



FEED THE FUTURE

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



**FEED THE FUTURE INNOVATION LAB
FOR THE REDUCTION OF POST-HARVEST LOSS**

ANNUAL REPORT

October 1, 2019-September 30, 2020



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UNIVERSITY

PHLIL External Advisory Council:

Dr. Robert Zeigler, Chair

- Director General (Emeritus) of the International Rice Research Institute

Dr. David Priest

- Chief Executive Officer of Farm Input Promotions Africa, Ltd.

Brett Rierson

- Managing Director of African Harvest Ventures

See their full bios at <https://www.k-state.edu/phl/about-the-lab/advisory.html>.

Where we work:



The Post-Harvest Loss Innovation Lab has comprehensive post-harvest programs in our four core countries of **Bangladesh, Ethiopia, Ghana, and Guatemala**.

In addition, PHLIL has wrapped up Mission Buy-In projects in Nepal and Honduras, with supplemental funds from the USAID Bureau for Food Security, and a previous Mission Buy-In in Afghanistan.

PHLIL benefits from significant cost-share investments from our partners, including substantial investment from Kansas State University and University of Illinois' ADMI Institute for the Prevention of Post-Harvest Loss.

Cover Photo:

PHLIL team operations around the world adapted in light of the ongoing COVID-19 pandemic that overshadowed much of FY20. In Ghana, Agricultural Extension Agent, Jennifer Anankani, displays a GrainMate moisture meter. Jennifer is part of a team of trainers affiliated with Sesi Technologies who are training smallholder farmers on how to measure moisture content to ensure their grain is properly dried, a basic and essential step to preventing postharvest losses.

Phase II (2019-2021) Program Partners

United States

Feed the Future Innovation Lab for Livestock Systems
Feed the Future Innovation Lab for Nutrition
Feed the Future Innovation Lab for Collaborative Research on Sustainable Intensification (Appropriate Scale Mechanization Consortium)
Helen Kellerr International
Iowa State University
Kansas State University
Michigan State University, Scientific Animations Without Borders
Oklahoma State University
Piestar
Purdue University - Purdue Improved Crop Systems (PICS) project
Romer Labs
South Carolina State University
University of Illinois at Urbana-Champaign, ADM Institute for the Prevention of Postharvest Loss
University of Kentucky
University of Nebraska – Lincoln
United States Department of Agriculture – Agricultural Research Service (USDA-ARS), Center for Grain and Animal Health Research

Bangladesh

ACI Motors, Ltd.
Bangladesh Agricultural Development Cooperation, Government of the People’s Republic of Bangladesh
Bangladesh Agricultural University
Bhai Bhai Engineering
Department of Agricultural Extension, Government of the People’s Republic of Bangladesh
GH Electronics
Jagorani Chakra Foundation
Kamal Machine Tools
Uttaron Engineering

Ethiopia

Ethiopian Institute of Agricultural Research
Bahir Dar University
Mekelle University

Ghana

Adventist Development Relief Agency (ADRA)
Agri Commercial Service Ltd.
American Soybean Association World Initiative for Soy in Human Health – Assisting Management in Poultry Layer Industry by Feed Improvement and Efficient Strategy (AMPLIFIES) project
Kwame Nkrumah University of Science and Technology
Ministry of Food and Agriculture (Northern and Upper West regional offices)

Guatemala

Asociación de Organizaciones de Los Cuchumatanes (Asocuch)/International Maize and Wheat Improvement Center (CIMMYT) – Buena Milpa project
Fundacion para Desarrollo Integral de El Tejar (FUNDIT)
SHARE Guatemala

Universidad del Valle

Additional Partners

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) (Germany; in Ghana, Ethiopia)
Mars Global Food Safety Center (China)
Nepal Academy of Science and Technology (Nepal)
Vestergaard Frandsen (Switzerland)

Acronyms

ADRA – Adventist Development Relief Agency
AMPLIFIES – Assisting Management in Poultry Layer Industry by Feed Improvement and Efficient Strategy
ASMC – Appropriate Scale Mechanization Consortium
BAU – Bangladesh Agricultural University
BADC – Bangladesh Agricultural Development Corporation
BDU – Bahir Dar University
DAE – Department of Agricultural Extension
EIAR – Ethiopian Institute of Agricultural Research
FAO – Food and Agriculture Organization of the United Nations
HKI – Helen Keller International
KNUST – Kwame Nkrumah University of Science and Technology
KSU – Kansas State University
LPG – Liquefied Petroleum Gas
LSIL – Feed the Future Innovation Lab for Livestock Systems
ME – Management Entity
NAST – Nepal Academy of Science and Technology
PHL – Post-harvest loss
PHLIL – Feed the Future Innovation Lab for the Reduction of Post-Harvest Loss
PICS – Purdue Improved Crop Storage
PMP – Performance Management Plan
RCT – Randomized Control Trial
SAWBO – Scientific Animations Without Borders Organization
SIIL – Feed the Future Innovation Lab for Collaborative Research on Sustainable Intensification
STR – a low cost dryer made locally in Asia (acronym based on Vietnamese)
Uof I – University of Illinois at Urbana-Champaign
USAID – United States Agency for International Development
USDA-ARS – United States Department of Agriculture – Agriculture Research Service

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2020 Annual Report

Feed the Future Innovation Lab for the Reduction of Post-Harvest Loss

I. Executive Summary

The Feed the Future Innovation Lab for the Reduction of Post-Harvest Loss (PHLIL) is a strategic, applied, research and education program aimed at improving global food security by reducing post-harvest losses in stored product crops, such as grains, oilseeds, legumes, root crops and seeds. The Lab's efforts are focused in four Feed the Future countries: Bangladesh, Ethiopia, Ghana and Guatemala. Projects in each country are led by a U.S. or in-country Principal Investigator (PI) and in-country coordinators and overseen by the Lab's Director, with input from local and international academic, private sector, governmental and non-governmental organizations. In its seventh year, the program has continued making significant advances towards scalable innovation packages and cultivating the necessary capacity to reduce post-harvest losses at scale in our target countries.

The activities and outcomes of the first five years placed PHLIL in a strategic position to address the next stage of critical research questions. These include expanding research into areas such as kernel sorting to reduce mycotoxin contamination, safe alternatives to pesticide use and addressing market needs in drying technologies, while still addressing critical questions around barriers to adoption, effective extension and education and sustainable scaling, including gender and youth considerations in all of these areas.

From developing new research questions and designing research plans to building upon previously existing and new partnerships, the Post-Harvest Loss Innovation Lab's seventh year of operation was focused on continuing to reduce post-harvest losses across our core countries. Given the covariate shocks presented by the onset of the pandemic, efforts to secure the harvest were more important than ever. PHLIL team members worked hard to develop innovative adaptations to workplans in the face of operational challenges associated with the COVID-19 pandemic. As a result, the program met or exceeded all Feed the Future indicator targets for the year. **Significant achievements included:**

- **BANGLADESH:** inclusion of the BAU-STR dryer in Government of Bangladesh mechanization subsidy program with up to 5,000 dryers to be locally produced and sold in the next five years, successful adaptation of the BAU-STR dryer to use Liquid Petroleum
- **GHANA:** continued growth of Sesi Technologies and associated sales of the PHLIL-developed GrainMate moisture meter, rapid growth of Women in Poultry Association businesses due to adoption of post-harvest loss interventions in Ghana; University of Development Studies learning how to apply the Technology Gender Assessment Tool in their research and teaching
- **ETHIOPIA:** the PHLIL-inspired National Post-Harvest Advisory Committee in Ethiopia continuing to meet and mainstream evidence into decision-making and policy
- **OVERALL:** eleven peer-reviewed publications produced; post-harvest topics now integrated in university curricula in Bangladesh, Ethiopia, Ghana, Guatemala, Honduras and Nepal.

Moving into the last year of the program, national partners have become even more empowered as the program adapted to deliver without international travel during the pandemic. The research program in this second phase of activities (2019-2021) extends down the pathway to scaling to understand and remove potential barriers for inclusive and resilient improvements for target beneficiaries. Moving forward, the program will focus on transferring PHLIL innovations and going the last mile to ensure sustainability of in-country capacity that the program has worked to establish in the first seven years. An essential part of this

strategy has always been to cultivate inclusive partnerships to substantially contribute to global efforts to reduce post-harvest loss, promote agriculture-led growth, strengthen resilience of people and systems, and contribute to a well-nourished population.

II. Focus Country Key Accomplishments

Program-wide outputs, including for Feed the Future indicators, include:

- 668 short-term (35.6% female), and 17 long-term trainees (degree-seeking) directly supported by the program in FY2020
- 11 research publications
- 5 technologies transferred and/or ready to scale

Overall:

The PHLIL Management Entity and broader teams invested substantial effort over the course of more than half a year to adapt operationally and strategically to continue delivering during the COVID-19 pandemic. The program met or exceeded all of its Feed the Future indicator targets, an achievement that cannot be understated given the magnitude of the challenge. This aspect of managing the program consumed much of the bandwidth of the ME for much of the fiscal year.

By country:

In all four core countries, post-harvest loss innovation packages have begun scaling with next-users along the pathway to impact, followed intentionally by research into obstacles to and opportunities for scaling and impact. Selected key accomplishments by country include¹:

Bangladesh

- The Government of Bangladesh has included dryers with the specifications of the BAU-STR dryer into the official government agricultural mechanization subsidy program (exact dryer models are not allowed to be named for this subsidy, however the BAU-STR dryer is the only dryer that is locally produced, is much lower price than any imports and the only one that meets the specifications of the subsidy). This will result in up to 5,000 BAU-STR dryers being subsidized and distributed for use in Bangladesh in the next five years.
- A public-private partnership was forged with Moti Auto Rice Mill, wherein they are paying the majority of the cost associated with developing, piloting, adapting and conducting training with a new mid size dryer. The PHLIL team is working with them and local manufacturers to achieve local production, and calculations estimate that ~1.5 million smallholder farmers could benefit if 25% of medium scale, semi-automated local mills adopt this technology that they have been beseeching the PHLIL team to develop.
- KSU agricultural economics team is conducting a randomized control trial (RCT) to assess liquidity and risk constraints for the usage of hermetic storage bags for rice seed storage.

