FEED THE FUTURE
The U.S. Government's Global Hunger & Food Security Initiative

FY2023 ANNUAL REPORT

FEED THE FUTURE INNOVATION LAB FOR FOOD SAFETY

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PURDUE UNIVERSITY

Cornell University

Feed the Future
Innovation Lab for Food Safety (FSIL)

Annual Report
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Management Entity

The Feed the Future Innovation Lab for Food Safety (FSIL) is jointly managed by Purdue and Cornell Universities. The management entity (ME) provides technical leadership that guides 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 leverage 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

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Purdue University

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**Technical Expert through May 1, 2023, when he began a new position at The Pennsylvania State University*

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Dr. Martin Wiedmann
Gellert Family Professor in Food Safety
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Advisory Committee

The FSIL Advisory Committee is critical to meeting the Innovation Lab's goal of reducing the burden of foodborne disease and strengthening the food safety of nutrient-dense foods through transformative partnerships across academic, public, and private sectors. The management entity relies on Advisory Committee members to counsel FSIL on research priorities, represent FSIL in various capacities, and serve as a resource and support for FSIL research subaward processes.

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

Bob Baker
Senior Food Safety Advisor
World Food Programme

Betsy Baysinger
Director, Trade and Scientific
Capacity Building Division
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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.
Global Food Safety Initiative Board Member

Where the Innovation Lab Works

The Food Safety Innovation Lab maintains four long-term projects in its initial focus countries of Bangladesh, Cambodia, Kenya, and Senegal and two two-year projects in Nepal and Nigeria.

List of Program Partners

U.S.	Arizona State University
	Cornell University
	Kansas State University
	Purdue University
	Tennessee State University
	Texas State University
	The Ohio State University
	The Pennsylvania State University
	Tuskegee University
	University of Alaska Fairbanks
	University of Florida
	University of Georgia
	Utah State University
Bangladesh	Bangladesh Agricultural University
	University of Dhaka
Cambodia	Center of Excellence on Sustainable Agricultural Intensification and Nutrition
	Institut Pasteur du Cambodge
	Institute of Technology Cambodia
	Royal University of Agriculture
	World Vegetable Center
Kenya	Kenya Medical Research Institute
	University of Nairobi
Nepal	Agriculture and Forestry University
	SAHAVAGI
Nigeria	Bowen University
	Obafemi Awolowo University
	University of Ibadan
Senegal	Conseil National du Développement de la Nutrition
	Institut de Technologie Alimentaire
	Institut Sénégalais de Recherches Agricoles

Acronyms

AoI	Area(s) of Inquiry
AFU	Agriculture and Forestry University
AOR	Agreement Officer's Representative
ATP	Adenosine Triphosphate
BFRI	Bangladesh Fisheries Research Institute
CE SAIN	Center of Excellence on Sustainable Agricultural Intensification and Nutrition (Cambodia)
COM-B	Capability, Opportunity, Motivation-Behavior
COVID-19	Coronavirus Disease 2019
DDL	Development Data Library
DNA	Deoxyribonucleic Acid
EMMP	Environmental Mitigation and Monitoring Plan
FAO	Food and Agriculture Organization of the United Nations
FGD	Focus Group Discussions
FS	Food Safety
FSIL	Innovation Lab for Food Safety
FSWG	Food Safety Working Group (Nepal)
FY	Fiscal Year
GFSS	Global Food Security Strategy
IAFP	International Association for Food Protection
IBC	Institutional Biosafety Committee
IPC	Institut Pasteur du Cambodge (Cambodia)
IR	Intermediate Result
IRB	Institutional Review Board
ISRA	Institut Senegalais Recherches Agricoles (Senegal)
ITA	Institut de Technologie Alimentaire (Senegal)
ITC	Institute of Technology Cambodia
KAP	Knowledge, Attitudes, and Practices
KEMRI	Kenya Medical Research Institute
ME	Management Entity
MEL	Monitoring, Evaluation, and Learning
MS	Master of Science
MSI	Minority Serving Institution
NGO	Non-governmental Organization
OSU	The Ohio State University
PCR	Polymerase Chain Reaction
PhD	Doctor of Philosophy
PI	Principal Investigator

RFA	Request for Applications
RUA	Royal University of Agriculture (Cambodia)
TOC	Theory of Change
TCC	Total Coliform Count
TSC	Total *Salmonella* Count
TVC	Total Viable Count
USAID	United States Agency for International Development
WGS	Whole Genome Sequencing
WP	Work Plan
WTP	Willingness to Pay

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Executive Summary

In FY2023, the Feed the Future Innovation Lab for Food Safety (FSIL) subaward projects in Bangladesh, Cambodia, Kenya, Nepal, Nigeria, and Senegal made significant progress in data collection to better understand microbial food safety challenges in each focus country, analyze the roles and opportunities for women in food safety and in different food value chains, and identify appropriate food safety interventions. All projects entered their final year of activities (year three for long-term subawards in Bangladesh, Cambodia, Kenya, and Senegal and year two for short-term subawards in Nepal and Nigeria) and many have started to analyze data and disseminate results. In FY2023, FSIL subaward projects published nine peer-reviewed journal articles, gave seven conference presentations, and hosted workshops and training sessions for producers, extension agents, government stakeholders, and the private sector.

Local capacity strengthening continued to be a priority area for the FSIL Management Entity (ME) and all subaward projects. A total of 29 graduate students have received support from FSIL to date, including 21 female students. Ten of the graduate students have now completed their degrees. The FSIL ME supported three graduate students to attend the International Association for Food Protection (IAFP) annual meeting in Toronto, Canada to engage with the most current and groundbreaking food safety research and network with leading global food safety experts. Short-term trainings were held on survey enumeration, statistics and data analysis, microbiological laboratory methods, gender research theory, and food safety practices, with a total of 244 trainees (117 female and 127 male). Subaward projects also hosted a training on food safety for growers of fresh produce (Nepal), are developing food safety curricula focused on fresh produce for students and producers (Cambodia), held a dissemination event for fish farmers and government stakeholders (Bangladesh), and developed a new public-private partnership to develop safer fish feed (Bangladesh). In April 2023, the FSIL ME hosted a virtual project workshop focused on local capacity strengthening for project teams to reflect on progress achieved so far in local capacity strengthening, develop plans for the remainder of the program, and identify opportunities to advance locally led development.

The FSIL ME continued to monitor and guide subaward activities through regular meetings and site visits in Bangladesh, Cambodia, Nepal, Kenya, and Nigeria. The second hybrid annual meeting was held in November 2022 at Texas State University, the lead institution for FSIL's project in Bangladesh and one of three minority serving institutions (MSIs) leading FSIL projects. It provided an opportunity for project leaders, USAID representatives, the FSIL ME, Technical Experts, and Advisory Committee members to share progress, learnings, and feedback. FSIL highlighted project progress on Agrilinks, e-newsletters, and social media throughout the year with an emphasis this year on highlighting results and publications, capacity strengthening efforts, and profiles on project leads from focus country institutions and MSIs. The ME also hosted a two-part webinar series on risk-based approaches to addressing food safety.

Research Program Overview and Structure

In 2019, USAID selected Purdue University, in partnership with Cornell University, to lead the first-ever Feed the Future Innovation Lab for Food Safety. FSIL's vision is to strengthen food security for developing nations through research and capacity development that increases the production of, and access to, safe and nutritious food. FSIL aims to generate and facilitate the dissemination of knowledge, practices, and technologies that improve and enhance climate-resilient food safety systems for communities, households, and commercial value chains.

Alignment with the Global Food Security Strategy

Food safety intersects with three objectives of the U.S. Government Global Food Security Strategy FY2022-2026 (nutrition, resiliency, and economic growth), as it is necessary for food security. Therefore, there is a clear need to consider food safety challenges and opportunities when conducting and translating research designed within the strategy. FSIL's research portfolio is framed by three Areas of Inquiry (AoI), which closely align with the Global Food Security Strategy (GFSS) objectives.

- AoI 1 - Improved Nutrition and Human Outcomes: Research under this AoI focuses on the consumption of safe and affordable food as a means of reducing undernutrition. The AoI emphasizes that nutritious foods can still result in illness or disease in the event they are unsafe due to contamination with biological or chemical hazards.
- AoI 2 - Reduce and Mitigate Risk for Enhanced Resilience: Research under this AoI focuses on food safety behavior, practices, and awareness that are closely tied to a population's resilience. One of the overarching aims of resiliency is to reduce the human and economic costs of recurrent crises, which are exemplified in endemic diarrheal diseases caused by contaminated food and water.
- AoI 3 - Advancing the Productivity Frontier through Economic Development: Research under this AoI focuses on developing opportunities for foods and commodities to reach new local and export market opportunities. Developing and implementing advanced food safety regulations and monitoring systems will ensure products meet the international food safety standards required for entry into global trade.

Overview and Objectives

To enhance food safety (FS) globally, FSIL pursues the following objectives:

- Increasing awareness of food safety
- Enhancing capacity to conduct food safety research
- Developing policies that enable conditions for food safety research, translation, and practice
- Accelerating translational research technologies and practices for households, communities, and the food industry

