase through the alignment of local and international safety standards and by increasing consumer awareness of local certification processes.**

In addition, providing information on the certification process through a video about the production processes, certifying authority, monitoring processes, and branding significantly increased consumers' WTP for USDA organic cucumbers at traditional markets. The effect was not observed in supermarket shoppers, who were younger, more educated, and wealthier. **These findings indicate that consumers in traditional markets may be less aware of certifications and the availability of certified products, and additional information located in markets may be beneficial for increasing consumer demand.** This work was shared at the 32<sup>nd</sup> International Conference of Agricultural Economists (Mwambi et al., 2024), and a manuscript will be submitted for peer review in FY2025.

## Nepal

**In surveys of 604 consumer households representing the five major metropolitan areas of Nepal, more than half of consumers perceived labels indicating “safely produced” or “pesticide residual-free” as moderately to very important when selecting produce to purchase. In addition, they were willing to pay a price premium of more than 30% for salad with labels indicating microbial safety or the absence of pesticide residuals.**

Young consumers were also willing to pay a price premium for safer produce. In an economic choice experiment, 224 youth



“Consumers are important actors who can drive positive change in market systems through their demand for safe, nutritious foods. Their purchasing decisions can create demand, impact pricing, and spur the supply side to offer value-added products with sustainable production practices, nutrient enrichment or higher levels of food safety.

Even with limited budgets, consumers in low- and middle-income countries balance priorities such as food type, quantity and quality, including food safety. Understanding and quantifying consumer demand for food safety can provide incentives to producers and to make informed decisions on market development of safer food products.”

-Aditya Khanal, Nepal short-term subaward PI  
Photo credits: Prakash Shrestha/Hallfax Media & Kathacharya Productions



(aged 20-26) were presented with the choice of purchasing a 0.5 kg cucumber packet from four categories, with increasing prices for microbial and chemical safety. **Cucumbers with labels indicating both chemical and microbial safety were chosen 40% more often than the unlabeled cucumbers despite a price premium of 60 Nepalese Rupees. Youth were more likely to choose an option with food safety labeling when they had greater awareness of the importance of food safety or were reminded of it through an informational nudge.** Data from the two surveys indicate that consumers could drive demand for safer food, and price premiums could incentivize growers to adopt safer production practices.

Additional surveys were conducted to assess if Nepali fruit and vegetable producers were willing to accept additional costs to strengthen on-farm food safety practices. **In a survey of 1,052 growers across 10 districts, producers were willing to incur an additional 13% cost to improve food safety. Access to credit and financial support, food safety awareness and education, market access, land ownership, risk perception, and risk mitigation were found to be key considerations to incentivize producers' investment in food safety.**

These results were published in the *Journal of Agribusiness in Developing and Emerging Economies* (Khanal et al., 2024a) and shared at the 2024 Annual Meeting of the Southern Agricultural Economics Association (Timilsina et al., 2024).

When the results of these surveys were shared with Nepali stakeholders at a national policy consultation in April 2024, attendees voiced concerns that increased food prices for safer food would hinder affordability. There was consensus that access to food is a right for all Nepalis, and access to safe food should be a right for all Nepalis as well. While market demand is important and can be an effective incentivization for producers to adopt safer production practices, implementing safe growing practices will raise production costs for producers and market prices for consumers. **Food safety policy development should ensure that policies to improve fresh produce safety consider affordability to all stakeholders.**



The April 2024 national policy consultation on fruit and vegetable food safety, held in Kathmandu, Nepal, was attended by 120 stakeholders representing the fields of food science, nutrition, food systems research, agricultural extension, academia, policy creation, business, farming, and development. Photo credit: Prakash Shrestha/Halfax Media

## Food Safety Capacity Strengthening

Robust capacity to conduct food safety research and outreach enables stakeholders to develop, implement, and support science-based policies and practices that positively impact the wellbeing of consumers. FSIL prioritized equipping local stakeholders with knowledge, skills, and networks to support sustainable progress in food safety systems. Projects engaged academic researchers, graduate students, growers, producers, processors, retailers, consumers, and government officials to strengthen human and institutional food safety competencies. Specific areas of knowledge included gender-sensitive research methods, awareness of food safety risks, microbiology research techniques, experimental design and statistical analysis, social science methodology, analysis of food pathogen transmission, risk assessment, and safe food production methods (e.g., GAPs and GAQPs). Capacity strengthening occurred through graduate student programming, grower and producer training workshops, conferences, and policy consultation workshops that strengthened local and global food safety networks.