¹ Note that this is a subset of key accomplishments, for brevity; more detail is provided in subsequent sections.

- The burning unit of BAU-STR dryer was modified by using LPG (Liquefied Petroleum Gas) as a fuel instead of risk husk briquettes, allowing the dryer to be used in areas where risk husk briquettes are unavailable; LPG has wider availability than rice husk briquettes in some parts of Bangladesh.

Ethiopia

- The nascent National PHL Advisory Committee, which PHLIL in-country leadership and research outputs helped prompt the formation of, continued to meet regularly. The group both considered research-based evidence for national activity programming and identified further knowledge gaps that the PHLIL team are working to address with research.
- An integrated post-harvest management trial is being conducted on-farm, with mitigation technologies substantially reducing post-harvest loss issues. The National Post-Harvest Loss Advisory Committee requested this trial and is eager to help scale the innovations.
- Based on previous PHLIL connections with Global Good/Intellectual Ventures, the PHLIL team was approached by that organization and Arc'teryx to test a dryer that had been developed by this Bill Gates' initiative and Arc'teryx. Ethiopia was identified as a country to test the dryers and planning is underway to deliver prototypes for testing at Mekelle and Bahir Dar universities.

Ghana

- Sesi Technologies and the GrainMate Moisture Meter have continued to experience significant success. Isaac Sesi and his company, with guidance from Dr. Paul Armstrong (USDA-ARS, original developer of the EMC moisture meter, now named the GrainMate, under PHLIL) have continued working on improvements for release of a next, improved version in late 2020. Under PHLIL Phase I, the initial model was developed by Dr. Paul Armstrong (USDA-ARS), and adapted by Sesi Technologies in collaboration with USDA-ARS.
- PHLIL invested substantial effort to import ZeroFly Hermetic bags manufactured in Nigeria, for purchase and use by members of the Dormaa Chapter of the Women in Poultry Association (WPA) and smallholder farmers in Northern Ghana. Closure of the border with Nigeria and the pandemic presented substantial challenges, however the bags are now arriving in Ghana in late 2020.
- WPA producers have realized substantial growth and expansion in their businesses, due to adoption of PHLIL-featured practices and interventions. As a result, they have increasing demand for maize grain from smallholder farmers in Northern Ghana, and trucks going to purchase grain bring larger, nutritious eggs for sale.

Guatemala

- Activities in Guatemala were brought to a close, focusing on finalization of a survey with farmers in the lowlands for potential adaptation of the PHLIL post-harvest manual.
- PHLIL SHARE continues to use the PHLIL manual and post-harvest knowledge in work with smallholder farmers in the country.
- Walfer Martinez, a key member of SHARE and part of the PHLIL team, integrated post-harvest loss topics into his lectures at a university in Huehuetenango.

III. Research Program Overview and Structure

PHLIL focuses on several key areas with significant post-harvest challenges: **drying (including moisture measurement), storage, insect pest/pesticide alternatives** and **mycotoxin contamination**, as well as working with fumigation management and other issues. The program takes a phased approach to building human and institutional capacity, conducting research to develop and identify suitable innovations, and piloting innovation packages towards adoption and use for sustainable impact.

In addition, PHLIL recognizes and works to address and incorporate four cross-cutting components into our programming:

- **Gender:** Ensuring gender issues in post-harvest are incorporated into the research on technologies and approaches
- **Youth:** Ensuring young people are engaged in post-harvest loss prevention technologies and the appropriate scaling mechanisms
- **Engagement:** Ensuring our training materials and education strategy are supported by research
- **Agricultural Economics:** Ensuring our technologies are affordable and accessible to those that need them for their livelihoods, and assessing economic barriers to adoption

The PHLIL program establishes human and institutional capacity in every project country, empowering our national partners as innovation leaders and the champions to reduce post-harvest losses in their respective national systems.

IV. Theory of Change and Impact Pathway(s)

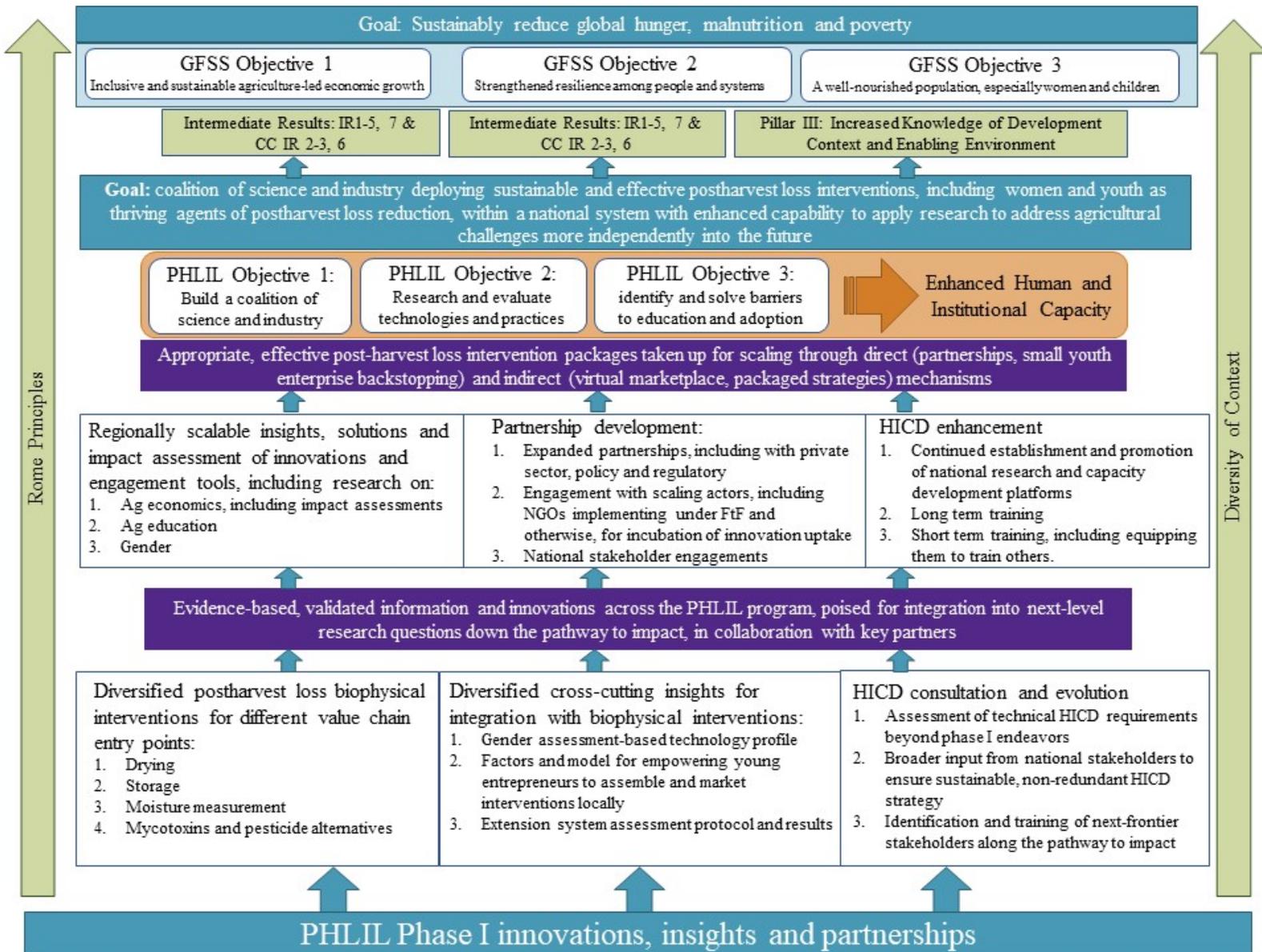


Figure 1: PHLIL Revised Program Description Theory of Change, for 2019-2021 program activities.

V. Research Project Report

Bangladesh

Focus crop: Rice

Location: Bogra, Jessore, Khulna, Sherpur, Mymensingh, Naogaon, and Netrokona

Collaborators: *University:* Bangladesh Agricultural University (BAU);

Government: Department of Agricultural Extension, Bangladesh Agricultural Development Cooperation;

NGO: Jagorani Chakra Foundation; Helen Keller International *Private-sector:* Bhai-Bhai Engineering, ACI

Motors Ltd., Uttaron Engineering, Kamal Machine Tools, GH Electronics, Moti Auto Rice Mill

Achievements:

Objective: The BAU-STR dryer will further be modified to use liquid petroleum gas (LPG) as a fuel source.

Stakeholder engagement and market assessments by the project team previously elevated development of a locally produced, LPG fuel-based version of the BAU-STR dryer. Since rice husk briquettes (fuel for the BAU-STR dryer already developed by PHLIL) are not universally available in Bangladesh, the project team has now successfully designed and tested a version that uses LPG and can be locally manufactured, as outlined below.

In order to design a LPG-based modified heating system, the following considerations were made:

- Heating unit should be capable of producing hot air of 42°C at the center of the inner bin.
- The burner can be made by locally available materials.
- Connection of the hot air pipe with the stove should be stable.

A suitable burner for LPG which can produce hot air of 42°C was selected from the local market. A temperature sensor was placed at the top of the inner bin to check the temperature during the testing. A high pressure regulator was used for controlling the flow of the LPG. To control the temperature in 42°C, the regulator was calibrated accordingly. A flow meter was also installed to monitor and record the amount of LP gas used during the experiment. A blower was made in the workshop by using locally available materials and the performance of the blower was measured. The modified blower's performance was similar to the imported Vietnamese blower on the original version of the STR dryer.