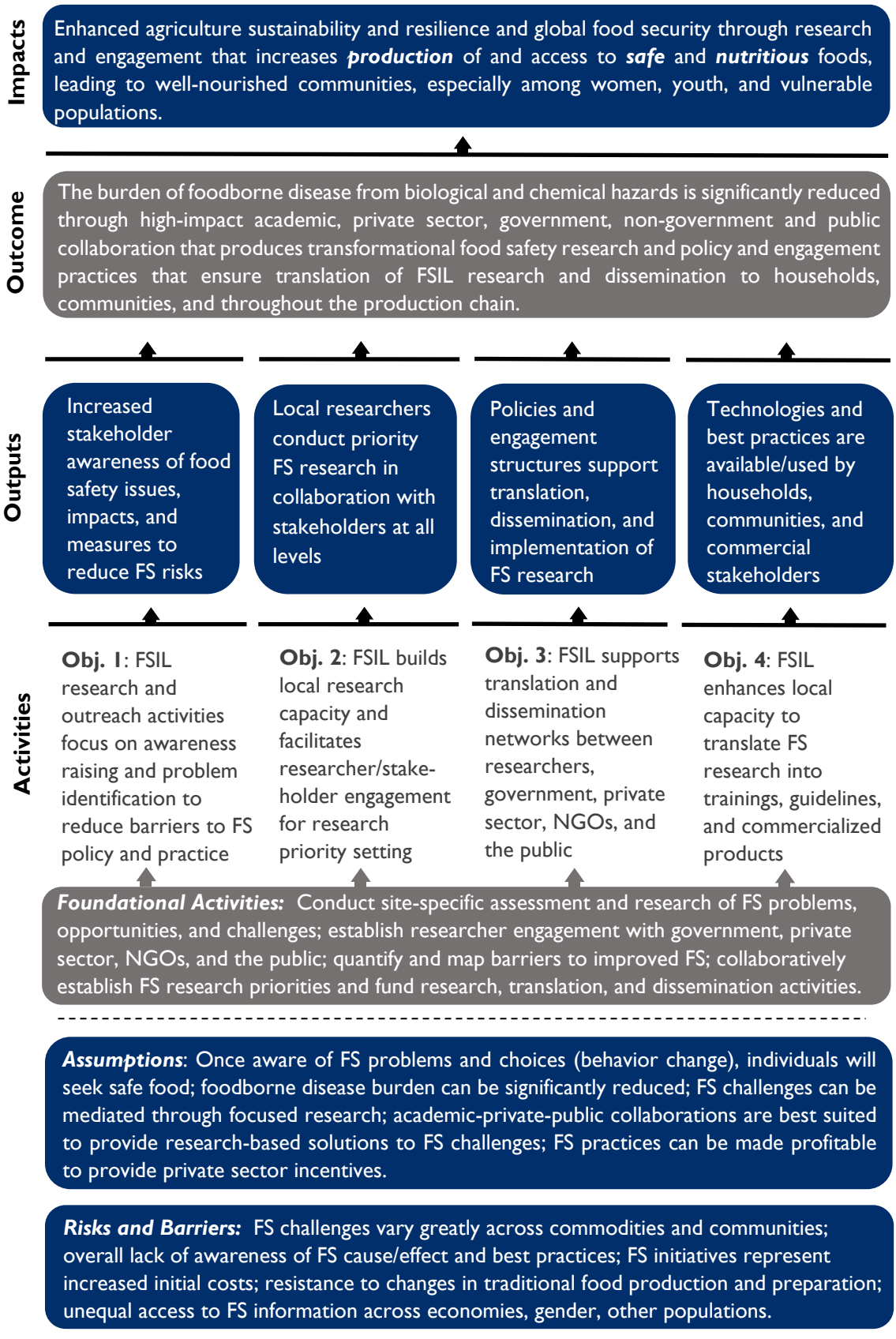
Research Portfolio Design

In FY2021, FSIL funded four new competitively awarded long-term subawards in Bangladesh, Cambodia, Kenya, and Senegal that built on the findings of FSIL's foundational research grants (QuickStarts). FSIL released its second request for applications (RFA) in April 2021, focusing on Minority Serving Institution (MSI)-led partnerships for global food safety research to complement the technical scope of active long-term subawards. The final selection and administration of subawards for two additional projects, based in Nepal and Nigeria, occurred in FY2022. FSIL maintained support for each of the six subawards throughout FY2023, and they are scheduled to be completed between February and April 2024.

Cross-Cutting Themes

Across the FSIL research portfolio, the cross-cutting themes addressed include gender equity, youth engagement, human and institutional capacity development, and food safety enabling environments.

Theory of Change (TOC) and Impact Pathway



Focus Country Key Accomplishments

Bangladesh

In FY2023, the FSIL long-term subaward in Bangladesh made progress toward its goal of enhancing food safety in the fish and chicken value chains. The team completed analysis of antibiotic residues and heavy metals in fish cultured under best management practices and fish typically found in the market. They found that while the fish from best management practices often had lower levels of contamination, contamination for all fish was typically within acceptable limits. They also completed willingness to pay (WTP) auctions and found that consumers are willing to pay higher prices for safer fish, with women and wealthier male consumers particularly valuing safety attributes. A successful knowledge dissemination event was held in March to share findings of the project so far and understand priorities for future work. Four M.S. students also completed their degrees, and two Ph.D. and three M.S. students have degrees in progress.

FSIL's research aligns with the GFSS Bangladesh Country Plan[1] and particularly its component of Food Safety and Sanitary and Phytosanitary Standards. The Bangladesh subaward is generating food safety economics data that supports the development of food safety policy and the ongoing activities of the Bangladesh Food Safety Authority. Graduate students are also being trained by the project, enhancing local capacity to conduct research and monitoring of food safety issues.

Cambodia

FSIL's long-term subaward in Cambodia continued to target food safety gaps in the production, distribution, and sale of vegetables in Cambodia to reduce their risk of contamination with bacterial pathogens. The team completed all data collection for a longitudinal study measuring *Salmonella* and *Escherichia coli* contamination of vegetables, a gender analysis of women vegetable producers, and a study examining how behavior theory can influence adoption of food safety practices in Cambodia. For the behavior research, two peer-reviewed articles were published about perceptions of food safety and barriers to and opportunities for adoption of food safety practices. The team also conducted two capacity strengthening workshops related to whole genome sequencing (WGS) and statistical analysis, which equipped the participants with skills needed to produce high-quality, trustworthy, and publishable research results. Finally, four M.S. graduate students and one Ph.D. student were supported by the project in FY2023, with two M.S. students completing their degrees.

FSIL's research contributes to multiple Intermediate Results (IRs) and Sub-IRs within the Cambodia Country Development Cooperation Strategy[2], including Sub-IR 1.1.3: Strengthened capacity in science, technology, and innovation for women and youth. The project is strengthening both microbiology and social science food safety research capacity in Cambodia while identifying and developing interventions to control high-risk bacterial pathogens in vegetable production, distribution, and sale.

[1] https://cg-281711fb-71ea-422c-b02c-ef79f539e9d2.s3.us-gov-west-1.amazonaws.com/uploads/2018/11/Bangladesh_GFSS_Country_Plan_Public_CLEARED_7.11.18_508_Compliant.pdf

[2] https://www.usaid.gov/sites/default/files/2022-12/Cambodia_CDCS_External_2025.pdf

Kenya

In FY2023, the FSIL long-term subaward in Kenya continued conducting research to improve safety in the poultry value chain in peri-urban Kenya using a risk-informed approach. The project completed data collection for an analysis of the roles and opportunities for women and youth in the poultry value chain, including 30 key informant interviews, eight focus group discussions, and 250 surveys. Analysis and manuscript preparation for that work is underway. The project also made significant progress in developing sampling plans and laboratory protocols for a baseline study to determine the prevalence of *Salmonella* and *Campylobacter* in the poultry value chain and to identify critical control points for intervention. Two M.S. students and one Ph.D. student received support from the project and engaged in research activities in FY2023.

FSIL's emphasis on food safety in the poultry value chain aligns with the GFSS Kenya Country Plan[3] and its inclusion of poultry as a Tier 2 commodity. The FSIL subaward in Kenya partners with women and youth poultry farmers through the identification and testing of food safety interventions.

Senegal

FSIL's long-term subaward in Senegal continued efforts to strengthen food safety capacity in Senegal's growing dairy sector for a resilient, safe dairy industry, reduced foodborne disease, and improved market access in FY2023. The team developed and implemented a comprehensive survey of households, dairy producers, and mini-dairies. A total of 428 individuals from households, 158 individuals involved in milk collection and accumulation, and nine mini-dairies were surveyed. The data will yield insights about food safety practices and perceptions, challenges, and roles of women and youth in dairy production and processing in Senegal. In addition, the team held trainings on microbiological analysis of milk, mastitis management, biosecurity and biosafety, and gender theory. Two M.S. students also completed their degrees, and three others continue to be supported by the project.

FSIL's ongoing research aligns with the GFSS Senegal Country Plan[4] and its aim to develop a functional food safety regulatory system based on sound science and international standards. The project is raising awareness of food safety issues and their impact on public health, conducting research-based food safety training programs, and identifying practical food safety interventions.

[3] https://cg-281711fb-71ea-422c-b02c-ef79f539e9d2.s3.us-gov-west-1.amazonaws.com/uploads/2018/11/FTF_Kenya_Country_Plan_WS_Edits_9.21.pdf
[4] https://cg-281711fb-71ea-422c-b02c-ef79f539e9d2.s3.us-gov-west-1.amazonaws.com/uploads/2018/11/Senegal_Country_Plan_WS_Edits.pdf

Nepal

In FY2023, FSIL's short-term subaward in Nepal continued work to improve microbial food safety of the fresh produce value chain in support of their goals to increase consumer fresh produce consumption and improve dietary diversity. The team completed all planned data collection for the subaward, which includes survey data from 604 households and 1052 commercial produce growers throughout Nepal, *E. coli* prevalence data from 156 household and 238 agricultural water samples, and data from a food safety economics choice experiment with youth. The data is at various stages of analysis and dissemination. In addition to research objectives, the team improved capacity among fresh produce value chain leaders through the establishment of a Food Safety Working Group (FSWG). With the FSWG's support, they are developing a produce safety manual for fresh produce growers and hosted the first of several planned produce safety workshops delivered to various stakeholders.

FSIL's research supports the GFSS Nepal Country Plan[5] and its focus on improving access to and use of diverse, safe, and nutritious foods. By equipping entrepreneurs and policy makers with guidance for market-led, demand-driven food safety practices and labeling recommendations for fresh produce, informed by analysis of consumer behavior, the project aims to stimulate a rapid increase in access to safe and nutritious produce in Nepal.

Nigeria

In FY2023, the FSIL short-term subaward in Nigeria made progress towards identifying facilitators of and barriers to reducing the prevalence of foodborne disease in Nigerian households with young children. The project completed data collection for a survey of 682 households to understand knowledge, attitudes, and practices (KAPs) related to food and water safety, and they collected anthropometric and dietary data from one child under five years old in each of the surveyed households. They also completed a sanitation assessment of 250 households to understand the microbial contamination levels of household and food contact surfaces, and they began an Our Voice activity, which allows mothers to document their daily experience and decision making in providing safe and nutritious foods for their families.

FSIL research aligns with the GFSS Nigeria Country Plan's[6] Component C: Improving Access to and Use of Diverse, Safe, Nutritious, and High-Quality Foods. By understanding the most common food safety risks in households, levels of childhood stunting, the challenges faced by mothers in providing safe and nutritious foods for their children, and the critical policy needs to support the implementation of Nigeria's national food safety plan, the project will prioritize programs and policy actions to improve household food safety.

[5] https://cg-281711fb-71ea-422c-b02c-ef79f539e9d2.s3.us-gov-west-1.amazonaws.com/uploads/2018/11/GFSS-Nepal-Country-Plan.pdf

[6] https://cg-281711fb-71ea-422c-b02c-ef79f539e9d2.s3.us-gov-west-1.amazonaws.com/uploads/2018/11/Nigeria_GFSS_Country_Plan_-_Final_WS_Edits_2.pdf

Research Project Reports

Enhancing Food Safety in Fish and Chicken Value Chains of Bangladesh (Bangladesh Long-Term Subaward)

Location: Bangladesh; Districts: Mymensingh, Bogura, Dhaka, Gazipur, Jashore, Khulna, Patuakhali, and Rajshahi

Description: The project is promoting informed decisions and actions to enhance the food safety of farmed fish and frozen uncooked chicken products. By identifying areas along the value chain that need improvement and developing tools to quantify the benefits of improved food safety, the project is fostering an enabling environment to support consumers' access to safe, nutritious food products.

Theory of Change and Impact Pathway(s): This project contributes toward Objectives 1-4 of the FSIL TOC.

Collaborators: Texas State University (U.S.), University of Dhaka (Bangladesh), Bangladesh Agricultural University (BAU; Bangladesh)

Achievements (Aligned with Bangladesh WP Objective 1):
Analysis for antibiotic residues and heavy metals was carried out on rohu, tilapia, and pangasius fish that had been cultured in ponds following best management practices recommended by the Bangladesh Fisheries Research Institute (BFRI) and compared to fish cultured in control ponds. Heavy metal concentrations were below permissible levels for both trial and control fish for all species, and most samples tested negative for antibiotic residues, with the only positive samples found in control pangasius fish. Experimental auctions were also held to determine consumers' WTP for rohu fish raised under the best management practices, and the results will be analyzed in combination with previous WTP results from tilapia and pangasius fish. A second crop of fish is now being raised under best management practices using a custom feed produced in partnership with Spectra Hexa Feeds, Ltd. Based on feed ingredient recommendations from BFRI, the formulation contains fewer additives and is free of antibiotics. If the trial results are promising with respect to fish productivity, quality, and safety, Spectra Hexa Feeds is enthusiastic about producing the feed commercially at a lower price than most feeds currently on the market. Knowledge, attitude, and practice (KAP) surveys and WTP choice experiments for fish and chicken consumers and fish farmers and traders were also initiated, with 1,015 (out of a planned 1,150) KAP surveys and 505 (out of a planned 610) choice experiments completed.