**FSIL projects hosted 60 food safety workshops that trained 2,317 stakeholders (56% women), funded 33 graduate students, and created 190 resources to share research findings with stakeholders.** Many stakeholders lacked awareness of food safety risks and/or had greater familiarity with chemical food safety hazards (e.g., pesticide residues) than microbiological hazards. Local capacity strengthening in FSIL projects increased stakeholders' basic food safety and microbiology knowledge, disseminated practices that producers can implement to improve food safety, guided research and intervention priorities, and made modern tools and technologies accessible to researchers. **However, there remains an urgent need for food safety capacity strengthening across all FSIL target countries to train production-level stakeholders, support data-driven food safety policies, increase consumer food safety awareness, and bolster the technical capacity of laboratories and researchers.**

### Bangladesh

Governments are integral partners in affecting sustainable food system change through policy development, resource investment, regulatory support, and stakeholder coordination. Throughout the project, the team prioritized sustained engagement with several government agencies, including the Bangladesh Food Safety Authority, Bangladesh Fisheries Research Institute, and the Department of Fisheries. Based on collaboration between the project and the Bangladesh Fisheries Research Institute, a private feed company trialed the production of safer fish feed tested by the project; likewise, the project collaborated with the Department of Fisheries for guidance on GAQPs. The project also hosted several



“If you want capacity growth that really stands by itself, that’s independent of any specific person, it needs to be growth through people, through capacity development. We need to be training students that can take the baton further.”

-Nora Bello (pictured left), Cambodia long-term subaward co-PI

Photo credits: Marvin Tzirin & Jesse Vipham





dissemination events with government and aquaculture value chain stakeholders. Key dissemination events included:

- July 2022: A sensitization meeting and initial project presentation in Dhaka with 170 participants, including government officials, academics, and farmers.
- March 2023: A demonstration event in Muktagacha, showcasing pond trial results to over 20 fish entrepreneurs and government dignitaries.
- May 2024: A concluding dissemination event in Dhaka with 150 attendees, leading to recommendations for adopting standard GAQPs and incorporating them into Bangladesh's 9th Five-Year Plan, currently under development by the National Planning Commission.

In addition to government engagement, the project supported nine master's students and two Ph.D. students. Ten researchers, students, and lab technicians also received 40 hours of specialized microbiology training.

## Cambodia

Graduate student and research training is an essential part of building local capacity, as it equips the next generation of researchers and professionals with knowledge and practical expertise to support the long-term success and resilience of institutions and communities. The Cambodia project's capacity-building initiatives were particularly impactful, involving 304 participants across 13 events; 70% of participants were women. The training sessions covered a range of scientific and professional skills, including survey development, qualitative research methods, experimental design, statistical analysis, scientific writing, and Whole Genome Sequencing. Support was provided to five graduate students, including three Cambodian master's students and two U.S. students (M.S./Ph.D.) now positioned for leadership in food safety research. The project also sponsored four students to attend International Association for Food Protection (IAFP) conferences in 2023 and 2024, professional development opportunities which expanded their knowledge of cutting-edge food safety research and their global network of colleagues. Given Cambodia's progress in implementing food safety regulations, it is important to continue developing the next generation of food safety scholars to conduct rigorous, impactful research to support data-driven food safety policies and practices.