LPG BAU-STR dryer performance:

Technical and financial performance of the LPG-based heating system for the dryer was evaluated from May 4 - 25, 2019 in Boro season and November 25 - December 11, 2019 in Aman season. BRRI dhan28 (Boro season) and BRRI dhan49 (Aman season) were used as rice paddy seed/grain samples during the study. The dryer performance was evaluated by using combinations of two different heating units: rice husk briquette- and LPG-based, and two blowers: Vietnamese and locally manufactured. Three fuel/blower combinations were tested:

- **T1:** briquette plus locally manufactured blower; this is the extensively validated BAU-STR dryer that is already scaling in Bangladesh
- **T2:** LPG plus Vietnamese blower (LPG-imported)
- **T3:** LPG plus locally manufactured blower (LPG-local)

Each treatment was repeated three times. Temperature was maintained at 42±0.5°C for drying paddy seed. Results of the treatments can be found in the table below.

	Boro Season (May 4 through 25, 2019)		
	Treatment 1 Briquette/local blower	Treatment 2 LPG/imported blower	Treatment 3 LPG/local blower
Moisture Removal / Drying Rate	2.0% MC/hour	2.4% MC/hour	1.9% MC/hour
Drying Efficiency	60.16%	56.16%	56.90%
Germination Percentage of Seeds	86±1%,	91±2%,	93±2%
Operating Cost	Tk. 0.73/kg	Tk. 0.96/kg	Tk. 0.98/kg
Benefit-Cost Ratio	1.66	1.05	1.01
	Aman Season (November 25 through December 11, 2019)		
	Treatment 1	Treatment 2	Treatment 3
Moisture Removal / Drying Rate	2.0% MC/hour	2.0% MC/hour	2.1% MC/hour
Drying Efficiency	53.92%	65.37%	70.29%
Operating Cost	Tk .078/kg	Tk. 1.13/kg	Tk. 0.89/kg
Benefit-Cost Ratio	1.51	0.74	1.18

- The drying rate of paddy in every treatment was comparable, a sign of success since the BAU-STR dryer (rice husk briquette with locally produced blower) is highly effective at drying rice paddy in the field in Bangladesh.
- The drying efficiency of treatment 3 (LPG/local blower) was highest in Aman season.
- Germination percentage was highest in T3, indicating better seed quality after drying than the other dryer configurations.
- The payback period of each treatment was less than a year.

Collectively, these data provide compelling evidence that the newly developed BAU-STR dryer with a locally produced blower and LPG fuel source outperforms the already effective rice husk briquette version previously developed by PHLIL. It should be noted that the benefit-cost ratio is higher with the rice husk briquette STR dryer, however payback period is still projected to be less than one year for each of the three dryer models. Based on these technical, financial and seed quality analyses, the locally manufactured LPG-fueled BAU-STR dryer is the best drying options for the farmers and seed producers of Bangladesh.

Objective: Develop an appropriate scale dryer and mycotoxin testing for use on parboiled paddy rice for small-medium sized paddy traders and rice mills

The PHLIL program and stakeholders had identified medium-scale rice mill drying capacity as a critical opportunity to help accelerate ag-led growth for the benefit of smallholder farmers. This was also based on discussions during a country visit with PHLIL External Advisory Council Chairman and Director General Emeritus of the International Rice Research Institute, and the in-country and overall program management leadership. Smallholder farmers rely on their local, small-medium scale rice/husking mills to sell their paddy rice, however competition from larger, fully automated mills are threatening to push this category of more local mills out of business.

Consideration was given to how many smallholder farmers could potentially benefit from a dryer model that could be adopted by these semi-automated mills, helping them remain competitive and operational and

therefore affording access to market to local rice growers. An estimate with conservative assumption of 25% improved dryer uptake estimates that ~1.5 million smallholder farmers could potentially benefit from increasing competitiveness of this category of mills:

- A conservative assumption is that mills process 20 million MT per year.
- Assuming ~25% adopt the dryers, 5 million MT could be dried with the improved dryers the program is developing.
- On average, farms in Bangladesh produce 3.4 MT/yr;
 - 5 million MT/3.4 MT = 1.47 million farmers out of ~15 million farmers in Bangladesh.
- How were these ~1.5 million farm families affected?
 - The risk of not being able to sell at harvest due to moisture content (and rainfall) is removed.
 - Effectively insures that they are protected from severe price declines at harvest because mills that serve them will be able to buy.
 - Finally Boro and Aus harvest are ~60% of their total paddy harvest (Aman being the third harvest), so dryers could insure that the bulk of harvest that now is in a precarious position with respect to market has a more certain sales outlet.

Public-private partnership: characterizing insufficient drying capacity

The PHLIL research team visited a husking mill in Mymensingh and interviewed the key management personnel following a semi-structured questionnaire. The mill was thoroughly studied to characterize the milling process, technical capability, financial performance, main obstacle(s) to achieving full capacity and related needs.

While actual milling capacity of the husking mill was 1 ton/hour, lack of a dryer and reliance on simple sun-based drying limits the capacity to only 41.7%. The husking mill was using traditional technology such as drum boiler, husk-fired furnace, chimney to exhaust smoke, sun drying of paddy and Engelberg huller for milling. Lack of mechanical dryers, skilled operators, mechanics, spare parts, the ascendant strong syndicate of fully automated rice mills, role of commission agents and inadequate bank loans were identified as the critical challenges to the mill. The husking mill can operate 300 days in a year. Relying on natural sun drying, the mill can process 2 batches (12 ton per batch) of paddy in 3 days - 200 batches or 2,400 ton of rice paddy in 300 days. But this capacity is underutilized due to unavailability of an appropriate mechanical dryer. Milling capacity of 1 ton/hr. far outpaces sun drying capacity. To match milling machine capacity, daily drying capacity of 12 tons of rice paddy is required, which more than doubles the overall operational capacity. The one and only way to realistically achieve this drying capacity is with a 12 ton/batch capacity mechanical dryer, which the mill was very interested in adopting. Further surveys paused due to sudden COVID 19 pandemic situation, and further engagements will be conducted using prepared semi-structured questionnaire.

PHLIL-led experiments at Moti-Auto rice mill will be conducted to characterize and optimize its technical and financial performance. The experiment will measure the total drying time, moisture removal rate, drying efficiency, and fuel consumption rate and grain loss. The head rice recovery and overall capacity utilization of the mill will also be measured. Financial analysis will compare the mechanical dryer with existing sun drying on the concrete floor.

Achievements

- Moti-Auto rice mill (and others) is seeking a twelve-ton per batch capacity appropriate mechanical dryer, so drying capacity can match milling capacity.
- A Memorandum of Understanding (MoU) has been signed with Moti Auto Rice mill, Shyamgonj, Mymensingh where the dryer will be installed and used as experimental site. In this new PHLIL Public-Private partnership, Moti-Auto rice mill is providing ~70% of the cost for manufacturing the re-circulating batch dryer. Furthermore, they are providing access to PHLIL to conduct the associated drying experiments and training demonstrations using this dryer in their mill.

- Bondhu Engineering, Jamalpur has been selected for manufacturing the re-circulating batch dryer after an assessment of appropriate local manufacturers. They have started manufacturing the dryer with the guidance of the PHLIL-Bangladesh team.

Collection and test of paddy samples (Aman season) from storage of rice mills for investigation of mycotoxin contamination

Following initial work by PHLIL to sensitize stakeholders and measure mycotoxins in rice, millers have continued to seek assistance from the BAU team to analyze their samples. This has been used as an opportunity to continue engaging these stakeholders and extend mycotoxin analysis of rice on a limited scale.

- In Boro 2019, a total of 36 paddy samples were collected from rice mills of 3 districts (Mymensingh, Sherpur and Netrokona) in 4 categories (Auto Rice Mill, Semi-Auto Rice Mill, major Husking Mill and small Traders) for investigation of mycotoxin contamination. The samples were tested at the PHLIL-established Interdisciplinary Institute for Food Security (IIFS) Laboratory, BAU, Mymensingh for the investigation of mycotoxin contamination. The samples from major rice mills were tested for detection of Aflatoxins and Fumonisin. Both Aflatoxin (reference value: 20 ppb) and Fumonisin (reference value: 3.5-3.8 ppm) levels were below the limit in all samples.
- After harvesting Aman paddy 2020 (storage period January to May 2020), a total of 36 paddy samples were collected again during the COVID- 19 pandemic from the same locations for investigation of mycotoxin contamination, using appropriate pandemic-associated safety measures. No Aflatoxin contamination was observed within the reference value, and samples had Fumonisins less than 3.5 ppm.

Objective: Test and promote hermetic storage for seed in collaboration with the Bangladesh Government

PHLIL is collaborating with Bangladesh Agricultural Development Corporation (BADC), the Bangladesh Government's seed producing institution which supplies 38% of rice seed in the country, to conduct experiments investigating the technical and financial performance of hermetic bags for storing seed. These experiments took place at BADC Seed Processing Center and Paddy Seed Storage at Balashpur, Mymensingh and Madhupur, Tangail. Based on the experiments in Aman and Boro seasons at BADC seed processing centers, detailed technical and financial analyses of hermetic GrainPro bags and cocoons, along with existing traditional bulk seed storage practices, are being carried out for determining the best management practices of paddy seed storage.

Using a Completely Randomized Design (CRD) with three replications, the project compared hermetic storage (GrainPro bags) with traditional jute storage bags. Fifteen 40-kg bags were placed on wooden pallets in the BADC storage facility, and measurements were taken every 15 days for three months. Once a hermetic bag was opened, it was not used again for measurements. Moisture content, germination rate, and insect infestation rates were recorded, with data analysis ensuing. From the experiments of the Aman season (January – May 2020), seed storage with hermetic bags was found technically suitable for paddy seed storage. With engagement of the PHLIL research team, BADC observed that compared with their existing large scale storage practices at BADC, use of hermetic storage technology reduces the necessity and cost of: fumigation/insecticide treatment, re-drying and re-lotting, periodic moisture measurement & germination tests, and operator/technician wages. Essentially, use of hermetic bags for seed storage on BADC premises eliminates the need for all of the intermediate activities done in traditional storage practices; seeds can be stored and later used without any intervening management activities.