Capacity Building: Two project-supported Ph.D. students are currently enrolled in their degree programs in agricultural economics and microbiology. Four M.S. students completed their degrees in FY2023, and three new M.S. students have enrolled and are conducting thesis research in collaboration with the project.

Lessons Learned and Broader Application: The project initially planned to conduct a hedonic price analysis, which is a revealed preference method, to analyze WTP for different attributes of safer fish products. However, they found that there was not a sufficient variety of products existing in the current Bangladesh market to conduct the analysis. Therefore, the project pivoted to a stated preference study, which will be used in combination with experimental auctions to understand consumers' WTP for safer fish. This experience highlights that research methods must be selected based on current local conditions and that research projects must remain flexible to adapt plans when needed. The project has also learned that engagement of stakeholders such as BFRI, the State Minister of Planning, the Department of Fisheries, and the Bangladesh Food Safety Authority (BFSA) throughout the planning and implementation of the project has been critical in helping to expedite activities after the COVID-19 pandemic and in providing a platform for timely dissemination of project findings. The project is currently collaborating with the Department of Fisheries and BFSA to develop a training manual for producing safer fish and will conduct trainings in FY2024.

Publications and Presentations:

Dey, M. M., Rahman, M. S., Khan, M., Dewan, M., Nazir, K. H. M. N. H., & Sudhakaran, P. (2023). Willingness to pay for safer food: Evidence from an experimental auction of fish in Bangladesh [Conference presentation]. Aquaculture America 2023. New Orleans, LA, United States.

Khan, M., Hossain, M., Islam, M., Rahman, M., Sudhakaran, P., & Dey, M. M. (2023). A systematic review of fish adulteration and contamination in Bangladesh: A way forward to food safety. *Reviews in Aquaculture*, *15*(4), 1574-1589. https://doi.org/10.1111/raq.12801

Mahmud, M. M., Kabir, A., Hossain, M. Z., Mim, S. J., Yeva, I. J., Khatun, M., Rahman, M. S., Dey, M. M. & Nazir, K. H. M. N. H. (2023). First report of *Aliarcobacter cryaerophilus* in ready-to-cook chicken meat samples from super shops in Bangladesh. *Journal of Advanced Veterinary and Animal Research*, *10*(1), 113-117. https://doi.org/10.5455/javar.2023.j659

Rahman, M., Dey, M. M., Khan, M., Dewan, M., Nazir, K. H. M. N. H., & Sudhakaran, P. (2023). Willingness to pay for safer food: Evidence from an experimental auction of fish in Bangladesh [Conference presentation]. 11th Asia Society of Agricultural Economists. Shibuya, Japan.

Reducing Foodborne Pathogen Contamination of Vegetables in Cambodia: Innovative Research, Targeted Interventions, and Impactful, Cambodian-Led Engagement (Cambodia Long-Term Subaward)

Location: Cambodia; Siem Reap and Battambang provinces, Phnom Penh municipality

Description: The goal of the project is to safeguard the nutritional gains of a healthy diet for Cambodian children, households, and communities by strengthening food safety across the vegetable value chain. Project partners are bridging existing food safety gaps and solidifying shared food safety agendas across universities and the public and private sectors. Together, they are testing and implementing data-driven strategies to measurably reduce the incidence of foodborne pathogen contamination of vegetables consumed in Cambodia.

Theory of Change and Impact Pathway(s): This project contributes toward Objectives 1-4 of the FSIL TOC.

Collaborators: Kansas State University (U.S.), Purdue University (U.S.), The Pennsylvania State University (U.S.), Royal University of Agriculture (RUA; Cambodia), Center of Excellence on Sustainable Agricultural Intensification and Nutrition (CE SAIN; Cambodia), Institute of Technology Cambodia (ITC; Cambodia), Institut Pasteur du Cambodge (IPC; Cambodia), World Vegetable Center (Cambodia)

Achievements (Aligned with Cambodia WP Objective 1): For the longitudinal study measuring contamination of vegetables, *Salmonella* and *E. coli* were isolated from samples collected at farms, distribution centers, and markets. All isolates were confirmed and shipped to Pennsylvania State University for WGS, which is currently underway. Data collection for the gender analysis was completed, with the team conducting 22 structured interviews with Cambodian female vegetable producers about their roles, responsibilities, and opportunities and 13 focus group discussions (FGDs) about adoption of food safety practices. Behavior research was also completed, and two peer-reviewed articles have been published related to perceptions and adoption of food safety practices. From a survey of vegetable producers and vendors, the project found that a majority of respondents were at least "moderately concerned" about the safety of vegetables sold in Cambodia, but 84.9% reported that chemical contamination was of greater concern than microbial contamination. Most respondents from both groups (producers and vendors) perceived the majority of contamination to occur on farms rather than in markets. The results are currently being used to develop two food safety curricula: one for elementary school students and the other for vegetable producers, distributors, and vendors, with an emphasis on outreach to women informed by the gender analysis. The curriculum for students will be integrated with existing CE SAIN-led programming.

Capacity Building: The team hosted two research trainings in FY2023. In April, Pennsylvania State University hosted a week-long virtual workshop on whole genome sequencing and analysis for 13 students, faculty, and researchers at ITC, IPC, and RUA who participated in the longitudinal study or had interest in utilizing the technology. In May, Dr. Nora Bello from Pennsylvania State University conducted an intensive five-day in-person course on experimental design and statistical analysis for 24 participants from ITC, IPC, and RUA. In addition, Dr Bello held one-on-one consultations with attendees to identify the most appropriate statistical methods for their research projects and develop code to perform analyses on their own datasets. The two courses provided project-affiliated graduate students and faculty with the tools necessary to produce high-quality, trustworthy, and publishable results. Additionally, students who participated in previous courses on qualitative and quantitative social science methods participated in both experimental design and data collection for the gender analysis to put the information learned into practice. Two M.S. students also completed their degrees in FY2023, and the project is continuing to support two M.S. students and one Ph.D. student.

Lessons Learned and Broader Application: As data analysis is completed for the longitudinal study in FY2024, learnings about critical control points in the produce value chain will be combined with findings from the behavior research to identify and recommend priority interventions for improving safety of fresh produce in Cambodia. These recommendations will be shared through policy briefs and stakeholder meetings. For local capacity strengthening, a key component to the success of the statistics training course was the extent to which it was tailored to the specific needs and interests of the participants. A pre-course survey was used to assess background knowledge and gaps, lectures and exercises were developed using relevant datasets from ongoing local collaborations, and participants were able to bring their own datasets and questions to consulting sessions. Although the idea of an off-the-shelf course that can be provided in multiple contexts sounds appealing, the additional effort to tailor the course to the specific audience ensured that the material was relevant and beneficial to all the participants.

Publications and Presentations:

Hay, V. (2023). *Efficacy of cleaning and sanitation methods in reducing foodborne pathogens on common food contact surfaces in Cambodian fresh food markets* [Master's thesis, Kansas State University]. K-State Research Exchange. https://krex.k-state.edu/handle/2097/43060

Mosimann, S. (2022). *Perceptions of Food Safety and of Personal Capability, Opportunity, and Motivation for Food Safety Practices Among Cambodians Involved with Informal Vegetable Markets* [Master's thesis, Purdue University]. Hammer Research Repository. https://hammer.purdue.edu/articles/thesis/Perceptions_of_Food_Safety_and_of_Personal_Capability_Opportunity_and_Motivation_for_Food_Safety_Practices_Among_Cambodians_Involved_with_Informal_Vegetable_Markets/21688289

Mosimann, S., Ouk K., Bello, N.M., Chhoeun, M., Vipham, J., Hok, L., & Ebner, P. (2023). Describing capability, opportunity, and motivation for food safety practices among actors in the Cambodian informal vegetable market. *Frontiers in Sustainable Food Systems*, *7*. https://doi.org/10.3389/fsufs.2023.1060876

Mosimann, S., Ouk, K., Bello, N., Chhoeun, M., Thompson, L., Vipham, J. H., & Ebner, P. (2023). Describing food safety perceptions among growers and vendors in Cambodian informal vegetable markets. *Frontier in Sustainable Food Systems*, *7*. https://doi.org/10.3389/fsufs.2023.1111580

Chakula Salama: A Risk-based Approach to Reducing Foodborne Disease and Increasing Production of Safe Foods in Kenya (Kenya Long-Term Subaward)

Location: Kenya; Kiambu County

Description: The overarching goal of Chakula Salama – which means "safe food" in Swahili – is to improve food security and nutrition in Kenya. Project leaders are developing the country's capacity for systems-based, risk-informed approaches to food safety which can reduce the risk of foodborne disease, increase the production of safe food, and improve economic outcomes. To demonstrate this approach, they are focusing on small-scale poultry production by women and youth in peri-urban areas of Kenya.

Theory of Change and Impact Pathway(s): This project contributes toward Objectives 1-4 of the FSIL TOC.

Collaborators: The Ohio State University (OSU, U.S.), University of Florida (U.S.), Kenya Medical Research Institute (KEMRI; Kenya), University of Nairobi (Kenya)

Achievements (Aligned with Kenya WP Objective 1): In early FY2023, the team published a literature review on the roles of men, women, and youth in the smallholder poultry value chain in Kenya. They also received Institutional Review Board (IRB) approval and successfully completed a gender analysis for small-scale poultry production in peri-urban Kenya. Data collection for the analysis included 30 key informant interviews, 8 focus group discussions, and 250 surveys. The team found that women and youth are the primary actors in poultry farming. Women are largely responsible for poultry-rearing activities, including purchasing, watering, and feeding chicks; cleaning the poultry house; and veterinary care. However, some physically intensive activities, such as building the poultry house, were more often undertaken by men. Results indicated that poultry farmers need access to increased training on postharvest foodborne disease prevention methods and best practices in food safety to reduce the risk of *Salmonella* and *Campylobacter* contamination in the poultry value chain, and interventions should target women and youth. The team also developed a draft manual on safe practices for the slaughter and handling of poultry, including the post-harvest carcass wash intervention that was selected from the risk ranking workshop held in FY2022. Finally, the team made significant progress on developing sampling and laboratory protocols for a baseline survey of *Salmonella* and *Campylobacter* in small-scale poultry production and received IRB approval for the study from KEMRI and the University of Nairobi.

Capacity Building: The project continues to directly support one M.S. student and one Ph.D. student. The Ph.D. student's dissertation is focused on the gender analysis, and significant progress has been made towards their degree this year. Capacity was also strengthened through collaborative efforts in developing the laboratory protocols and field sampling plans. Students and investigators worked closely together to agree on the details and content of protocols and sampling plans and to work through the expectations of different institutions and researchers across different research fields.

Lessons Learned and Broader Application: The project has faced delays due to challenges in obtaining IRB approvals. One specific challenge has been that OSU required that the project obtain IRB approval from all three partner institutions (OSU, KEMRI and the University of Nairobi), which is challenging when each institution requires slightly different information. Study documents had to be slightly revised for each institution, and ensuring that all of the documents were complete and contained the updated, identical information became a challenging and time-consuming process. When possible, it is recommended that IRB approval be the purview of a single institution and that partner institutions agree to cede their approval.

Publications and Presentations:

Garsow, A. V., Kim, E. G, Colverson, K. E., Ilic, S., Kunyanga, C., Bainah, A. & Kowalcyk, B. B. (2022). A review of the roles of men, women, and youth in ensuring food safety in the smallholder poultry value chain in Kenya. *Frontiers in Sustainable Food Systems, 6,* https://doi.org/10.3389/fsufs.2022.1041472

Food Safety Capacity Building in Senegal: Enhancing Resilience of the Dairy Value Chain by Leveraging Public-Private Partnerships (Senegal Long-Term Subaward)

Location: Senegal; Louga, Matam, and Saint Louis regions

Description: The goal of the project is to transform the overall safety of dairy and dairy products produced in Senegal, which will improve the nutritional status and economic prospects for the women and youth who play critical roles in dairy production. Project partners are advancing data-driven food safety practices, policies, and training to support the development of well-equipped food safety professionals in Senegal.