## Kenya

Research centered on local priorities is better positioned to support sustainable and scalable food safety solutions. Leveraging this approach, the Kenya Phase I project held a risk ranking workshop in 2022 that engaged smallholder poultry farmers, local veterinary experts, government representatives, and academics to discuss food safety risks and interventions for evaluation to improve the safety of the poultry value chain. Of the thirty participants who attended the workshop, 60% were women. The project team first introduced the concept and process of risk ranking and explained potential interventions to reduce the risk of foodborne disease. The stakeholder participants then agreed on factors that would be used to evaluate and rank the risks and interventions in breakout groups before coming to consensus. Factors included risks to human health, potential to reduce contamination from foodborne pathogens (including *Salmonella* and *Campylobacter*), impact on women and youth, and farmer and consumer acceptability and affordability. Ultimately, the group identified improved carcass handling and training on slaughter practices as practical priorities for intervention. The risk-ranking workshop strengthened the local network of poultry stakeholders, creating strong ties between farmers and researchers. From this risk prioritization workshop and other work, the project is developing a manual and training program to teach farmers food-safe slaughter practices. Two master's students and one Ph.D. student supported by the project also attended the workshop, which built their knowledge and capacity to lead research prioritization efforts in the future.

## Nepal

The project focused on capacity-strengthening efforts that supported producer training and fostered government engagement. One of the project's key capacity-strengthening efforts was the delivery of comprehensive GAPs training programs to improve stakeholders' knowledge of safe growing practices for fresh produce. The five workshops engaged 341 fresh produce growers and extension workers across four provinces, with women representing 53% of participants. Based on feedback received at the training sessions and research from the project, a GAPs manual emphasizing microbial food safety was developed for produce growers and extension workers (Kilonzo-Nthenge et al., 2024). Over 500 printed copies have been distributed, and the manual is publicly accessible online. The manual provides knowledge essential to identifying risks and offers practical guidelines to implement practices that reduce the spread of foodborne pathogens on farms. A Nepali translation of the manual will be available in FY2025.

The project also engaged 120 participants, including government representatives, academics, farmers, distributors, private sector actors, and civil society organizations in a national policy consultation in April 2024. The workshop, held in collaboration with the Nepal Food Scientists and Technologists Association, disseminated the project's findings and fostered dialogue to sustain momentum on produce safety. A post-workshop report was prepared for dissemination to government officials and other stakeholders to share collective recommendations and continue dialogue between FSIL and the government of Nepal (Nepal Food Scientists and Technologists Association et al., 2024). By strengthening local food safety capacity in the produce value chain through education on microbial contamination and the importance of good practices, the project not only supported immediate improvements but also aligned with the Nepal government's implementation of the 2024 Food Hygiene and Quality Bill, helping to shape future food safety policy.

## Nigeria

The project's capacity-strengthening activities enabled researchers to assess household food safety using portable, ready-to-use microbiology tests. FSIL developed a private-sector partnership with Neogen, a U.S.-based food safety testing company. Neogen supplied researchers with materials for food safety analyses including adenosine triphosphate (ATP) detection swabs and dehydrated *E. coli* and coliform enumeration plates to survey household kitchen surfaces for indicators of microbial contamination. The ready-to-use materials were portable (about the size of a pen or notecard) and easy to store, transport, and use in the field. These are important factors in making food safety testing more accessible to researchers and private sector users in resource-limited environments. Ready-to-use microbiology materials are particularly beneficial in low- and middle-income countries because they fully eliminate or significantly reduce the need for a dedicated laboratory space, sterilization equipment, and sterile lab consumables. U.S.-based Neogen staff used video conferencing to conduct a hands-on workshop to prepare nine laboratory technicians to use the swabs and plates. This partnership not only enabled the project to efficiently and accurately assess household food safety risks, but it also allowed both parties to learn from and engage with each other on food safety research challenges specific to resource-limited environments.