Photo: PHLIL works with BADC to set up on-site trials comparing hermetic bags with their typical paddy rice seed storage practices.

Demonstration and monitoring of hermetic bags at selected Department of Agricultural Extension intervention Farmer Field Schools

PHLIL conducted training at DAE Farmer Field Schools to continue sensitizing and training key stakeholders and potential adopters. A total of 108 GrainPro bags were distributed amongst the farmers for storing paddy seed during the Aman season (FY19) in Phulpur, Mymensingh, Sherpur, Bagura, and Wazirpur, Barishal. A two-day long training program on “Addressing Economic Constraints of Technology Adoption for Post-harvest Practices and Rice Seed Storage in Bangladesh” was also conducted jointly with Helen Keller International (HKI) - Bangladesh for enumerators. Participants in the training program learned proper usage and storing of paddy seed in hermetic bags. After the experiments were set up at BADC seed processing centers, some of the activities such as demonstration and monitoring of hermetic bags at the field level study sites could not be done physically due to the COVID-19 pandemic. PHLIL-Bangladesh team members are in communication over cell phone with the lead farmers of the study in order to continue motivating the farmers to use hermetic bags for paddy seed storage.

Achievements

- From the experiments of Aman/2020, seed storage with hermetic bags was found technically suitable for paddy seed storage. Hermetic bag experiments at the BADC premises demonstrated that they eliminate the need for all the intermediate activities required in their traditional storage practices (eg, periodic moisture measurement, re-drying, fumigating).
- For Boro/2020, a BADC bulk paddy seed storage trial comparing hermetic cocoons, GrainPro bags and their traditional practices has been set up successfully in Madhupur. Given that it was established during the COVID-19 pandemic, appropriate safety measures were observed.
- O₂ and CO₂ levels inside the hermetic storage technologies were measured successfully in first 31 days of storage during the pandemic situation

PHLIL Ag Economics team randomized control trial on liquidity and risk for hermetic bags

The PHLIL agricultural economics team (faculty at Kansas State University) have been testing the purchase and use of hermetic bags by smallholder farmers in Bangladesh to determine the economic factors that may support or prevent adoption of these technologies for rice seed storage. A smooth and successful partnership formed between three research entities working on this study: Kansas State University, Bangladesh Agricultural University, and Helen Keller International (HKI) – Bangladesh.

The research design (sampling strategy, survey models, and experimental design) was finalized and pre-registered with the American Economic Association’s Randomized Control Trials registry. With the assistance of Helen Keller International – Bangladesh, the baseline survey data collection was completed by late 2019. Preliminary examinations of the baseline data have been completed, and notably the data secured from Sherpur and Narail districts are of high quality. The data will help the team to understand the demand

for hermetic bags and production practices in general, particularly for post-harvest practices. Also of note: in the process of collecting data, 126 GrainPro bags were supplied to households who won the auction.

Due to the COVID-19 pandemic, the endline survey originally scheduled for late FY2020 has been postponed. The Ag Econ team continues to work diligently with the HKI-Bangladesh team to reschedule and modify endline activities.

Objective: Ensure that opportunities are made available for women and youth to contribute to and benefit from PHLIL post-harvest interventions

Gender Dimensions and Technology Assessment

Professor Paul McNamara and Dr. Anna Snider (AgReach, University of Illinois) continued work on a FY19 field-based gender technology assessment initiative to inform the technology profile for hermetic storage bags and the BAU-STR dryer. Using data collected in late FY19, 25 users and non-users in Mymensingh & Netrkona districts and 12 users and non-users in Jessore district were surveyed.

Gender based technology profiles were developed to show that women are responsible for postharvest activities including winnowing, parboiling, drying, storing and sometimes threshing of paddy. By using a BAU-STR dryer and hermetic bags, women can save a significant amount of time and labor. Due to use of a BAU-STR dryer, paddy can be dried easily and in bad weather too. Therefore, women become more comfortable in storing paddy. By using hermetic bags, women are relieved as they do not have to do any kind of intermittent operations during the paddy storage period. Paddy seed quality remains intact in hermetic bags (similar to observation above at BADC).

Although an initial investment is required to purchase a BAU-STR dryer, and technologies have not yet been readily available in all parts of the country, the BAU-STR dryer and hermetic bag storage have given women confidence to adopt new technologies. As a result, women are finding that they have more free time to invest in other income generating activities.

Training and sensitization activities were planned for FY20. The objective of the training is to create awareness on gender dimensions amongst household members. Most female household members are neglected, though their contributions are great. As women are unpaid workers, men do not always recognize their work. Most of these training programs have been delayed due to the COVID-19 pandemic. With plans underway to implement them in FY21.

Youth Engagement

PHLIL-Bangladesh hosted a workshop for agricultural engineering undergraduate students on entrepreneur development for agricultural technologies, including a focus on the design and development of the BAU-STR dryer.

From the technology based gender profiles, it was found that 36.11% of the farmers fell in the age group 18-35 years, considered 'youth.' However, 16.67% of the sampled LSP (Local Service Providers) fell in the age group 18-35 years. Due to social norms, the ownership usually belongs to the head of household (father). A literature and desk review on youth engagement for post-harvest technology entrepreneurship is in progress.

Objective: Implement an engagement strategy that reaches out to key stakeholders

The 5th annual meeting of the PHLIL-Bangladesh Engagement Advisory Team was held on Monday, August 10, 2020 via Zoom online video conferencing platform due to the COVID-19 pandemic. The purpose of the meeting was to review strategies for scaling up of identified technologies, training curriculum, project messaging and implementation strategies. The meeting was inaugurated by a greeting speech from the Chair Professor Dr. B. K. Bala. In his speech, he mentioned that post-harvest loss reduction is one of the

sustainable options for ensuring future food security. He requested all stakeholders to strengthen the PHLIL Phase II project in order to build an integrated post-harvest loss reduction approach.

PHLIL Bangladesh successfully held its 5th annual stakeholder meeting using a virtual format, on September 9, 2020. There was positive coverage in the media, with a national newspaper article that captured the very strong words of support that were registered during the event by the chief guest, Secretary of Agriculture Md. Nasiruzzaman, in his keynote address. He stated that the BAU-STR dryer and hermetic bags have proven to be effective technologies in reducing postharvest loss for grains in Bangladesh and need to be expanded and introduced to more farmers. He also mentioned that because of the BAU-STR dryer, small scale dryers have been included in the official government agricultural mechanization subsidies, with up to 5,000 to be scaled out to farmers in the next five years. The PHLIL Bangladesh team made specific policy recommendations, which were also considered during the meeting.



Photos: (left) PHLIL-Bangladesh annual stakeholder meeting, adapted to be virtual due to the pandemic. The meeting conclusions and this photo was featured in several national media outlets. (right) On September 20, 2020, Mr. Bodruddoza Md. Farhad Hussain (Sangram), MP, Member of Parliamentary Standing Committee, Ministry of Social Welfare visited different labs of the Department of Farm Power and Machinery, Bangladesh Agricultural University, Mymensingh. He stopped to discuss the BAU-STR dryer, given his interest in agricultural mechanization.

Objective: The PHLIL-developed BAU-STR dryer will continue to be promoted and scaled

The BAU-STR dryer is becoming ever more popular and recognizable to farmers in Bangladesh. In order to train them to understand and operate the BAU-STR dryer efficiently, several trainings and workshops were conducted. PHLIL-Bangladesh also organized refresher trainings on use of the BAU-STR dryer and hermetic storage to the already-trained farmers from Bogura, Mymensingh and Barishal districts in late 2019 and early 2020, prior to the COVID-19 pandemic. Farmers were reminded about proper handling and operation of the BAU-STR dryer and hermetic bags.

Capacity Building:

PhD and MSc Students

Four graduate students were selected: an MSc student focused on drying, an MSc student focused on seed storage, and an MSc student studying women's involvement in drying. A PhD student at Kansas State University was selected to work with the Ag Economics team on an impact evaluation of technology adoption, as one part of their overall PhD program.

Lessons Learned:

- The absence of global travel due to the COVID-19 pandemic triggered an even heavier reliance on in-country leadership and support. Due to the existing strong management and communication system, PHLIL Bangladesh was able to continue conducting research and reaching farmers, as originally

intended. In-country teams shifted operations to account for safety measures as required, complying with regulations: e.g. mask-wearing, reduced face-to-face interactions, reduced numbers of attendees for trainings, and social distancing.

- The annual national stakeholder meeting pivoted to a virtual format which provided great insights for both the U.S.-based and in-country teams with regard to remote learning and meetings. Despite a few minor setbacks, the meeting still made national news indicating strength in the management, communication, and infrastructure systems of the teams.

Publications:

Alam, M. A., Saha, C., Alam, M., Manir, M. R., Hasan, M., & Rashid, M. (March 2020). Experimental investigation of solar bubble dryer for rough rice drying in Bangladesh. *Journal of Bioscience and Agriculture Research* **23(02)**: 1920-1930.*

Alam, M. A., Saha, C., Alam, M., Manir, M. R., Rana, M., & Rashid, M. (March 2020). BAU-STR dryer for rough rice drying at farmers and small trader's level in Bangladesh. *Journal of Science, Technology and Environment Informatics* **09(01)**: 629-638.*

Ara, J., Ali, M., Hossain, M., Awal, M., & Alam, M. (March 2020). Quality of Milled Rice in Different Storage Technologies. *International Journal of Postharvest Technology and Innovation* **06(03)**: 220-237.*

*peer-reviewed

Conference Proceedings:

Saha, C., Sabbir, A. Y. B., Sarkar, S., & Alam, M. (July 2020). Development and Evaluation of LPG Based Heating System for BAU-STR Dryer. 2020 ASABE Annual International Meeting, Omaha, Nebraska, USA.