Theory of Change and Impact Pathway(s): This project contributes toward Objectives 1-4 of the FSIL TOC.

Collaborators: University of Georgia (U.S.), Tuskegee University (U.S.), Institut de Technologie Alimentaire (ITA; Senegal), Institut Sénégalais de Recherches Agricoles (ISRA; Senegal), Conseil National du Développement de la Nutrition (CNDN; Senegal)

Achievements (Aligned with Senegal WP Objective 1): Progress in FY2023 focused on completion of a comprehensive, harmonized survey of households, producers and mini-dairies to understand production and processing practices in the dairy value chain as well as involvement of women and youth. The comprehensive survey was developed based on findings from a pilot survey conducted in early FY2023. Three mini-dairies were surveyed in each of three regions: Louga, Matam, and St. Louis, for a total of nine mini-dairies. Additionally, 158 responses were obtained from individuals involved in milk collection and accumulation, and 428 responses were obtained from individuals in households. The survey data has been processed and anonymized, and it is currently being analyzed. The survey data will yield insights to inform future work, including identification of sampling sizes for microbiological baseline data and assessment of the feasibility of different intervention strategies. In addition to completion of the survey, two peer-reviewed journal articles were published focusing on production and processing aspects of dairy and their impact on food safety in the dairy value chain.

Capacity Building: Prior to implementing the harmonized survey, a training was held for 24 enumerators to familiarize them with the survey and best practices for survey enumeration. In preparation for microbiological sampling, Dr. Woubit Abebe of Tuskegee University conducted in-person training for laboratory professionals in skills specific to analyzing samples for pathogens in milk, such as polymerase chain reaction (PCR) techniques, and on concepts related to diagnosis, prevention, and management of mastitis, biosafety, and biosecurity in the dairy value chain. Gender training for U.S. and Senegalese team members was also conducted to strengthen understanding of gender theory and concepts and the role of gender in agriculture. Finally, two M.S. students defended their theses and completed their degrees.

Lessons Learned and Broader Application: The project team holds monthly meetings with all U.S. and Senegalese partners. In addition to these project-wide meetings, frequent smaller sub-group meetings focused on specific objectives have been critical in the progress achieved thus far. Frequent meetings with other existing USAID funded projects in Senegal, such as Business Drivers for Food Safety, have also been beneficial in aligning mutual interests and leveraging existing frameworks within the dairy value chain. The two projects plan to collaborate and jointly develop training materials in FY2024. The FSIL project team has also learned the importance of understanding the organizational structure of all partner institutions, as some co-PIs must obtain clearance from superiors at their institution prior to communicating and sharing data. Further, it is critical to ensure from the outset of a project that all partners have a clear and mutual understanding of research objectives and a plan to manage and utilize all data before it is collected.

Publications and Presentations:

Abebe, W., Faraj, R., Diallo, Y., Thippareddi, H., & Singh, M. (2023). Food safety issues in dairy production in Senegal: Challenges and pragmatic solutions for the dairy value chain. *Food Protection Trends*, *43*(1), 94-101. https://ag.purdue.edu/food-safety-innovation-lab/wp-content/uploads/2023/02/Food-Safety-Issues-In-Dairy-Production-In-Senegal-2023.pdf

Diedhiou, M. (2022). *Caractérisation des systèmes d'élevage laitier dans le département de Linguère et influence des facteurs sanitaires sur la productivité du lait* [Master's thesis presentation]. National School of Agriculture (ENSA). Thiès, Senegal.

Leone, C., Thippareddi, H., Ndiaye, C., Niang, I., Diallo, Y., & Singh, M. (2022). Safety and quality of milk and milk products in Senegal - A review. *Foods*, *11*(21), 3479. https://doi.org/10.3390/foods11213479

Ndour, B. (2023). *Diagnostic de la qualite sanitaire des produits issus des mini laiteries dans le departement de linguere* [Master's thesis presentation]. Polytechnic School of Dakar. Dakar, Senegal.

Market-Led Food Safety in Nepal: Harnessing Production Incentives and Consumer Awareness (Nepal Short-Term Subaward)

Location: Nepal; Morang, Sarlahi, Kaski, Chitwan, Makawanpur, Kathmandu, Kalikot, Surkhet, Palpa, Banke, Rupandehi

Description: The goal of the project is to stimulate a rapid increase in access to nutritious produce in Nepal by identifying the factors that will drive the supply of and demand for safer salad vegetables. Researchers are assessing indicators of current food safety risks, understanding the food safety behaviors of vegetable producers and consumers, and identifying incentives that could transform food safety policies and practices. The work will enable entrepreneurs and policy makers to reach informed decisions on prioritizing food safety investments and support the awareness of safer food consumption and dietary diversity in Nepali households.

Theory of Change and Impact Pathway(s): This project contributes towards Objectives 1-4 of the FSIL TOC.

Collaborators: Tennessee State University (U.S.), Arizona State University (U.S.), SAHAVAGI (Nepal), Agriculture and Forestry University (Nepal)

Achievements (Aligned with Nepal WP Objective 1): Significant progress was made for several project activities over the reporting period. Consumer household food safety and WTP data collected in FY2022 were tabulated and analyzed. A total of 604 consumer household food safety and WTP observations were collected, and the data were presented at an agricultural policy conference in Nepal and published in a Nepal policy journal. Gender differences and the role of women in household food consumption and food safety decisions were emphasized in the analysis. A choice experiment with information nudges about food safety was conducted among youth, and data were analyzed and presented at the Southern Agricultural Economics Association annual meeting. Water data collection from the previous reporting period continued and was completed in FY2023. 156 consumer water samples from five metropolitan areas and 238 agricultural water samples from 10 districts were analyzed for *E. coli* prevalence. The percentage of samples positive for *E. coli* was 69% in consumer water and 55% in agricultural water. The data was presented at the 9th National Conference in Food Science and Technology in Nepal. Additional surveys were collected from 1,052 commercial fresh produce growers across 10 districts to assess knowledge, attitudes, and practices (KAPs) about food safety from the producer perspective. Based on the commercial grower surveys and in collaboration with key stakeholders, collaborators started drafting a comprehensive food safety training manual for fresh produce growers. Finally, food safety workshops for a variety of stakeholders were planned. One workshop was delivered in FY2023 with 69 attendees from the private sector, extension, academic, and research institutions, and additional workshops are planned for early FY2024.

Capacity Building: This project continues to strengthen the research capacity of Agriculture and Forestry University (AFU). In the previous reporting period, an Institutional Review Board (IRB) and Institutional Biosafety Committee (IBC) were created through facilitation of this project. The IRB and IBC were used by other Innovation Labs and funding institutions during the current reporting period. Other capacity building progress includes 10 enumerators trained in survey collection, laboratory technicians trained to analyze water samples for the presence of *E. coli,* co-PIs at Nepal institutions benefitting from collaboration with U.S. co-PIs through increased experience with academic writing and presentation, and students at AFU learning food safety and engagement principles through the project's facilitation of a food safety poster competition. The project also facilitated the creation of a Food Safety Working Group (FSWG) in Nepal with representation from organizations including FAO-Nepal, the Government of Nepal's Department of Agriculture, and the Nepal Agricultural Research Council. The FSWG is currently positioned to assist in creating a comprehensive food safety training manual for produce growers and to host a policy workshop in FY2024.

Lessons Learned and Broader Application: Surveying more than 1,000 farmers representing all provinces and regions while ensuring the integrity of the sampling procedure was challenging. There was no existing list of growers nor a well-defined definition of a commercial produce farm. It required a bottom-up participatory approach to fieldwork: finding a local guide and collaborating with local government and agriculture offices was important to preparing a sample pool of commercial fresh produce growers. The use of a mobile application that allowed communication and sharing of location and photos in the field was also helpful to field workers and local guides in coordinating the mass data collection required for the survey.

Publications and Presentations:

Khanal, A. R. (2023). Consumer demand, food safety, and market systems. *Agrilinks*. https://agrilinks.org/post/consumer-demand-food-safety-and-market-systems

Khanal, A. R. (2023). Food related concerns, awareness on safety, and illness at home: Examining consumer households in Nepal [Conference presentation]. 2023 NACA Conference: Confronting Complexities, Transforming Possibilities, Phoenix, AZ, United States. Virtual.

Khanal, A. R., Gurung, R., Timilsina, R., & Poudel, S. (2023). Awareness of food safety to ensure food security: examining gender roles in safer fresh produce consumption among metropolitan households in Nepal [Conference presentation]. Agricultural Policies and Practices in Nepal: Pathways for Transformation, Kathmandu, Nepal. Virtual.

Khanal, A. R., Gurung, R., Timilsina, R., & Poudel, S. (2023). Food safety awareness, food policies, and gender: A review and an empirical examination from Nepal. *Nepal Public Policy Review*, *3*(1), 169-193. https://doi.org/10.59552/nppr.v3i1.62

Khanal, A. R., Timilsina, R., & Dhungana, P. (2023). Do environmental awareness and food safety information nudges enhance the affinity to safer food among youth? Findings from a choice experiment in Nepal [Conference presentation]. Southern Agricultural Economics Association Annual Meeting, Oklahoma City, OK, United States.

Paudel, D., Neupane, R. C., Sigdel, S., Poudel, P., & Khanal, A. R. (2023). COVID-19 Pandemic, climate change, and conflicts on agriculture: A trio of challenges to global food security. *Sustainability*, *15*(10), 8280. https://doi.org/10.3390/su15108280

Timilsina, R., Khanal, A. R., Basnet, H., Sharma, B., & Aryal, R. (2023). Is the water safe? Testing the water used by consumers and commercial growers in fresh produce systems in Nepal [Conference presentation]. 9th National Conference in Food Science and Technology, Kathmandu, Nepal.

Strengthening Household and Community Food Safety in Nigeria (Nigeria Short-Term Subaward)

Location: Nigeria; Ibadan

Description: The project is identifying facilitators of and barriers to reducing the prevalence of foodborne disease in Nigerian households with young children. Using a community-based approach that harnesses the perspectives of youth, mothers, primary health care providers, community development personnel, government representatives, civil society leaders, and community-based organizations, researchers are collaboratively identifying strategic, feasible activities to mitigate and prevent household foodborne illnesses.

Theory of Change and Impact Pathway(s): This project contributes towards Objectives 1-4 of the FSIL TOC.

Collaborators: University of Alaska Fairbanks (U.S.), Utah State University (U.S.), Bowen University (Nigeria), Obafemi Awolowo University (Nigeria), University of Ibadan (Nigeria)

Achievements (Aligned with Nigeria WP Objective 1): The research team completed data collection for a survey of 682 households in five local government areas in Ibadan to understand knowledge, attitudes, and practices (KAPs) related to food and water safety. In addition, they collected anthropometric and dietary data from one child under five years old in each of the surveyed households. The data has been cleaned, preliminary results were shared at the Society of Nutrition Education and Behavior annual meeting, and final data analysis is underway. The team also successfully completed a household environmental sanitation assessment with 250 households and is currently analyzing the data. They swabbed household and food contact surfaces and measured adenosine triphosphate (ATP), *E. coli*, and coliform prevalence to understand contamination levels in Ibadan homes, assess the efficacy of current cleaning and food safety practices, and determine potential areas for intervention. Finally, the team received IRB approval for the Our Voice activity, which is designed to document the lived experience of mothers as they navigate household and community factors to provide safe and nutritious foods for their families. They recruited and consented 55 mothers, who completed the first phase of data collection, which entailed responding to daily prompts with the Discovery Tool mobile application.