## Senegal

Senegal's supply chain of small farms, aggregation sites, artisanal processing facilities, and transport from rural areas to urban centers creates challenges for protecting the microbial quality and safety of dairy products and can lead to the spread of foodborne pathogens including *E. coli*, *Listeria monocytogenes*, and *Salmonella*. Over the past three years, the project provided food safety training for 164 small-scale dairy producers and processors in the Matam, Saint-Louis, and Louga regions of Senegal and the capital city of Dakar. The initial workshops addressed food safety challenges with an introduction to microbiology, sanitation, and product and process controls and a presentation on gender and youth in the dairy value chain. The focus was on immediate, practical knowledge and practices that the private sector can apply to improve both the safety and quality of their products, such as excluding milk from cows with mastitis and consistent use of refrigeration at aggregation locations where milk is held before transport or processing. The most recent training was held in April 2024 at the Institut de Technologie Alimentaire (ITA) to train 12 female dairy processors in practices to protect their products' safety and quality, including sanitation, hygiene, pasteurization, and new product development. By targeting food safety knowledge gaps, raising food safety awareness, and delivering food safety training, the program empowered producers and processors to contribute to a safe local milk supply that not only supports food security and nutrition but also creates economic opportunity.

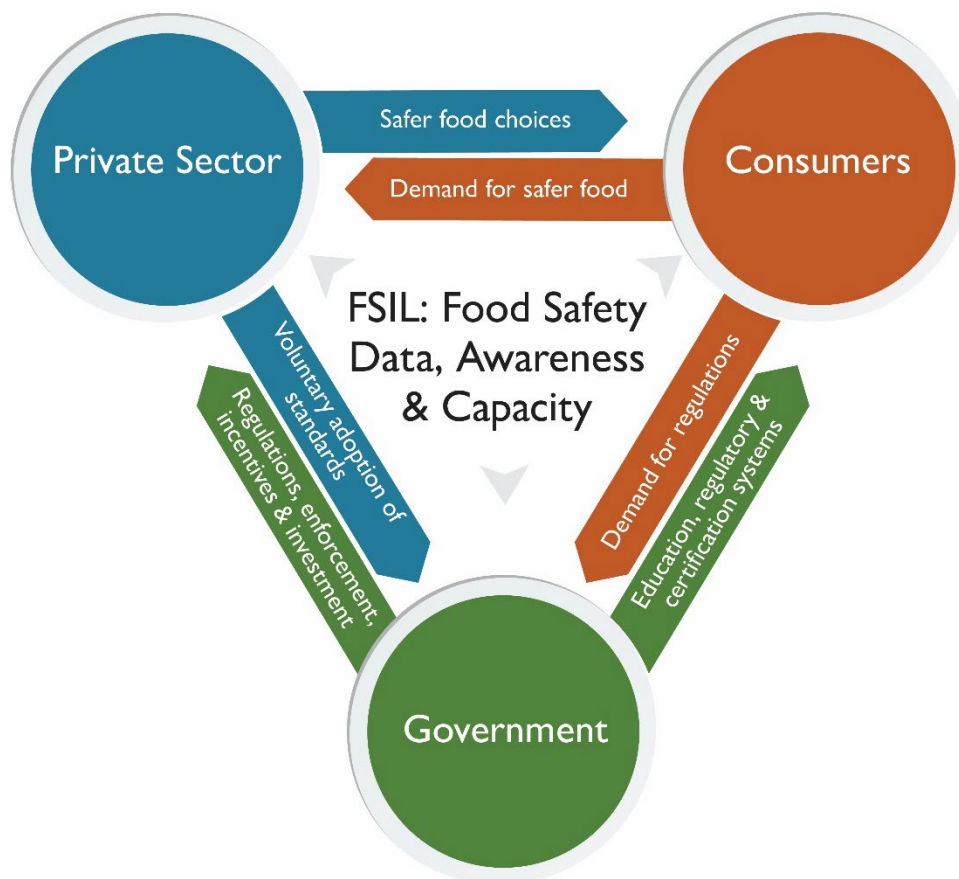
In addition to private sector capacity strengthening in food safety practices, the project has strengthened local food safety research capacity. The project held training workshops about survey enumeration, gender research, and microbiology laboratory skills, such as pathogen detection in milk using culture and polymerase chain reaction methods, for 87 participants. The project has also trained four master's degree students and one Ph.D. candidate. By enhancing dairy research capacity in Senegal, researchers are better equipped to develop and advocate for science-based policies and practices that support dairy producers and processors in reducing the transmission of foodborne pathogens.