Presentations:

Saha, C. & Alam, M. (December 2019). BAU-STR Dryer: A Solution for Reducing Post-harvest Loss of Paddy in Bangladesh. Presentation at Nutrition Symposium and Technology Expo - Agriculture to Nutrition Pathway, Hotel Lakeshore, Dhaka, Bangladesh.

Alam, M. (February 2020). Post-Harvest Loss Reduction Innovation Lab (PHLIL). Presentation at Annual workshop on BAU Research Progress, Bangladesh Agricultural University, Bangladesh.

Saha, C., Awal, M., & Alam, M. (February 2020). On-Farm Grain Storage Solutions for Smallholders in Bangladesh. Presentation at Securing Harvest: Forum on improved grain storage in South Asia, New Delhi, India.

Ethiopia

Focus Crops: Chickpea, Maize, Sesame, Sorghum, Wheat

Location: *Ambara region:* Bahir Dar Zuria, Gondor, Mecha, Wenberma districts; *Tigray region:* Mekelle and Almata districts; *Oromiya region:* Kalumsa district.

Collaborators: *Universities:* Bahir Dar University, Mekelle University; *Research Centers:* Ethiopian Institute of Agricultural Research

Achievements:

Formalize the inclusion of PHLIL knowledge and technologies in extension education by providing input into various nationally accessible extension materials

The Ministry of Agriculture and the National Post-Harvest Advisory Committee, which PHLIL served as the impetus to establish and participates in, previously asked PHLIL to revise the national extension manual for mitigation of mycotoxin contamination in food and feed. The team has been working on this, with input from in-country team members (including PHLIL PhD graduates) at Mekelle University and Bahir Dar University, and from US team members at Kansas State University, North Carolina State University and South Carolina State University.

Complete the revision and translation of extension training manuals into Tigrinya, Oromo and English

The Tigrigna version of the training manual is complete and ready for printing; comments on the Amharic and English versions of the training manual is getting incorporated.

Achievements

The preparation of Tigrigna Manual

Challenges

Due to the current locust invasion in the eastern and western Ethiopia, the national plant health and regulatory directorate staff are in the field. This has delayed the translation of the manual into Tigrigna and English.

Continue to engage the first National PHL Advisory Committee to assist Ethiopian stakeholders in developing national post-harvest strategies

The engagement team meetings were held in Addis Ababa, Mekelle University, and Mohoni Integrated Experimental Site. A major discussion was held on the overall PHLIL project activities and how to register filter cake as a technology to mitigate insect pest damage; as a program, it has been decided that conducting on-farm trials as well as any potentially necessary biosafety research is beyond the scope of PHLIL, however we are still engaged in discussions since the Government is very interested in this highly effective technology. The Ministry of Agriculture representative describes the importance of delivering efficacy data to support their decisions on filter cake, and have requested more data on its efficiency. A key concern of the Committee is pesticide residues in the food supply, considered as a major issue of intervention. PHLIL has been working with the Ethiopian Agricultural Research Institute to develop laboratory capacity and protocols to test for pesticide residues. The plant protection authority and technician are included in the validation test of pesticide residue Standard Operating Procedures for this laboratory.

The Committee is growing in prominent membership and influence. The State Minister and Director General of Ethiopian Agricultural research, the Director General of the plant health and regulatory section of the Ministry of Agriculture are involved in the Committee meetings. Consequently, Post-Harvest is now being prioritized by national institutes and the government more broadly. When the Committee identifies evidence gaps and capacity building needs, PHLIL graduate students and PhD graduates are requested to deliver their expertise. For example, Samuel Alemayehu (Mekelle University, PhD candidate who will soon be defending) presented to the national engagement team. PHLIL was also recognized and invited for the international conference organized by the national post-harvest loss reduction society, where Professor Abay was an invited presenter.

Achievements

- team of experts for the pesticide residue established.
- filter cake efficacy experiment confined to a research station
- Virtual Meeting of the National Post-Harvest Advisory Committee was conducted on April 27 2020
- MU PHLIL team meeting conducted and discussed the possibility of writing a book on post-harvest Management and food safety, and a team of professionals composed of food science, breeders, nutritionists, plant pathologists, and post-harvest scientist, and call for submission of book chapters from different institutions was forwarded. Several individuals including from other institutions gave positive responses.
- Despite the COVID-19 situation, planned activities and experiments were successfully completed\

Objective: Research on effective training implementation and factors contributing to or preventing adoption of post-harvest technologies

Engagement: Conduct Training on mycotoxin mitigation, drying and pest management

During the COVID-19 pandemic, the team has continued working remotely on the post-harvest management manual. PHLIL has forged linkages with Hawassa University and Norwegian University of Life Sciences for upcoming post-harvest trainings.

Objective: Determine the prevalence of pesticides in economically important grains

The knowledge gap in this field is high. In the Ethiopian national system, only one lab is dedicated to conduct pesticide residue analysis. The lab has limited/no resources or relevant equipment. The human resource capacity is very low, with only one person is acting as the researcher on this area. PHLIL has now engaged the director general of plant health and regulatory directorate and pesticide residue lab included as team members for this task. The PHLIL coordinator is from Debra Zeit research station (Dr Mekasha Chichyibelu). The PHLIL team is working to identify a set of protocols that this laboratory could conduct, within the fairly limited resources of the program, but which would represent a significant enhancement of national pesticide residue analysis capacity.

Objective: Enhance the inclusion of women and youth in PHL decision-making and technology uptake.

At Mekelle University, Professor Abay held exploratory discussions made with female graduate students who own small enterprises. The in-country PHLIL team also advised a regional team of experts working on a regional manufacturing road map. The draft road map had not included or considered post-harvest management. The PHLIL team also ensured that the role of gender and youth in post-harvest loss reduction are being considered as well.

Objective: conduct integrated on-farm post-harvest management trial for sorghum

The PHLIL team set up a post-harvest management trial on-farm for sorghum. Storage using hermetic technologies are proving effective, as expected, and farmers are impressed with the results. Traditional storage leaves the grains vulnerable to various post-harvest issues. With the advent of the COVID-19 pandemic, the team adapted and complied with local and national regulations to enable them to continue managing the trial. The National Post-Harvest Advisory Committee have continued inquiring about the results and are eager to support scaling of these interventions.



Photos: PHLIL Ethiopia team conducting a visit to collect data and engage host farmers for the integrated sorghum post-harvest management trial. Bottom right panel shows sorghum grains stored in traditional bags (left) versus in hermetic bags (right).

New Objective: pilot the Arc’teryx tent dryer for grains

Thanks to previous engagement with Global Good/Intellectual Ventures, PHLIL was approached to conduct in-field validation of the Arc’teryx tent dryer. Discussions led to the decision for these dryers to be trialed by PHLIL in Ethiopia. The dryer has performed well in tests conducted by Arc’teryx in Vancouver, Canada, however they are of course eager to have it trialed in the developing country conditions it was designed for.

Capacity Building:

The ME team, Jon Ulmer and Fetien Abay have worked to develop a plan for Dr. Andrea Bianchini (University of Nebraska Lincoln, PHLIL Honduras PI) to further enhance capacity at Mekelle University and Bahir Dar University on mycotoxin research. She was not previously engaged with the Ethiopia team, and plans have been developed that will enable her to conduct remote training and help in experimental design

and interpretation.

Lessons Learned:

- Engaging in the National PHL Advisory Committee has continued to be very useful to raise post-harvest as a priority of the Government.
- Adaptation to the pandemic was challenging, however due to the strong dedication of the in-country team as well as support by the US-based partners, the team effectively kept most activities moving forward safely.

Publications:

Fanta, A., Abera, M., Kalsa, K., Tenagashaw, M. W., & Habtu, N. (November 2019). Occurrence of Mycotoxins in Farm-Stored Wheat in Ethiopia. *African Journal of Food, Agriculture, Nutrition and Development* **19(4)**: 14829-14847.*

Abay, D., Ayimut, K. M., Assefa, D., Challa, D., Mahroof, R... (December 2019). Evaluating different hermetic storage technologies to arrest mold growth, prevent mycotoxin accumulation and preserve germination quality of stored chickpea in Ethiopia. *Journal of Stored product Research* **85**: 101-109.*

Asemu, A. M., Habtu, N., Delele, M. A., Bhadriraju, S., & Sajid, A. (February 2020). Drying characteristics of maize grain in solar bubble dryer (pp.13312). *Food Process Engineering* **43(2)**: 13312.*

Asemu, A., Habtu, N., Bhadriraju, S., Delele, M. A., Kalsa, K., & Sajid, A. (April 2020). Effects of Grain Drying Methods on Post-Harvest Insect Infestation and Physicochemical Characteristics of Maize Grain. *Food Process Engineering* **43(7)**: 1-18.*

*peer-reviewed

Conference Proceedings:

Kalsa K.K., Subramanyam B., Demisse G., Worku A., Workneh S., Gabbiye N. (2020) On-Farm Performance and Assessment of Farmers' Perceptions of Hermetic Bags for Farm-Stored Wheat and Maize in Northwestern Ethiopia. In: Habtu N., Ayele D., Fanta S., Admasu B., Bitew M. (eds) *Advances of Science and Technology. ICAST 2019. Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering*, vol 308. Springer, Cham.

Presentations:

Lambert, M. & Ulmer, J. (April 2020). Creating an instrument to measure technology adoption in Africa. Association of International Agricultural and Extension Education, Virtual.