Capacity Building: The research team developed a training manual prior to conducting the household survey and collection of anthropometric and dietary data, which included topics including project scope, research ethics, interviewing techniques, and professionalism. They recruited enumerators and conducted a two-day training with 27 participants (17 female and 10 male) based on the manual. The team also held two trainings for research assistants and technicians working with the project. One was led virtually by Neogen to train nine laboratory technicians in the use of 3M Clean-Trace ATP swabs and aerobic plate counts for the environmental sanitation assessment. The second was conducted in collaboration with the Our Voice team at Stanford University to train 11 research assistants and technicians on the goals and protocol of the Our Voice activity and use of the Discovery Tool mobile application.

Lessons Learned and Broader Application: The team is slightly behind on their work plan, although they still anticipate completing all planned activities before the end of the project. They have learned to allow more time to complete project activities, particularly with respect to project initiation. Laying the groundwork for the successful completion of the study by establishing relationships with community stakeholders, applying for and receiving IRB approval, developing protocols, and shipping supplies internationally—among others—is time-intensive, and delays are often unavoidable. They have also learned that it is logistically more feasible to plan for research activities to unfold sequentially. They had initially planned to conduct some research activities simultaneously, which was ultimately not possible due to limited financial and personnel resources.

Publications and Presentations:

Atoloye, A., Samuel, F., Aluko, O., Torimiro, N., Bamgbade, B., Areola, A., Otegbayo, B., & Bersamin, A. (2023). Association between food safety awareness, knowledge and behavior and the nutrition status of under-5 children [Poster presentation]. Society for Nutrition Education and Behavior Annual Meeting. Washington, D.C, United States.

Human and Institutional Capacity Development

Short-term training

Country of Training	Brief Purpose of Training	Who was Trained	M	F	Total
Bangladesh	Enumerators were trained in proper methods for collecting data through surveys and choice experiments	Civil Society	16	4	20
Cambodia	Project researchers were given a five-day intensive course on proper statistical and analysis methods	Civil Society	5	19	24
Cambodia	Researchers received training on WGS and WGS data analysis	Civil Society	4	9	13
Nepal	Enumerators were trained in data collection	Civil Society	6	4	10
Nepal	Produce growers and extension service providers received training in safe practices for fresh produce	Smallholder and Non-smallholder producers, Private sector, Government, and Civil Society	50	19	69
Nigeria	Enumerators were trained in data collection	Civil Society	10	17	27
Nigeria	Laboratory technicians and researchers were trained on use of 3M Clean-Trace ATP swabs and *E. coli* and coliform aerobic plate counts	Civil Society	6	3	9
Nigeria	Research assistants and technicians were trained on the Discovery Tool mobile application for the One Voice data collection	Civil Society	6	5	11
Senegal	Enumerators were trained on proper protocols for conducting surveys and collecting data	Civil Society	8	16	24
Senegal	Students and microbiologists were trained on biosafety, biosecurity, management of mastitis	Civil Society	6	11	17
Senegal	Project researchers were trained on gender theory and concepts and gender in agriculture	Civil Society	8	8	16
Senegal	Laboratory technicians and researchers were trained on pathogen detection in milk using culture and PCR	Civil Society	2	2	4
Total			**127**	**117**	**244**

Long-term training

Trainee Number	Sex	University	Degree	Major	Program End Date (M/Y)	Degree Granted (Y/N)	Home Country
1*	F	Purdue University	Ph.D.	Agricultural Sciences Education and Communication	May 2023	N	United States
2*	M	Purdue University	Ph.D.	Agricultural Economics	May 2023	N	United States
3	M	Cornell University	Ph.D.	Food Science and Technology	May 2024	N	United States
4	F	Royal University of Agriculture	M.S.	Agro Industry (Food Microbiology)	January 2024	N	Cambodia
5	F	Royal University of Agriculture	M.S.	Agro Industry (Food Microbiology)	January 2024	N	Cambodia
6	F	Purdue University	M.S.	Animal Science	December 2022	Y	United States
7	M	Purdue University	Ph.D.	Agricultural Sciences Education and Communication	June 2024	N	United States
8	F	Bangladesh Agricultural University	M.S.	Agricultural Economics	October 2022	Y	Bangladesh
9	F	Bangladesh Agricultural University	M.S.	Food Technology and Rural Industries	December 2022	Y	Bangladesh
10	F	Bangladesh Agricultural University	M.S.	Agricultural Finance and Banking	June 2022	Y	Bangladesh
11	F	Bangladesh Agricultural University	M.S.	Microbiology and Hygiene	October 2022	Y	Bangladesh
12	M	Bangladesh Agricultural University	Ph.D.	Agricultural Economics	December 2024	N	Bangladesh
13	F	National School of Agriculture	M.S.	Animal Production	May 2023	Y	Senegal
14	M	National School of Agriculture	M.S.	Value Chain Development, Agriculture & Agribusiness Entrepreneurship	December 2023	N	Senegal
15	F	Polytechnic School of Dakar	M.S.	Engineering in the Food Industry	March 2023	Y	Senegal
16**	M	National School of agriculture	M.S.	Value Chain Development, Agriculture & Agribusiness Entrepreneurship	November 2022	N	Senegal
17	F	National School of agriculture	M.S.	Value Chain Development,	December 2023	N	Senegal

				Agriculture & Agribusiness Entrepreneurship			
18	F	Institute of Technology of Cambodia	M.S.	Agri-Industrial Engineering	September 2023	Y	Cambodia
19	F	KEMRI	M.S.	Medical Microbiology	December 2023	N	Kenya
20**	M	KEMRI	M.S.	Medical Microbiology	December 2022	N	Kenya
21	F	Purdue University	Ph.D.	Agricultural Economics	August 2026	N	Senegal
22	F	Bangladesh Agricultural University	Ph.D.	Microbiology	May 2024	N	Bangladesh
23	F	Bangladesh Agricultural University	M.S	Food Science	December 2022	Y	Bangladesh
24	F	Bangladesh Agricultural University	M.S	Agricultural Economics	March 2024	N	Bangladesh
25	F	Bangladesh Agricultural University	M.S	Microbiology	March 2024	N	Bangladesh
26	F	Bangladesh Agricultural University	M.S	Agricultural Economics	March 2024	N	Bangladesh
27	M	University of Nairobi	Ph.D.	Food Safety and Quality	December 2024	N	Kenya
28	F	University of Dhaka	M.S.	Sociology	August 2022	Y	Bangladesh
29	F	Purdue University	Ph.D.	Animal Science	May 2024	N	U.S.

*Supported by FSIL for the fall 2020 semester

**Did not complete degree through FSIL

Environmental Mitigation and Monitoring Plan (EMMP)

Per the FSIL EMMP, activities requiring specific mitigation and monitoring efforts include 1) food safety research on raw food materials contaminated with biological and chemical contaminants; and 2) clinical (medical) evaluations and people-based surveys. During FY2023, FSIL continued to mitigate risks associated with these activities.

Each subaward's PI is responsible for uploading the required Institutional Review Board (IRB) and Institutional Biosafety Committee (IBC) documentation to the Piestar DPx platform for review by FSIL's Director and Associate Director. Once the documentation is approved by FSIL, it is submitted to the Agreement Officer's Representative (AOR) for review. In addition, FSIL conducts an internal EMMP audit semiannually to ensure all required documentation has been submitted per each subaward's activities.

For laboratory-based research, each subaward PI is responsible for documenting laboratory protocols, training personnel, and conducting regular on-site or virtual monitoring of laboratory sites to ensure safety protocols are followed.

Subaward	**IBC approval**	**Laboratory Standard Operating Procedures**	**Lab Safety Training Forms**	**Updated FY2023 Lab Safety Monitoring Forms**
Bangladesh long-term	Submitted to AOR	Submitted to AOR	Submitted to AOR	Submitted to FSIL ME
Cambodia long-term	Submitted to AOR	Submitted to AOR	Submitted to AOR	Submitted to FSIL ME
Kenya long-term	Submitted to AOR	Submitted to AOR	Submitted to AOR	Submitted to FSIL ME
Nepal short-term	Submitted to AOR	Submitted to AOR	Submitted to AOR	Submitted to FSIL ME
Nigeria short-term	Submitted to FSIL ME	Submitted to FSIL ME	Submitted to FSIL ME	Submitted to FSIL ME
Senegal long-term	Submitted to FSIL ME	Submission in FY2024*	Submitted to FSIL ME	Submission in FY2024*

*All laboratory work will take place in FY2024. Standard operating procedures and lab safety monitoring forms will be submitted to the FSIL ME prior to commencing laboratory work.

For people-based surveys or human subjects research, each PI is responsible for utilizing their respective IRB to obtain approval or exemption of the proposed activities.

Subaward	**IRB Approval/Exemption**
Bangladesh long-term	Submitted to AOR
Cambodia long-term	Submitted to AOR
Kenya long-term	Submitted to FSIL ME
Nepal short-term	Submitted to AOR
Nigeria short-term	Submitted to AOR
Senegal long-term	Submitted to FSIL ME

All forms that were submitted to the FSIL ME during FY2023 will be submitted to the AOR prior to November 2023.

Open Data Management Plan

FSIL continues to partner with Purdue University's Ag Data Services team to ensure that research teams have access to technical support related to data management and sharing. At project onset, Ag Data Services partners with each subaward to develop a data management plan. As project objectives are completed, Ag Data Services supports researchers in cleaning, organizing, and sharing their datasets.

In FY2023, Ag Data Services hosted data management virtual office hours for subawards to connect and discuss specific data-related questions. As projects are entering the final phase of the project life cycle and finalizing their datasets, Ag Data Services will conduct more frequent one-on-one office hours to ensure all datasets are completed and uploaded to the Harvard Dataverse and Development Data Library (DDL).

Governance and Management Entity Activity

Create and maintain effective management structures and practices that promote the success of active FSIL projects (Management Entity WP Activity 1.1)

FSIL held monthly meetings with each project team to discuss progress, plans, and obstacles. These meetings allowed FSIL to proactively address challenges, stay informed of research progress, and provide technical guidance where needed. Members of the management team conducted field visits to Bangladesh, Cambodia, Kenya, Nepal, and Nigeria to monitor activities, meet with the USAID Missions, and support the project teams. The trip to Cambodia also provided an opportunity to begin planning FSIL's FY2024 annual meeting. As a commitment to fostering success for the MSI-led projects in Nepal and Nigeria, the FSIL ME maintained the administrative support and contracting for all seven U.S. and foreign subawards for those projects.

The FSIL Gender Working Group met quarterly to exchange gender research strategies for food safety, discuss challenges and lessons learned, and identify opportunities to help women become champions of food safety. FSIL collaborated with other USAID-funded Feed the Future Innovation Labs through participation in the Feed the Future Innovation Lab communities of practice in gender and local capacity strengthening, the Innovation Lab Regional Partners Meeting in Kenya, and the Innovation Lab Directors meeting in Washington, D.C to share ideas and experiences. FSIL also continued collaboration and coordination with other USAID-funded food safety programming such as Business Drivers for Food Safety and EatSafe through regular meetings and communication. Collaboration with Business Drivers for Food Safety assisted in scoping a small research project for a FSIL-funded graduate student in Senegal and has led to plans for future collaboration in developing training materials for the dairy value chain with the long-term subaward in Senegal. The EatSafe team was helpful in sharing guidance in navigating security and travel to and within Nigeria during the presidential election period.