## FURTHER CHALLENGES AND OPPORTUNITIES

The Food Safety Innovation Lab was awarded a five-year extension through June 24, 2029, to build on the successes and learnings from the first five-year phase. During the second five-year phase, FSIL will focus on two objectives to strengthen food safety systems: (1) increasing food safety awareness by identifying data-driven behavioral levers that increase the demand for safer food and (2) supporting evidence-based policy formulation.

Food safety systems are composed of entities (government, consumers, the private sector), regulations, infrastructure, and services that collectively protect a food supply from biological, chemical, and physical agents that harm people. Each entity influences the other two through unique levers, such that all entities have the opportunity to strengthen (or weaken) the food safety system (Figure 3). During Phase II, FSIL will conduct research that fills key evidence gaps, increases food safety awareness, and builds capacity to motivate consumer, government, and private sector action that strengthens food safety systems. The research will increase consumer awareness of and demand for safer food, empower governments to generate and use food safety data, and motivate the private sector to adopt safe food production practices.

Figure 3. Levers for government, consumers, the private sector, and FSIL to strengthen food safety systems



To focus resources and efforts, the geographic focus for the second phase will narrow to Cambodia, Kenya, and Nepal. These three countries have food policy landscapes well positioned for food safety progress but face gaps in consumer awareness of and demand for safer food; producer and vendor education in safe food production practices; recognition of food safety as a public health priority; and food safety surveillance and enforcement infrastructure.

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## APPENDIX: PROJECT COLLABORATORS, ROLES, AND INSTITUTIONS

### Bangladesh Long-Term

Researcher	Role	Institution
Dey, Madan	PI	Texas State University
Rahman, Mohammad Saidur	In-country lead, Co-PI	Bangladesh Agricultural University
Luthfa, Samina	Co-PI, Gender specialist	University of Dhaka
Alim, Md. Abdul	Co-PI	Bangladesh Food Safety Authority
Khan, Md. Akhtaruzzaman	Co-PI	Bangladesh Agricultural University
Nazir, KHM Nazmul Hussain	Co-PI	Bangladesh Agricultural University
Sudhakaran, Pratheesh	Co-PI	Texas State University

### Bangladesh QuickStart

Researcher	Role	Institution
Vijayaraghavan, Kannan	PI	Sathguru, Inc. USA
Chaitanya, Srirama	Project manager	Sathguru, Inc. USA
KV, Satyanarayana	Co-PI	Sathguru, Inc. USA

### Cambodia Long-Term

Researcher	Role	Institution
Ebner, Paul	PI	Purdue University
Vipham, Jessie	PI	Kansas State University
Hok, Lyda	In-country lead, Co-PI	Center of Excellence on Sustainable Agricultural Intensification and Nutrition (CE SAIN)
Sieng, Sreymom	Co-PI, Gender specialist	Royal University of Agriculture
Bello, Nora	Co-PI	The Ohio State University
Chrun, Rithy	Co-PI	Royal University of Agriculture
Dudley, Edward	Co-PI	Pennsylvania State University
Gregerson, Katheryn	Project coordinator	Kansas State University
Kovac, Jasna	Co-PI	Pennsylvania State University
Peng, Chanthol	Co-PI	Institute of Technology Cambodia
Ramasamy, Srinivasan	Co-PI	World Vegetable Center
Sreng, Navin	Co-PI	Institut Pasteur du Cambodge
Trinetta, Valentina	Co-PI	Kansas State University

### Cambodia QuickStart

Researcher	Role	Institution
Vipham, Jessie	PI	Kansas State University
Hok, Lyda	In-country lead, Co-PI	Center of Excellence on Sustainable Agricultural Intensification and Nutrition (CE SAIN)
Trinetta, Valentina	Co-PI	Kansas State University



## COVID-19 Buy-In

Researcher	Role	Institution
Wiedmann, Martin	PI	Cornell University
Demmings, Beth	Project manager	Cornell University
Trmčić, Aljoša	Subject matter expert	Cornell University