Ghana

Focus crop: Maize

Location: Dormaa area (Dormaa East and West districts), Northern Ghana

Collaborators: *Universities:* Kwame Nkrumah University of Science and Technology (KNUST), University for Development Studies; *Government:* Ministry of Food and Agriculture (Northern and Upper West regional

offices); *NGOs*: Adventist Development Relief Agency; *Private sector*: Poultry farms in Dormaa, Agri Commercial Service Ltd., Vestergaard Frandsen, Sesi Technologies ; *USAID/USG Project Partners*: AMPLIFIES

Achievements:

Objective: Work to increase awareness, enhance demand, and help establish efficient distribution channels to increase adoption of GrainMate moisture meters and hermetic technologies by stakeholders in the agriculture sector

Ghana's PHLIL Phase II achievements build upon their success in the first five years of research working with Sesi Technologies, poultry producers, and Kwame Nkrumah University of Science and Technology (KNUST) to scale up the GrainMate moisture meter and the PICS and ZeroFly® hermetic bags.

In the last 2 years, at least 5,400 ZeroFly® Hermetic (ZFH) bags have been sold and the distribution channels for ZFH bags are taking shape, which PHLIL has worked actively to cultivate. Each ZFH bag retails for \$1.6-2.2 (GHS9-12). As of September 2020, 370 GrainMate moisture meters have been sold with 80 additional in stock and over 200 under production. Each device retails for \$90-100 (GHS500-550).

Sesi Technologies reported a number of improvements to the GrainMate in FY2020. Battery life of the new GrainMate has been improved from lasting only a few days to several weeks. A new sleep mode feature has been introduced that will help the device conserve battery if inadvertently left on for a long time. Additionally, it is now possible for users to take their meters to third parties such as the Ghana Standards Authority for calibration to ensure effective functionality and accurate readings over time. Sesi Technologies reports an overall improved moisture testing experience with a new "test" button and improved build quality to make it more robust. Finally, manufacturing costs have been reduced through the discovery of alternatives to some of the raw materials used in the meter.

USAID approval was secured to lease three cargo motor trikes to assess the effects of transport availability on scaling of ZFH bags in northern Ghana while expanding access for smallholder farmers. Approximately 1,700 of the 5,400 ZFH bags sold in Ghana in the last two years have been sold in northern Ghana, without the aid of readily available transportation to facilitate marketing of the bags.

PHLIL continued its work to support members of the Women in Poultry Association (WPA) Dormaa Chapter to address post-harvest loss issues and consequently increase profitability and business growth. Training was conducted in December 2019, with a visit by the US- and Ghana-based project team members to EvanJoes farm. WPA played a prominent role in hosting and partaking in the training. This was followed by project team visits to PHLIL technology adopting and not/not yet-adopting farms and aggregators in the area. While poultry farmers and aggregators storing grain typically felt they purchased and stored maize at a safe moisture content level, the project team found that it was those who had already adopted the GrainMate and hermetic storage technologies that actually met acceptable levels. The project also supported efforts by the WPA Dormaa Chapter's investment in installing a solar biomass hybrid dryer (SBHD). This SBHD will facilitate proper drying of maize before it is stored in ZFH bags by the 50 members of the association, who currently constitute the biggest market for ZFH bags in Dormaa.



Photos: Examples of typical, poor storage conditions observed at warehouses not/ not-yet adopting improved post-harvest practices and technologies. Issues include insect pest and fungal damage (center) and rodent infestation (right).



Photos: PHLIL training in December 2019, hosted by the WPA Dormaa Chapter at EvanJoes farm.



Photos: EvanJoes farm has increased poultry productivity, egg size and shell hardness, and significantly increased the size of their business since engaging with the PHLIL team (and previously the AMPLIFIES project).

PHLIL Ghana now has three marketing agents for the ZFH bags in Dormaa and four marketing agents in Northern Ghana. Importation of 10,000 ZFH bags from Nigeria to Ghana for distribution and marketing is underway and these bags are expected in Ghana before the end of the 2020 calendar year.

Objective: Conduct experiments on assessing the use of low-cost, locally built elevated platforms to mitigate high mycotoxin levels that are usually associated with heaping maize on the ground in the field after harvest

PHLIL previously published the finding that heaping of maize on the ground after harvest is associated with significantly increased levels of aflatoxin contamination. To investigate elevated platforms as a mitigation measure, an MPhil student at Kwame Nkrumah University of Science and Technology (KNUST) is pursuing course work and has finished writing a research proposal. The student is supervised by professors Enoch Osekre and George Opit. The main objective of these studies is to reduce post-harvest losses of stored yellow maize through the use of low cost, locally produced, elevated platforms and ZFH bags. One of the specific objectives of the research is to investigate the use of elevated platforms in the field for reduction of mycotoxin contamination in heaped maize.

Under this study's design, two treatments will be compared: the standard smallholder farmer practice of heaping harvested maize on the soil, where mycotoxin-producing fungi reside and can infect the ears upon contact; versus harvesting and evenly spreading maize directly onto elevated platforms, avoiding contact with the soil. Maize fields from four farmers, members of a farmer-based organization in Koradaso-Dormaa Ahenkro, will be used for this study. The fields will serve as the experimental blocks (replicates), with each field containing the two treatments and with two heaps for each treatment/field meaning that there will be two sub-replicates in each field. This will be a Randomized Complete Block Design (RCBD) experiment with four replications, two sub-replicates, and two treatments. Platforms are 2.4-m × 2.4-m raised to a height of 0.4 meters, and will be constructed to allow ventilation around the heaped maize on the platforms. Wood which is a readily available resource in Koradaso-Dormaa Ahenkro will be used to construct the elevated platforms.

This study is currently in progress. One aspect that was added to the experimental design is that Dr. Matthew Stasiewicz' laboratory at University of Illinois will use quantitative PCR to assess fungal levels, in addition to the aflatoxin and fumonisin analysis that is being conducted at KNUST; this will give a measurement of aflatoxin-producing fungi through the experiment, supplementing the data on the toxins themselves. All activities related to this study which were planned for FY20 have been completed.

Objective: Contribute to increased success (in sales and efficiency) of Sesi Technologies, serving in an advisory role to increase assembly efficiency, continue to make upgrades to the GrainMate, etc.

During FY19, Dr. Paul Armstrong (Co-PI, ARS) chose to use funds allocated for his activities to purchase materials and supplies that will facilitate more efficient assembly of GrainMate moisture meters in Ghana. As a result, in FY20 Dr. Armstrong mentored Isaac Sesi and the Sesi Technologies team toward the improvement of several functions and features mentioned previously. The improved GrainMate model is planned for introduction by the end of 2020.

Objective: Conduct research on effective training strategies for teaching and adoption

As the engagement team increased their research focus in FY20, their goal on understanding how farmers in Ghana make decisions to use technologies in their farming practices influenced trainings. Decisions are often impacted by knowledge, understanding, usefulness and even influential people. Dr. Jon Ulmer (K-State Professor of Agricultural Education) has participated in PHLIL Ghana trainings and given feedback that led to adaptations in the engagement/training approach used by the team. An instrument to survey the previous year's training participants was developed in late 2019. The intended launch of the data collection was to be spring 2020. However, due to COVID-19 pandemic-related delays, Drs. Ulmer and Misty Lambert (North Carolina State University) were unable to travel to Ghana to conduct interviews and launch the survey. By

mid-2020, it was decided that in-country graduate students previously associated with the project team would be hired to collect the data. Data collection is now underway, and results will be reported in FY21.

Objective: Through research, evaluate impact of use of GrainMate moisture meters and hermetic technologies, including positive strategies to promote awareness and adoption by women and youth-focused stakeholders in the agriculture sector

Representing AgReach, Professor Paul McNamara and Dr. Anna Snider traveled to Ghana in December 2019 to participate in PHL training activities and to meet with lab stakeholders. The AgReach team observed the PHLIL trainings in Dormaa, spoke with female and male farmers about how they use technologies and the barriers and benefits of these technologies. From this interaction the AgReach team developed several recommendations to increase the gender equity of PHLIL activities: training videos in Twi to reach more women and smallholder farmers; increased engagement with the Women in Poultry Association (WPA) to provide post-harvest best practices training; and continuing training for Crop Aggregation Centers and village farmer-based organizations. The AgReach team also developed a relationship with the University for Development Studies in Tamale for future collaboration.

In an effort to better reach female poultry farmers, the AgReach team collaborated with Scientific Animations Without Borders (SAWBO) to translate the existing [Post-Harvest Loss Prevention: Mycotoxins in Crops](#) video into Asanti Twi. This effort was complete by September 2020.

Also notable: significant progress was made with regard to the use of gender technology assessments. In July and August, Dr. Snider conducted a virtual training for faculty and graduate students at the University for Development Studies (UDS) on the gender technology assessments developed by the AgReach team. Following training, additional follow-up, fieldwork, and focus groups are being conducted by UDS faculty and students with smallholder farmers in Northern Ghana through FY21.

Objective: Test small-scale kernel sorting as an avenue to remove mycotoxin-contaminated maize from the food supply

In 2019, Dr. Matthew Stasiewicz at University of Illinois began discussions with the Ghana team to adapt and validate a single-kernel sorting technology, initially designed by USDA-ARS, which he previously adapted in Kenya. During FY20, his team has been engaging with collaborators on the PHLIL Ghana team to integrate their work into existing sampling collection and analysis activities.

Dr. Stasiewicz travelled to Ghana in December 2019 for a site visit designed to provide exposure to the team at KNUST prior to previously scheduled poultry farmer trainings during the week of Dec 16-20, 2019. During this trip, he first visited Professor Enoch Osekre and three of his graduate students at KNUST.

Subsequently, Dr. Stasiewicz traveled with the training team to visit Sunyani and poultry farmers in Dormaa. He was exposed to the current best practices in the region from EvanJoes farm. Stasiewicz was able to see the potential applications for kernel sorting as well as notice that most poultry farmers had a specific maize cleaning machine based on size separation of material (below). It was decided that the best research path forward will be to research both the efficacy of kernel sorting and the local grain cleaning technology so as to define the potential added value of this approach beyond what is already being done.



Photo: Drs. Paul Armstong (USDA-ARS) and Matt Stasiewicz (University of Illinois) discuss a locally innovated maize kernel sorter at EwanJoes farm (R), and the waste stream that has been sorted out, ridden with weevils since the sorted maize had not been stored in a hermetic bag.