In FY2023, FSIL held its second hybrid annual meeting in November 2022 at Texas State University. The meeting highlighted one of three minority serving institutions (MSIs) leading FSIL projects and featured project updates, a session on gender, and a special session depicting a case study of strengthening local capacity through government engagement. It provided an opportunity for project teams, Technical Experts, Advisory Committee members, USAID, and the ME to collaborate and share learnings. In the spring of FY2023, FSIL held a workshop for all project collaborators to conduct a focused and intentional evaluation of local capacity strengthening in the context of their projects and to identify opportunities to advance locally led development. Finally, FSIL collaborators reported on activities relevant to the Environmental Mitigation and Monitoring Plan in their semi-annual reports, with FSIL and USAID providing oversight and approval of the reported activities.

Develop robust MEL, communication, and open data platforms (Management Entity WP Activity 1.2)

FSIL continued to use the Piestar DPx platform as a tool for monitoring, evaluation, and learning, with each project reporting on achievements, challenges, progress against their work plan, and progress against indicator targets semi-annually. In FY2023, data collection was the main focus for most projects. As outlined in the Open Data Management Plan section, Purdue's Ag Data Services team supported FSIL projects by offering virtual office hours and one-on-one assistance in data collection, storage, and dissemination.

FSIL's communication strategies reached a large audience. A total of 22 unique posts were published to Agrilinks and the FSIL website in FY2023, with articles highlighting peer-reviewed publications, capacity strengthening activities, project PIs from in-country and minority-serving institutions, and topics relevant to Agrilinks' theme months. The FSIL ME also regularly published e-newsletters and shared updates on LinkedIn and X (the platform formerly known as Twitter), where FSIL has a combined social media presence of 1,953

followers, an increase of 770 from FY2022. FSIL also hosted two webinars[7] in June 2023, focusing on introducing and applying risk-based approaches to improve food safety. Both events attracted a total of 450 registrants.

Engage FSIL Advisory Committee and Technical Experts in providing guidance and support to ongoing activities (Management Entity WP Activity 1.3)

FSIL's Advisory Committee and Technical Experts met with project leaders at the FY2023 annual meeting to discuss their achievements and provide input regarding their planned activities. The meeting provided an opportunity for FSIL to highlight accomplishments from the past year and set objectives for the upcoming year. The experts shared their knowledge, insights, and advice to help the project leaders develop effective strategies and ensure successful outcomes. In the spring of 2023, a group of selected members of the Advisory Committee and Technical Experts participated in interviews as part of a mid-award external performance evaluation for FSIL. The evaluation aimed to provide feedback on research progress and performance, capacity strengthening efforts, and overall management of the FSIL portfolio. The overarching recommendation from the evaluation was that food safety research and outreach should continue to be a USAID priority.

FSIL collaborated with a Technical Expert to explore a potential small research project in the dairy value chain in Senegal to complement the Senegal long-term subaward, which would provide insight into consumer willingness to pay for certified safe dairy products. Moreover, FSIL has been working with a Technical Expert to identify opportunities to expand the engagement of MSIs in global food safety research. The PI of the Nepal project from Tennessee State University was invited to participate in a panel discussion at the Innovation Lab Directors meeting in Washington, D.C. The objective of the panel was to highlight opportunities for future engagement between USAID and MSIs.

[7] https://ag.purdue.edu/food-safety-innovation-lab/news/events/

Other Topics

Mid-award external performance evaluation finds that FSIL is making good progress towards its objectives and recommends that USAID maintain investments in food safety

An external performance evaluation[8] was conducted in FY2023, covering the period between June 24, 2019 to December 31, 2022 to assess FSIL's research program performance, capacity strengthening efforts, and overall management. It included a review of key program documents and interviews with the FSIL ME, principal investigators (PIs), co-PIs, USAID personnel, Technical Experts, and Advisory Committee members.

The review found that FSIL has a unified research strategy to address global food safety challenges, with a particular focus on microbial food safety and that FSIL has made good progress towards accomplishing its objectives in this area. The FSIL ME was also found to be highly effective, with the co-directorship structure working smoothly to allow the Director and Associate Director to maintain active research portfolios while meeting their FSIL commitments. This is beneficial because it allows them to remain directly engaged with food safety research relevant to FSIL, but it can only be successful with the support of a well-staffed ME and with understanding from their academic departments. Specifically, their home departments at Purdue and Cornell must reduce some of their academic and departmental responsibilities to accommodate the effort dedicated to supporting FSIL projects and the travel required to build relationships with in-country research teams and USAID staff. The ME was also found to be adaptive and willing to pivot to address issues in research and subaward administration. Combined with strong communication with subaward teams, this has allowed the ME to respond to unforeseen challenges and keep projects on track. Finally, FSIL was found to be a leader and strong supporter of USAID priorities, most notably through engagement with minority-serving institutions (MSIs) and gender-sensitive programming.

The report recommended that USAID increase or at least maintain its investment in food safety and that future investments in FSIL represent a best use of U.S. government funds to achieve the Feed the Future and USAID objectives. The report noted the importance of food safety research in achieving development goals:

> Food safety reaches across many development sectors, including food security and nutrition. The development community should continue to increase its understanding of how food safety is inextricably linked to food and health outcomes and prioritize research and interventions in food safety that can increase awareness and systems change in the policy and the private sector. (FSIL Mid-Award External Performance Evaluation[8], pg. 16)

Graduate students supported to attend the 2023 International Association for Food Protection (IAFP) Annual Meeting

In FY2023, FSIL supported three graduate students to attend the IAFP annual meeting, which took place July 15-19, 2023 in Toronto, Canada. The attendees included a Nepali M.S. student studying agribusiness at Tennessee State University who is conducting research to support the FSIL project in Nepal; a Kenyan research assistant at KEMRI who is contributing to the Chakula Salama project; and a Cambodian M.S. student from the Royal University of Agriculture who is studying food microbiology and working with the FSIL project in Cambodia. IAFP is the premier conference for food safety in the world, and it provided a valuable opportunity for the students to share knowledge about the FSIL projects that they support, gain knowledge to improve FSIL projects, foster their own career development, and build relationships with global food safety experts. The activity directly supported Objective 2 in the FSIL TOC by building local research capacity. Providing

[8] https://ag.purdue.edu/food-safety-innovation-lab/projects/resources/fsil-mid-award-external-performance-evaluation-2023/

professional development and knowledge exchange opportunities is an important way to strengthen the capacity of the next generation of local food safety experts and researchers. Participation in the conference provided these three emerging scholars with valuable perspective and connections:

> The IAFP conference was great exposure for me. I got to meet people from diverse backgrounds – academia, industry, government, intergovernmental organizations, and more importantly, from different parts of the world. I learned about different approaches to food safety risk assessment, methodologies for estimating the cost of foodborne illnesses, and the utilization of machine learning models and artificial intelligence in predicting food product quality—areas that align with my interest and long-standing areas of curiosity. Overall, I got a comprehensive understanding of the major food safety challenges, priorities, and policies across different regions of the world as well as the differences between the food safety challenges and priorities in developed countries like the U.S. and Canada and in the least developed countries like Ethiopia and Uganda. I believe this experience will help me to develop and prioritize research ideas to address food safety challenges during my academic pursuits ahead. (P. Dhungana, Tennessee State University)

> Traveling to Canada also changed my way of thinking and my approach to different things. I also improved my presentation skills through learning from the IAFP presenters, which gave me new ideas on what to do for my master's degree. I also got a chance to learn new field and lab methods of isolating *Campylobacter* and *Salmonella*, which are the key organisms that I am working on. (P. Njoki, KEMRI)

> IAFP was the first international conference I have participated in outside my own country, and for me it was priceless. I was able immerse myself into the scientist community, meet up with many professionals from different places in the world as well as my project's partners who have similar interest for food protection. This conference allowed me truly to develop my professional skill even stronger. I have never seen such many posters like this and presentation topics which were made available there. During their poster presentation, I had an opportunity to talk with them person-to-person about their projects and to understand what people were doing in their research field…These experiences help me to think more critically as well as adopting and enhancing a better skillset for my own development. (M. Chhoeun, RUA)

Next-generation pathogen detection: Sequencing wastewater in Kenya to establish baseline foodborne pathogen prevalence information

In FY2023, the FSIL ME, with leadership from Associate Director Dr. Randy Worobo and Postdoctoral Associate Dr. Jonathan Sogin, has made progress on a proof-of-concept project for rapid detection of foodborne pathogens and other organisms from environmental sources, including wastewater. In many low- and middle-income countries, the absence of definitive baseline data on foodborne pathogens is an obstacle to the science-based prioritization of research, training, and policy activities. Historically, researchers have overcome this by implementing large-scale sampling projects (e.g., swabbing the poultry value chain for *Salmonella*), which can take several months to years–assuming there is adequate in-country laboratory infrastructure to process and analyze samples. Without adequate laboratory infrastructure, sampling activities are severely limited and may yield little or no actionable information. A high-throughput, low-infrastructure method would facilitate the identification of the most important foodborne pathogens present in a locale, allowing researchers and policymakers to focus on the value chains which pose significant risks to public health and nutrition.

The ME's proof-of-concept method is capable of rapidly (<2 months)—and without significant in-country infrastructure—acquiring baseline pathogen information that yields useful information to researchers from several fields (e.g., agriculture, public health, and climate sciences). The method utilizes next-generation metagenomic sequencing, which can acquire genetic information from 100,000 or more organisms in a single sample. The resulting data yields the identities of organisms present in the sample including human, plant, and animal pathogens, and characteristics of those organisms including virulence and resistance factors. As shown during the COVID-19 pandemic, wastewater sequencing can yield community-level transmission data while eliminating the significant logistical hurdles involved with individual-level sampling. Paired with metagenomic sequencing technology, wastewater sampling can theoretically detect and characterize several pathogens from a single sample, thus presenting detailed community-level foodborne pathogen data. While metagenomic sequencing has existed for approximately a decade, detection of pathogens in wastewater samples is challenging because pathogens are typically present at very low quantities compared to 'background' organisms, including non-pathogenic bacteria, protozoa, metazoa, algae, and fungi.

In FY2023, the ME conducted small-scale proof-of-concept metagenomic sequencing of wastewater samples from Nairobi, Kenya and Ithaca, NY (for reference and comparison) for foodborne pathogen detection. The proof-of-concept sequencing method works as follows:

1) A trained individual takes environmental samples from desired locations and extracts deoxyribonucleic acid (DNA) from those samples using a commercial extraction kit;
2) The extracted DNA (stable at room or refrigeration temperature) is transported to a country capable of performing next-generation metagenomic sequencing;
3) A sequencing lab conducts the sequencing;
4) Researchers analyze the data to identify foodborne pathogens (or other organisms) using a high-performance computing cluster.

So far, the proof-of-concept project has yielded encouraging preliminary results. With sufficient sequencing depth, pathogens can be detected at relatively low concentrations (1 in 100,000 organisms), and wastewater has fewer background organisms than anticipated. The samples from Nairobi, Kenya contained several foodborne pathogens and a cattle parasite. In FY2024, the ME plans to conduct sampling at additional locations in Kenya to further test and refine this method.

Raising awareness of microbial food safety risks and mitigation opportunities

All of FSIL's projects continue to place a strong emphasis on increasing awareness of microbial food safety risks and measures to mitigate risks. Because the microorganisms which cause foodborne illness are not detectable to the naked eye and often do not alter a food's appearance or odor, people are often unaware of the prevalence of foodborne pathogens or of the connection between foodborne pathogens and illness. FSIL projects identify gaps in food safety awareness and host workshops and create outreach materials to address them. These awareness initiatives target producers, distributors, consumers, and—importantly—government officials, whose awareness is critical to implementing policies that will enable long-term, sustained improvements in food safety.