## Kenya Long-Term Phase I

Researcher	Role	Institution
Kowalcyk, Barbara	PI	The Ohio State University*
Onsare, Robert	In-country lead, Co-PI	Kenya Medical Research Institute (KEMRI)
Colverson, Kathleen	Co-PI, Gender specialist	University of Florida
Buffer, Janet	Project manager	The Ohio State University
Havelaar, Arie	Co-PI	University of Florida
Ilic, Sanja	Co-PI	The Ohio State University
Kariuki, Sam	Co-PI	Kenya Medical Research Institute (KEMRI)
Kunyanga, Catherine	Co-PI	University of Nairobi
Morgan, Kara	Co-PI	The Ohio State University
Scharff, Robert	Co-PI	The Ohio State University
Wright, Nasandra	Project manager (previous)	The Ohio State University
Yousef, Ahmed	Co-PI	The Ohio State University

\*Barbara Kowalcyk is now based at George Washington University

## Kenya Long-Term Phase II

Researcher	Role	Institution
Kunyanga, Catherine	PI	University of Nairobi
Onsare, Robert	PI	Kenya Medical Research Institute (KEMRI)

## Nepal Short-Term

Researcher	Role	Institution
Khanal, Aditya	PI	Tennessee State University
Timilsina, Ram Hari	In-country lead, Co-PI	Agriculture and Forestry University
Rijal, Sramika	Co-PI, Gender specialist (2022)	Agriculture and Forestry University
Gurung, Rita	Co-PI, Gender specialist (2022-2024)	Agriculture and Forestry University
Basnet, Hom B.	Co-PI	Agriculture and Forestry University
Kilonzo-Nthenge, Agnes	Co-PI	Tennessee State University
Mishra, Ashok K.	Co-PI	Arizona State University
Pal, Puskar B.	Co-PI	Agriculture and Forestry University
Poudel, Saroj	Co-PI	SAHAVAGI
Shrestha, Arjun K.	Co-PI	Agriculture and Forestry University

### Nigeria Short-Term

Researcher	Role	Institution
Bersamin, Andrea	PI	University of Alaska Fairbanks
Otegbayo, Bolanle	In-country lead, Co-PI	Bowen University
Aluko, Olufemi Oludare	Consultant for Bowen University	Obafemi Awolowo University
Areola, Abiodun Ayooluwa	Consultant for Bowen University	University of Ibadan
Atoloye, Abiodun	Co-PI	Utah State University (formerly University of Connecticut)
Bamgbade, Bunmi	Project manager	
Samuel, Folake Olukemi	Consultant for Bowen University	University of Ibadan
Torimiro, Nkem	Consultant for Bowen University	Obafemi Awolowo University

### Senegal Long-Term

Researcher	Role	Institution
Singh, Manpreet	PI	University of Georgia
Ndiaye, Cheikh	In-country lead, Co-PI	Institut de Technologie Alimentaire (ITA)
Marter-Kenyon, Jessica	Co-PI, Gender specialist	University of Georgia
Abebe, Woubit	Co-PI	Tuskegee University
Belko, Marième Niang	Co-PI, Gender specialist	Institut Sénégalais de Recherches Agricoles (ISRA)
Collins-McMaken, Victoria	Co-PI	University of Georgia
Diallo, Younoussa	Co-PI	Institut de Technologie Alimentaire (ITA)
Faraj, Rawah	Co-PI	Tuskegee University
Leone, Courtney	Technical expert	University of Georgia
Thiam, Mamadou Bocar	Co-PI	Institut Sénégalais de Recherches Agricoles (ISRA)
Thiam, Momar	Co-PI	Conseil National de Développement de la Nutrition
Thippareddi, Harshavardhan	Co-PI	University of Georgia

### Senegal QuickStart

Researcher	Role	Institution
Bauchet, Jonathan	PI	Purdue University
Sarr, Ibrahima	In-country lead, Co-PI	Institut Sénégalais de Recherches Agricoles (ISRA)