After the site visit, the Illinois team was able to propose a specific experimental design for evaluating the effect of kernel sorting technologies in conjunction with local grain cleaning technology, both on grain that is well dried and stored and that which is poorly stored.

The key achievements this period included (i) determining a path for local sample collection from Ghana and (ii) demonstrating that risk-based sampling can recover mycotoxin contaminated maize kernels at a greater rate than random sampling. It is notable that the original plan was to have the Stasiewicz lab work with grain from Guatemala, however when that portion of PHLIL had to be closed down earlier than expected, the plan shifted to working with grain from Ghana. Due to the associated delays of in-country sample collection, the Illinois-based graduate student spent significant research time refining the process of risk-based sampling of individual kernels, from locally available US samples, to recover maize kernels with mycotoxin contamination.

After switching from Guatemala to Ghana for sourcing of grain, delays were compounded by pandemic-related delays in the travel and research, coupled with the realization that the Illinois-based team would not be able to travel to Ghana to collect samples during summer 2020 as planned. The team determined that the best path forward was to work directly with a local PHLIL Ghana project collaborator to collect samples and prepare those for return shipping to the U.S. The team was then able to develop a detailed protocol for collecting maize samples from farms with and without local cleaning capacity, stratifying by well and poorly stored conditions as defined by storage moisture content, and characterizing the efficacy of local sorting capacity to reduce mycotoxins. The project team will now strive to plan a research visit sometime in the 2021 calendar year, which would allow them to bring sorting techniques already calibrated to Ghanaian samples for in-country evaluation. In the event that a trip is not possible, contingency plans are under consideration.

Capacity Building:

- One MPhil student is being trained in Crop Protection & Entomology at Kwame Nkrumah University of Science and Technology, expected to graduate in mid-2021. Work on elevated platforms extends the research focus and capacity of the university, including consideration of qPCR as a tool for future mycotoxin research.
- Approximately 20 faculty and graduate students at the University for Development Studies (UDS) were trained by AgReach gender expert, Dr. Anna Snider, on the Gender Technology Assessment. Of this group, two graduate students and two faculty will conduct fieldwork to inform Gender Technology Assessments of three post-harvest technologies. Additionally, UDS faculty are now committed and poised to using the assessments in their curriculum and trainings.

- The translation of an existing SAWBO-produced post-harvest loss mycotoxin video into Asanti Twi allows for extensionists and trainers to disseminate the video to reach more women with decision-making power on their farms who have historically had lower literacy levels than male counterparts.

Lessons Learned:

- The absence of global travel due to the COVID-19 pandemic triggered an even heavier reliance on in-country leadership and support. Due to the existing strong management and communication system, PHILIL Ghana was able to continue conducting research and reaching farmers, for the most part as originally intended. In-country teams shifted operations to account for safety measures as required, complying with regulations: e.g. mask-wearing, reduced face-to-face interactions, reduced numbers of attendees for trainings, and social distancing.
- Supply chains for the highly demanded ZFH hermetic bags were heavily impacted by pandemic-related shipment delays which caused unmet expectations by farmers in Ghana. The team continued to work through the shipment logistics and tried to reassure farmers of the bags' pending arrival as often as possible.

Publications:

Bosomtwe, A., Osekre, E., Opit, G., & Nsiah, E. (March 2020). Evaluation of Plastic and Steel Bins for Protection of Stored Maize against Insect Infestation in Ghana. *Journal of Global Agriculture and Ecology* **9(1)**: 30–42.*

Chavez, R. A., Cheng, X., & Stasiewicz, M. (March 2020). A review of the methodology of analyzing aflatoxin and fumonisin in single corn kernels and the potential impacts of these methods on food security. *Foods* **9(3)**: 297.*

Bosomtwe, A., Osekre, E., Bingham, G., & Opit, G. (September 2020). Evaluation of Zerofly® Hermetic Storage Bags for Protection of Maize Against Insect Pests In Ghana. *International Journal of Scientific & Technology Research* 9(09): 192-202.*

**peer-reviewed*

Guatemala

Focus crop: Maize

Location: Playa Grande, Municipality of Ixcán, Department of Quiché, Guatemala

Collaborators: *University:* Universidad del Valle; *NGOs:* SHARE, *Project Partners:* Buena Milpa

Due to restrictions in funding allocations for Guatemala this fiscal year, operations halted in spring 2020. Final achievements and concerns relate to sustaining efforts that the team has made in completing work that began prior to the stoppage in funds. The team was able to conduct a lowlands survey of agricultural practices, climate limitations, and socio-economic factors along the maize value chain. Refer to Semi-Annual Report 2020 for more information.

VI. Human and Institutional Capacity Development

a. Short-term training

Country of Training	Brief Purpose of Training	Who was Trained	Number Trained		
			M	F	Total
Bangladesh	Training on Gender Based Technology Assessment (October 12, 2019) Mymensingh	Civil Society	7	4	11
Bangladesh	Addressing Economic Constraints of Technology Adoption for Post-harvest Practices and Rice Seed Storage in Bangladesh (November 21, 2019) Jamalpur	Civil Society	19	2	21
Bangladesh	Training on BAU-STR dryer and Hermetic Bag Use (November 28, 2019) Bogura	Producers, Government, Private Sector, Civil Society	20	30	50
Bangladesh	Training on BAU-STR dryer and Hermetic Bag Use (December 1, 2019) Phulpur	Producers, Civil Society	19	29	48
Bangladesh	Training on BAU-STR dryer and Hermetic Bag Use (December 17, 2019) Barisha	Producers, Civil Society, Private Sector, Government	26	3	29
Bangladesh	Gender Workshop with Group Discussion (January 28, 2020) Mymensingh	Producers, Civil Society	13	25	38
Bangladesh Subtotals			104	93	197
Ethiopia	Training of subject matter specialists and grain store managers from farmers' cooperative unions in Amhara National Regional State (December 18-19, 2019) Bahir Dar, Amhara Region	Government, Private Sector	18	4	22
Ethiopia	Latex software training for PhD student (January 6-10, 2020) Bahir Dar, Amhara Region	Students	8	1	9
Ethiopia	Training on the use of ZeroFly® hermetic bags (January 23, 2020) Bahir Dar, Amhara Region	Producers, Government, Private Sector	35	15	50
Ethiopia	Mycotoxin management training (April 18-20, 2020) Mekelle, Tigray Region	Producers, Government	118	52	170
Ethiopia	Integrated Sorghum Post-harvest Loss Reduction Technology Promotion, Dissemination and Training (May 26 – June 5, 2020) Mohoni, Ramma, Abergele and Wajrat, Tigray Region	Producers, Government	118	52	170
Ethiopia Subtotals			297	124	421
Ghana	Poultry Farmers training on drying, storage, and good sanitation (December 16-20, 2019) Dormaa Ahenkro, Dormaa Central, Bono Region	Poultry Producers	17	8	25

Ghana	Poultry Farmers training on drying, storage, and good sanitation (March 16-20, 2020) Dormaa Ahenkro, Dormaa Central, Bono Region	Poultry Producers	0	11	11
Ghana	Evaluating Postharvest Technologies Through a Gender Lens (August 4 – September 22, 2020) Online for individuals in Tamale, Northern Region	Students	12	2	14
Ghana Subtotals			29	21	50
Overall Totals			430	238	668

b. Long-term Training

Trainee Number	Sex	University	Degree	Major	Program End Date	Degree Granted	Home Country
Bangladesh Team							
1	F	Bangladesh Agric. Univ.	PhD	Plant Pathology	December 2020	In process	Bangladesh
2	M	BAU	PhD	Farm Power and Machinery	February 2020	Yes	
3	M	BAU	PhD	Farm Power and Machinery	February 2020	Yes	
4	M	BAU	MSc	Agricultural Engineering	July 2021	In process	
5	M	BAU	PhD	Agricultural Engineering	December 2022*	In process	
6	M	BAU	MSc	Farm Power and Machinery	December 2019	Yes	
20	F	BAU	MSc	Agricultural Engineering	July 2021	In process	
21	F	BAU	MSc	Agricultural Economics	July 2021	In process	
Ethiopia Team							
7	M	Mekelle University	PhD	Plant Science	October 2020	In process	Ethiopia
8	M	Mekelle University	PhD	Plant Science	October 2020	In process	
10	F	Bahir Dar University	PhD	Food Engineering	September 2020	Yes	
12	M	Bahir Dar University	PhD	Food Engineering	September 2020	Yes	
22	F	Bahir Dar University	MSc	Food Technology	October 2020	In process	
23	M	Bahir Dar University	MSc	Food Engineering	February 2021	In process	
24	M	Bahir Dar University	MSc	Chemical Engineering	February 2021	In process	
Ghana Team							
13	M	Kwame Nkrumah University of Science and Technology	MPhil	Crop Protection (Entomology)	July 2021	In process	Ghana
Nepal Buy-In							
14	F	Kansas State University	MSc	Plant Pathology	March 2021	In process	Kenya

* This student will be supported by BAU after the end of the PHLIL program.