Bangladesh. In March 2023, FSIL's project in Bangladesh hosted a demonstration and dissemination event at one of the experimental fish ponds in Muktagacha, Mymensingh. The event effectively showcased the project's activities to individuals who can influence policymaking as well as local fish farmers interested in learning about safer fish production. Stakeholders in attendance included the Vice-Chancellor of Bangladesh Agricultural University, Director General of the Bangladesh Fisheries Research Institute, Deputy Director of the Department of Fisheries (Mymensingh Division), and more than 20 fish entrepreneurs and farmers. The project

team described project activities, including feed preparation, monitoring growth and weight of the fish over time, regular inspection of ponds, harvesting and selling fish, and future work plans. They also shared results, including that contamination from heavy metals and antibiotic residues were typically within acceptable limits for both fish raised using best management practices and control fish representative of fish typically purchased in the market in Mymensingh, although contamination levels were higher in the control fish. In addition, Dr. Samina Luthfa (University of Dhaka) presented results from a gender analysis. She noted that that although women have a major role in all aspects of fish farming, they have almost no decision-making power and that engaging with women offers great potential to strengthen the food safety of fish produced in Bangladesh. Results from the project will continue to be shared with farmers and policy makers to promote safer fish farming in Bangladesh.

Cambodia. FSIL's project in Cambodia has been conducting rigorous behavior research to increase awareness of food safety risks and promote the adoption of food safety practices. The researchers recognize that increasing awareness is only one critical factor of successful behavior change, and they used the Capability, Opportunity, Motivation-Behavior (COM-B) model to identify other potential barriers to behavior change. Within the COM-B model, capability captures an individual's psychological and physical capacity, including awareness and skills; opportunity encompasses outside factors that make the action possible, such as access to resources; and motivation covers the mental processes that spark action, including identity, beliefs, and emotions. Taken together, COM-B data can both identify the major obstacles to behavior change and identify low barrier areas where intervention could have greater immediate success. The team also conducted a survey to understand perceptions and awareness of food safety. They are using the social-behavioral data to develop two food safety curricula that will be used to increase awareness of microbial food safety and encourage behavior change.

Nepal. FSIL's project in Nepal conducted knowledge, attitude, and practice (KAPs) surveys among household consumers and vegetable producers. Although final analysis of the results is still in progress, a preliminary analysis revealed that knowledge of microbial food safety was relatively low among consumers and producers, and the identified gaps in knowledge have been used to inform development of a food safety training manual and training sessions for producers and extension agents. The materials are being created in collaboration with a Food Safety Working Group that was convened by project partners and includes representatives from the Agriculture and Forestry University, the Department of Agriculture of the Nepal Government, the Nepal Agricultural Research Council, and FAO-Nepal.

Management Entity Presentations

Oliver, H. (2022). Research Strategies Addressing Food Safety in LMICs. Presentation at International Congress of Nutrition, Virtual.

Oliver, H. (2023). Feed the Future Innovation Lab for Food Safety. Presentation at the Agrilinks Food Safety Month, Virtual.

Oliver, H. (2023). Feed the Future Innovation Lab for Food Safety (FSIL). Lecture at the University of Florida's International Development course, Gainesville, Florida, United States.

Oliver, H. (2023). Feed the Future Innovation Lab for Food Safety (FSIL). Presentation at the USAID Workshop for Mission Staff, Washington, D.C., United States.

Oliver, H. (2023). Food safety and food security research strategies to solve this global challenge. Lecture at the Purdue University's Innovation Hub training for Indiana regional college students, West Lafayette, IN, United States.

Oliver, H. (2023) Health Equity Initiatives. Presentation at Purdue University's Department of Nutrition Departmental Seminar, West Lafayette, IN, United States.

Worobo, R. W. (2023). Big Data and FSIL. Presentation at Neogen Food Safety Meeting, Pittsburg, PA, United States.

Worobo, R. W. (2023). Food Safety and the Food Safety Innovation Lab. Presentation at Cornell University, Ithaca, NY, United States.

Issues

Kenya

The PI leading the project at The Ohio State University (OSU) moved to a new institution in late FY2023, and OSU determined that she could not maintain PI status on the project as an adjunct faculty member. Further, OSU could not find a suitable replacement PI, largely due to complexities with the project for Institutional Review Board (IRB) approvals. As a result, OSU decided to relinquish the award, effective August 31, 2023. This action also canceled the second-tier subawards that OSU held with the collaborating institutions on the project and temporarily paused all project activities. To expedite completion of the project, FSIL expects the project to continue under the leadership of the Kenya Medical Research Institute (KEMRI) and the University of Nairobi, which have already granted initial IRB approval for the work. In early FY2024, FSIL will work with the PIs at KEMRI and the University of Nairobi to update the scope of work for the project and submit to USAID a request for consent for the new subawards. A request for consent to a no-cost extension will also be submitted, as work will likely not be able to restart until late Q2 FY2024.

Nigeria

The project has faced financial challenges due to political changes in Nigeria. A long-standing fuel subsidy was removed at the end of May 2023, which caused fuel prices to approximately triple and for inflation rates to rise to their highest level in nearly 20 years (26.7%)[9]. This has resulted in increased costs for all aspects of the project. To adjust for the increased costs, the FSIL ME worked with the project team to update their budget for the remainder of the project and have submitted a request to USAID to increase the overall budget. The team has also faced challenges because the process of receiving money from the U.S., converting it to naira, and making it available for use by the project team is slower than anticipated. To help streamline the payments, the FSIL ME has offered to take on the co-PI consulting agreements directly.

[9] https://www.reuters.com/world/africa/nigerias-inflation-rises-2672-yy-september-2023-10-16/

Future Directions

Management Entity

In FY2024, the FSIL management team will continue holding monthly meetings with each subaward to monitor activities and provide guidance. As projects complete their final objectives, ME support for projects is expected to focus on translating research results into actionable recommendations for the public and private sectors, including through the development of policy briefs. Members of the ME will also attend in-country project wrap-up with project teams and local stakeholders to assist with amplifying the communication of project outcomes, building connections to scale up food safety practices and policies, and identifying future research priorities.

The program's third in-person annual meeting will be held in November 2023 in Phnom Penh, Cambodia. FSIL project leaders will share updates and future plans for their projects. The FSIL ME will organize sessions to promote sustainable outcomes from projects, including effective engagement with local actors, development of policy briefs, and effective communication. USAID, Advisory Committee members, and Technical Experts will share feedback on project activities and on future directions for FSIL.

FSIL will continue promoting project activities and accomplishments through quarterly e-newsletters, LinkedIn, X (formerly Twitter), and Agrilinks. In FY2024, these communications will focus largely on sharing project results and outcomes. In late spring 2024, FSIL will host a webinar series to share results and learnings from the six subawards. Purdue's Ag Data Services will continue to support FSIL with data sharing on Harvard Dataverse and the DDL, with a majority of the datasets from FSIL's current projects expected to be uploaded in FY2024. The Gender Working Group, comprised of gender leads in each focus country, will continue to meet quarterly to share lessons learned, provide support, and strengthen the community of gender researchers in food safety projects. The FSIL management team will continue to foster relationships with USAID Missions and other implementing partners to identify opportunities for collaboration and knowledge sharing.

Bangladesh Long-Term Subaward

Researchers will complete the ongoing second field trial of best management practices for fish production and conduct a cost-benefit analysis of best management practices to address a knowledge gap that was previously identified by stakeholders. Findings from the research on best management practices will be disseminated through a training manual for producing safer fish, and trainings will be conducted with the Bangladesh Food Safety Authority (BFSA). The team will also complete the ongoing KAPs surveys, choice experiments, and FGDs and analyze the data. For the choice experiments, they will estimate a regression model to quantify the impact of safety attributes on consumer WTP and evaluate the impact of information related to food safety on WTP. Results and recommendations from the project will be shared through a stakeholder meeting with representatives from the feed industry, government, fish farmers, and fish farming cooperatives.

Cambodia Long-Term Subaward

In FY2024, researchers will complete a WTP study using a choice experiment to determine consumer WTP for certified safe vegetables, and they will complete analysis for the longitudinal study, whole genome sequencing, and gender analysis and submit manuscripts for publication. The learnings from these studies will yield insights about critical control points in the produce value chain, which will be combined with findings from the previously completed behavior research to identify and recommend priority interventions for improving safety of fresh produce in Cambodia. These recommendations will be shared through policy briefs and stakeholder meetings. The team will also complete design of the food safety curricula that are being developed for students and vegetable producers, distributors, and vendors and then deliver and assess the courses. In continuing capacity building efforts, the team will deliver a course on scientific writing for graduate students and faculty affiliated with the project. This course will be the last in a series of courses that have focused on experimental design, methods, and data analysis. Taken together, these courses aim to provide all team members with the

skills necessary to produce and report the high-quality and repeatable results necessary to improve food safety in Cambodia.

Kenya Long-Term Subaward

In the first half of FY2024, the project will focus on updating the scope of work and budgets due to the restructure of collaborating institutions after OSU relinquished the award. The team will also update sampling plans and laboratory protocols based on the updated project scope. Additional work will depend on the updated scope of work, but it is expected to include baseline sampling for prevalence of *Salmonella* and *Campylobacter* along the poultry value chain in peri-urban Kenya and finalizing the manual on safer poultry production and processing methods that was drafted in FY2023. Data analysis from the gender study will also be completed, and manuscripts to share the results will be drafted and submitted for publication in peer-reviewed journals.

Senegal Long-Term Subaward

The team will complete analysis of the survey data on production, processing, and involvement of women and youth in the dairy value chain and submit manuscripts for publication in each of those three areas. The survey results will also inform a sampling plan to collect milk samples for microbiological analysis from farms and mini-dairies. The analysis will include aspects of milk quality and mastitis management as well as pathogens and indicators of pathogens, and it will provide crucial baseline data on the safety concerns for dairy and dairy products in Senegal to inform future interventions and research. Learnings from the data will be used to develop trainings for actors in the dairy value chain, and they will be shared through policy briefs, white papers, and articles in local food and dairy industry magazines in Senegal.

Nepal Short-Term Subaward

In FY2024, the project team will complete the remainder of their planned project activities. The results of the *E. coli* prevalence data in household and agricultural water, food safety KAPs survey of fresh produce growers, and choice experiment among youth will be disseminated as additional or new conference presentations, journal articles, and/or policy briefs. The team will complete the remaining produce safety workshops in early FY2024; based on the delivery of the workshops, grower training needs will be noted and disseminated to policymakers and integrated in the food safety training manual for fresh produce growers that is currently in development. The food safety training manual for fresh produce growers will be completed in collaboration with the FSWG and presented to the Government of Nepal for use as a resource for extension workers and educators. As a culmination of the entire project, the team will collaborate with the FSWG, with navigational support from the USAID Nepal Mission, to host a produce safety policy workshop to present the findings of their work and how best to integrate produce safety policy into the Government of Nepal's next five-year plan.

Nigeria Short-Term Subaward

The team will complete data collection for the Our Voice activity during early FY2024 and then conduct interviews and panel discussions with key stakeholders—including primary health care providers, community development personnel, representatives from the State Ministry and civil societies, and community-based organizations—to understand the extent to which strategies described in the Nigerian National Policy on Food Safety are recognized and implemented. The team will use the data to develop geographic information systems (GIS) maps showing community-level foodborne illness vulnerability and story maps that include data from the Our Voice activity to create a geo-narrative. Finally, the team will bring together key stakeholders, including youth, mothers, primary health care providers, community development personnel in Local Government Areas, representatives from the Ministry of Health, and community organizations, to share results from the study and to identify and prioritize programs and policy actions to improve household food safety through nominal group technique discussions.

Appendix A – List of Awards to U.S. Partners

Project Name: Feed the Future Innovation Lab for Food Safety (Management Entity)
Project Dates: 06/25/2019 to 06/24/2024
Institution: Cornell University
Funding:

- FY2023: $408,237
- Project to date: $1,581,929

Project Name: Enhancing Food Safety in Fish and Chicken Value Chains of Bangladesh (Bangladesh Long-Term Subaward)
Project Dates: 10/01/2020 to 3/31/2024
Institution: Texas State University
Funding:

- FY2023: $0
- Project to date: $312,339

Project Name: Reducing Foodborne Pathogen Contamination of Vegetables in Cambodia: Innovative Research, Targeted Interventions, and Impactful, Cambodian-Led Engagement (Cambodia Long-Term Subaward)
Project Dates: 10/01/2020 to 3/31/2024
Institution: Kansas State University
Funding:

- FY2023: $162,417
- Project to date: $583,149

Project Name: Reducing Foodborne Pathogen Contamination of Vegetables in Cambodia: Innovative Research, Targeted Interventions, and Impactful, Cambodian-Led Engagement (Cambodia Long-Term Subaward)
Project Dates: 10/01/2020 to 3/31/2024
Institution: Purdue University
Funding:

- FY2023: $34,312
- Project to date: $73,580

Project Name: Chakula Salama: A Risk-based Approach to Reducing Foodborne Disease and Increasing Production of Safe Foods in Kenya (Kenya Long-Term Subaward)
Project Dates: 10/01/2020 to 3/31/2024
Institution: The Ohio State University
Funding:

- FY2022: $128,867
- Project to date: $570,411

Project Name: Food Safety Capacity Building in Senegal: Enhancing Resilience of the Dairy Value Chain by Leveraging Public-Private Partnerships (Senegal Long-Term Subaward)
Project Dates: 10/01/2020 to 3/31/2024
Institution: University of Georgia
Funding:

- FY2023: $200,000
- Project to date: $599,999

Project Name: Drivers of Safer Food Production and Consumption in Nepal: Understanding the Adoption of Food Safety Practices and Consumer Consciousness in Fresh Produce (Nepal Short-Term Subaward)
Project Dates: 03/01/2022 to 02/28/2024
Institution: Tennessee State University
Funding:

- FY2023: $98,843
- Project to date: $163,477

Project Name: Drivers of Safer Food Production and Consumption in Nepal: Understanding the Adoption of Food Safety Practices and Consumer Consciousness in Fresh Produce (Nepal Short-Term Subaward)
Project Dates: 03/01/2022 to 02/28/2024
Institution: Arizona State University
Funding:

- FY2023: $19,121
- Project to date: $37,567

Project Name: Household-level Food Safety Risk and Community Capacity to Monitor and Mitigate Foodborne Illness in Nigeria (Nigeria Short-Term Subaward)
Project Dates: 05/01/2022 to 04/30/2024
Institution: University of Alaska Fairbanks
Funding:

- FY2022: $0
- Project to date: $60,383

Project Name: Household-level Food Safety Risk and Community Capacity to Monitor and Mitigate Foodborne Illness in Nigeria (Nigeria Short-Term Subaward)
Project Dates: 07/01/2022 to 04/30/2024
Institution: Utah State University
Funding:

- FY2023: $40,914
- Project to date: $68,852

Appendix B – Success Stories

Success Story 1: Intensive Course Strengthens Statistics Capacity for Cambodian-Led Agricultural Research

Cambodia – September 1, 2023

From informing an experiment's design to interpreting results, statistics help identify which findings should be translated into policy and practice. Because statistics expertise is a key part of strengthening agricultural research capacity, researchers with the Feed the Future Innovation Lab for Food Safety (FSIL) held an intensive week-long agricultural statistics course at Cambodia's Center of Excellence for Sustainable Agricultural Intensification and Nutrition (CE SAIN) at the Royal University of Agriculture (RUA) in Phnom Penh. The 24 participants included students, faculty, postdoctoral fellows, and research associates from CE SAIN, RUA, the Institute of Technology of Cambodia (ITC), and the Institut Pasteur du Cambodge (IPC).

"This statistical modeling training program has been incredibly beneficial to me as a researcher, allowing me to enhance my skills and improve the overall quality of my research," said Oudam Heng, ITC lecturer and researcher. "Prior to participating in this training session, I faced significant challenges when it came to selecting an effective method for analyzing and interpreting my research data in a more scientific manner. In addition to gaining a deeper understanding of statistics, this program has also provided me with valuable knowledge on designing studies with adequate power to reach conclusive results."

The course was taught by Dr. Nora Bello, professor of systems modeling in the Department of Animal Sciences at The Ohio State University and co-PI of a FSIL-funded, Cambodian-led research project to reduce foodborne pathogens in nutritious but highly perishable salad vegetables in Cambodia.

The statistical topics covered, selected based on a pre-course survey that assessed the local research needs and the background knowledge of a sample of participants, included experimental design and the selection of appropriate statistical methods for data analysis. Lectures, class discussions, and hands-on practical data analysis exercises using statistical software drew on relevant datasets from on-going local collaborations.

In addition, consulting sessions with Dr. Bello helped researchers specify a statistical model tailored to their research project. Further support included troubleshooting how to fit the model to their data and how to conduct testing and articulate results. And because consulting sessions were open to all attendees, the class worked as a group to practice statistics using the wide range of research projects and data brought forward by their peers.

Bello also shared examples of how to describe the methods and results for different statistical analyses in a journal article. This and other collaborative course activities were intended to bridge what Bello feels is an increasingly urgent global gap between domain-specific scientific research and statistical expertise—one that she notes is crucial for research to retain its credibility and impact on decision making.

"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," said Bello. "We need to be training students that can take the baton further. The need for training in more sophisticated methods of data analyses is but a natural consequence of growth in research capacity."

Photo caption: Students and researchers from the Center of Excellence for Sustainable Agricultural Intensification and Nutrition (CE SAIN) at the Royal University of Agriculture (RUA), Institut Pasteur du Cambodge (IPC), and Institute of Technology of Cambodia (ITC) participated in a week-long statistics course to bolster local capacity in experimental design and data analysis (Photo credit: Nora Bello)

Success Story 2: Detecting Foodborne Pathogens in Dairy: Strengthening Research Partnerships and Capacity in Senegal

Senegal – August 9, 2023

The rapid growth of Senegal's dairy sector has outpaced the implementation of food safety practices and policies to reduce the risk of foodborne disease from the consumption of raw and fermented milk. Outreach by a project funded by the Feed the Future Innovation Lab for Food Safety (FSIL) has equipped partners at the Institut de Technologie Alimentaire (ITA) and the Institut Sénégalais de Recherches Agricoles (ISRA) with knowledge and tools to detect and identify foodborne pathogens in the domestic milk supply.

"To date, Senegal's milk production and processing industries have not yet been thoroughly studied beyond a literature review and a handful of student theses," said Dr. Woubit Abebe, professor and director of the Center for Food Animal Health, Food Safety, and Food Defense in the Department of Pathobiology at Tuskegee University and co-principal investigator (PI) of the FSIL dairy safety project. "I think this project will provide a breakthrough in understanding the major pathogens associated with milk quality and safety in Senegal."

With Abebe, the teams at ITA and ISRA worked through detailed protocols outlining the method that will be used for microbial assessment – from sample size determination and sample collection to genetic analysis of pathogenic bacteria. At ITA, the academic home to the project's in-country co-lead Dr. Cheikh Ndiaye, Abebe introduced lab staff to food safety lab techniques to identify milk from cows with mastitis and other infections that increase the risk of foodborne illness. They included inexpensive commercial testing kits whose use is widespread in the United States and other countries but not yet common in Senegal.

At ISRA, Abebe worked with staff including Dr. Fatou Tall Lo, head of the microbiology department, and engineer Aida Diop, focusing on genetic analysis to identify foodborne pathogens in milk samples. These tools will enable the labs to process samples to isolate, characterize, and identify priority organisms for Senegal's milk safety.

"We were honored to have Dr. Abebe in our lab and have her share her experience with mastitis diagnosis and milk quality assessment, we intend to strengthen this collaboration through the project's activities," said Dr. Lo. "The procedures she shared are being adapted in the laboratory, particularly for genetic diagnosis. The supplies she brought for detection of certain foodborne pathogens will allow us to better improve research for better food security."

The data on foodborne pathogens in milk will be used to develop outreach programs to strengthen food safety during milk production, raise awareness about food safety issues, and inform science-based food safety regulations. Long-term, sustainable change will require strong local research capacity, and the partnership with colleagues at ISRA and ITA fuels Abebe's optimism.

"I found the people to be wonderful, very cooperative, and ready to proceed and help out," she said. "Their capabilities are exactly what we need to conduct the research."

Photo caption: Researchers at the Institut de Technologie Alimentaire (ITA) participate in trainings in food safety lab techniques to detect foodborne pathogens in milk and dairy products. (Photo credit: Woubit Abebe)

Success Story 3: Challenging Gender Norms and Creating Opportunities Through Capacity Strengthening for Fieldwork

Nepal – September 15, 2023

When Rita Gurung was a graduate student in India, she witnessed her male friends finding paid research fieldwork positions and wondered what cultural assumptions about women's aptitude or suitability for fieldwork were limiting her access to these opportunities.

"Professors and project leaders routinely excluded female students from fieldwork because they thought they couldn't safely send the women alone in rural areas, or that their efficiency would not be on the same level as the men," said Gurung.

Now an Assistant Professor at Nepal's Agriculture and Forestry University, Gurung is determined to create career-building opportunities for both male and female students. As project co-PI and gender specialist with the Feed the Future Innovation Lab for Food Safety, she started by recruiting and training six female and four male graduate students to conduct a large-scale survey of farmers' food safety knowledge, attitudes, and practices across farming communities in Nepal. Her goals: integration of classroom theory with real-world practice, strengthening local research capacity, and challenging gender norms for field research.

Trainings covered survey methods, the Qualtrics survey app, food safety and gender, and challenging situations they might encounter in the field. The team successfully conducted 1,057 surveys in 10 districts, collecting valuable data on current food safety knowledge and practices for the project. In addition, Gurung observed the female students developing confidence in dealing with the challenges of rural fieldwork and skills in communication, while keeping pace with their male peers in meeting daily quotas.

Beyond learning about best practices in survey execution—including sample size considerations and use of Qualtrics—female participants shared that they gained perspective on the diversity of agricultural practices and challenges farmers face in providing safe, nutritious food for consumers. In addition, they learned the value of teamwork in dealing with unexpected situations in the field. Communicating with farmers of both genders from different regions gave enumerator Shila Bashyal, an M.S. student in horticulture at AFU, the opportunity to develop research skills not possible in a classroom setting.

"The training enumerators receive before a survey usually focuses on what questions need to be asked, in which order they should be asked, and how they should be asked, but this prepares us to get only 50% of the answers," said Bashyal. "The rest requires communication and interpersonal skills that we ourselves must develop."

"Professionally, it enhanced communication skills and increased my confidence level," said AFU M.S student Bandana Thapaliya. "Moreover, I worked with different communities different from my own, fostering a deeper understanding of cultural diversity and sensitivity. I came across the different cultivation practices used by farmers in different parts of the country and even the farmers' perspectives regarding the use of pesticides and food safety."

Thapaliya suspects that challenging fieldwork gender norms will be beneficial to the project—and beyond.

"In a few communities, especially in the Terai regions of Nepal, female respondents found female enumerators easier to interact with," she noted. "And they were quite empowered seeing us doing research and visiting different places in Nepal."

Photo caption: Social science skills, including conducting surveys, enable researchers to understand and address current food safety knowledge, attitudes, and practices, such as those used by this Nepali vegetable farmer. (Photo credit: Kathacharya Productions/FSIL)