PHLIL has additional graduate students who are engaged in PHLIL-affiliated research activities but who are not funded by USAID. These students are enrolled and funded wholly separately from PHLIL funds; however, they are assisting in research activities, often due to their being advised by faculty on our team. Thus we still seek to capture their significant contribution to our program:

Trainee Number	Sex	University	Degree	Major	Degree Granted	Home Country
Ghana Team						
15	M	University of Illinois Urbana Champaign	PhD	Food Science	In progress	Guatemala
25	M	Kwame Nkrumah University of Science and Technology (KNUST)	MPhil	Agricultural and Biosystems Engineering	In progress	Ghana
Guatemala Team						
16	M	University of Nebraska, Lincoln	PhD	Food Science and Technology	In progress	Guatemala
Engagement Team						
17	F	Iowa State University	PhD	Ag Education	In progress	Cameroon
Ag Econ Team						
18	F	Kansas State University	PhD	Ag Economics	In progress	Pakistan
19	M	Kansas State University	MSc	Ag Economics	In progress	Guatemala

c. Institutional Development

PHLIL developed and enhanced substantial human and institutional capacity in post-harvest research across all partner countries in Phase I. In the second phase of our research program, in-country capacity continues to be enhanced and elevated to influence national-level discussions, decisions and activities. In one example, two PHLIL PhD graduates in Ethiopia have been elevated to play more leading roles in phase II research and engagement. These researchers are using the technical expertise developed in their PhD programs, while simultaneously learning new management and administrative skills. In another example, AgReach conducted a workshop for faculty at the University of Development Studies in Ghana to learn and integrate the Gender-based Technology Assessment in their research and teaching.

VII. Innovation Transfer and Scaling Partnerships

Phase 4: Demonstrated uptake by the public and/or private sector

Post-Harvest Loss Prevention Manual

Description: A train-the-trainer manual and suite of materials was developed for post-harvest loss prevention training. The suite of materials includes a facilitator's guide and accompanying presentation slides (will also be available in printed slides format for use without a computer); a farmer's guide, which includes mostly pictures and minimal text; and cards and posters with key messages.

Steps Taken: Manual has been published in the PHLIL website and shared with the extension network trainers, partnering organizations, and stakeholders.

Partnerships Made: A partnership was developed with the USAID funded project Buena Milpa which is managed by CIMMYT and a local NGO in Huehuetenango called Asocuch. Another partnership was explored with INCAP (Centroamerican and Panamanian Institute of Nutrition) to utilize the technical manual. Additionally, they requested that our PHLIL Guatemala Technical Team train their trainers.

Countries: Guatemala

Phase 3: Made available for uptake as a result of USG assistance

BAU-STR Dryer - LPG

Description: The BAU-STR dryer, modified from Vietnam, is a mobile small-batch grain dryer that can be operated on farm. It provides an effective drying technology alternative to traditional sun drying in terms of rate and efficiency. The dryer has been modified from its original version using rice husk briquettes for energy to using Liquefied Petroleum Gas (LPG), which has wider availability throughout Bangladesh than rice husk briquettes, and has been validated for rice, wheat, and maize.

Steps Taken: The burning unit of the BAU-STR dryer was modified by using LPG as fuel. After iterative efforts, a suitable blower was manufactured by locally available materials; blower performance was satisfactory with the new fuel source.

Next Steps: A public-private sector pathway is plausible for the BAU-STR dryer. Currently, the private sector is manufacturing the dryers, some of which have been purchased by individuals and others have been purchased by the Department of Agricultural Extension. The Government of Bangladesh has

approved a mega project worth about 360 million USD for popularizing appropriate agricultural machinery where drying machineries will be disseminated to the farmers on subsidy along with other need-based agricultural machines.

Partnerships Made: Discussions have been made with M/s Kamal machine tools, Uttaran Engineering Workshop and Bhai Bhai Engineering workshop for manufacturing of the dryer. Amin Electronics, Mymensingh is helping to manufacture the blower in Bangladesh.

Countries: Bangladesh

Gender Technology Assessment; a tool to increase technology adoption by men and women farmers

Description: The Gender Technology Assessment is an analytical tool to assess the potential gender-related and nutritional impacts of specific agricultural technologies on men and women. The tool utilizes a gender analysis framework and can be used to improve the design and dissemination of agricultural technologies in ways that increase adoption by men and women farmers. Multiple USAID-funded projects have been using this toolkit originally developed by INGENEAES. PHLIL's team has recently trained a group of Ghanaian faculty and staff at the University for Development Studies using this toolkit.

Steps Taken: This approach was developed specifically by the PHLIL gender team, AgReach, to help ensure gender equality in agricultural practices. The Assessment Tool is used by social scientists to help inform policy and market recommendations.

Next Steps: By transferring this research tool to national universities engaged in social science research, our partners are positioned to integrate gender considerations into research and emerging interventions that can better benefit women across the food system. The tool can potentially benefit a large proportion of the producers in the country and beyond.

Partnerships Made: Bangladesh Agricultural University, ADM Institute for the Reduction of Postharvest Loss / University of Illinois Urbana- Champaign, Kwame Nkrumah University of Science and Technology, University for Development Studies (Ghana), Oklahoma State University, Kansas State University

Countries: Bangladesh, Ghana

SAWBO Mycotoxin Video on best practices, adapted to Asante Twi

Description: SAWBO videos are short educational animations used to help educate or inform an audience. A version of a previously produced mycotoxin mitigation video was translated to Asante Twi and is currently being disseminated and used to help facilitate work with female poultry farmers in Ghana.

Steps Taken: A collaboration between PHLIL gender specialists at AgReach and Michigan State University's Scientific Animations Without Borders (SAWBO) team was made. Two previously produced SAWBO videos on post-harvest loss reduction were targeted for translation into local Ghanaian languages to better reach rural populations, and in particular women and youth. The translated video has been distributed to the Women in Poultry Association, Young Professionals in Agriculture and Rural Development, MoFA's Women in Agriculture Development, and Ghana Farmers' Association. Though internet connectivity problems have slowed distribution, farmers' organizations have been instrumental in the distribution and the videos are appreciated.

Next Steps: The video will continue to be shared as widely as possible, particularly through connections with women's farmer cooperatives. An additional video on post-harvest storage is targeted for translation and dissemination.

Partnerships Made: ADM Institute for the Reduction of Postharvest Loss at University of Illinois, Michigan State University (SAWBO), Oklahoma State University, Kansas State University

Countries: Ghana

Phase 2: Under Field Testing

Integrated Storage Technologies for Sorghum in Ethiopia

Description: Piloting on-farm integrated post-harvest management of sorghum or subsequent scaling with smallholder farmers in Ethiopia, downstream of program activities.

Steps Taken: Trial experimental setups at two locations were well designed and ready for sampling. Baseline samples from each location and storage strategies were analyzed for moisture content, temperature, and nutrition content. 200 PICS bags were purchased and disseminated to sorghum growers for grain preservation. The technology was purchased through the financial support of Mekelle University.

Next Steps: The baseline sample was kept under -20° C until mycotoxin kits were supplied from the USA. Available storage technologies were well demonstrated to farmers. Farmer trainings are planned by the PHIL team.

Partnerships Made: South Carolina State University, Mekelle University, Kansas State University, Ethiopian National Postharvest Loss Advisory Committee, producers in four locations of the Tigray region, hermetic storage bag manufacturing companies

Countries: Ethiopia

VIII. Environmental Management and Mitigation Plan (EMMP)

The Environmental Mitigation and Monitoring Program (EMMP) for the Lab is regularly reported through the Piestar Reporting Hub and the ME maintains regular oversight, including on site review when in country. On site review is conducted regularly by PHLIL AOR Ahmed Kablan as well. A PERSUAP was developed and the EMMP for Ghana modified to allow grains to be stored in ZeroFly Hermetic bags, which is consistent with their approved use by the Ghana Environmental Protection Agency, the World Food Program and other official bodies.

IX. Open Data Management Plan

The Management Entity (ME) makes information and data publicly available via the Harvard Dataverse. The ME has communicated with the country PIs regarding depositing data in the Harvard Dataverse. The program coordinator inputs each dataset into the USAID Data Development Library (DDL), the ME monitors and tracks data uploads into the Harvard Dataverse and uploads them into the DDL once each data set is verified. The approved Data Management Plan is available.

X. Project Management Activities

The Management Entity was fully engaged in evasive action to continue operations and activities in the face of the COVID-19 pandemic. Consultation with USAID (AOR), the IL Council, Kansas State University, and partner institutions and organizations were conducted to ensure safety (first) and deliver. Given the covariate shocks presented by the onset of the pandemic, efforts to secure the harvest were more important than ever.

The Management Entity also worked to repurpose Guatemala funds, due to changes in US Government policy related to investments in Central America. Substantial effort, discussions, redesign (in consultation with our AOR) and ultimately final approval from USAID resulted in repurposed funds and activities to the remaining three core countries.

The Management Entity also underwent a significant shift in personnel. Assistant Director Dena Bunnell and Program Coordinator Caroline Kolins moved on to higher level positions outside of the program and KSU. They worked with the Director to ensure a smooth transition to the new Assistant Director, Jessa Barnard. KSU granted an exception to the pandemic-related hiring freeze to bring Barnard on board, and she has integrated very well into the team. Given that both moved on within the same month, and that the team size went from four to three, the Director and other ME members had to invest substantial effort into the transition, which has been successful.

As a leader and partnership catalyst within the broader research for development community, the ME also continued fostering strategic engagements as part of our impact strategy. These included delivering presentations at U.S. and international fora, and publication of post-harvest related technical publications from additional research. Efforts moved to remote engagement starting in March 2020 as the pandemic advanced into the US and partner countries.

Conference session organization and presentations:

- 04/20 PHLIL hosted and organized AgriLinks' Theme Month on Post-Harvest. It was the third most attended AgriLinks webinar of 2020, with 370 attendees from 57 countries, of which 97% said the content was relevant to ongoing development efforts, 93% found the content engaging, and 82% indicated that they could apply it to their work. In addition, 14 blogs were facilitated by PHLIL, with 58 tweets, 57,539 impressions and 963 engagements.
- 01/20 World Mycotoxin Forum – Asia “Empowering national systems to mitigate mycotoxins: Post-Harvest Loss Innovation Lab Nepal and Bangladesh Highlights”
- 12/19 Nepal National Mycotoxin Stakeholder Workshop “Priming a national response: towards an integrated approach to address mycotoxins in Nepal”
- 11/19 Sara Lee Lecture, Michigan State University “Securing the harvest: integrating efforts to safeguard the global harvest against mycotoxins”
- 09/19 World Mycotoxin Forum (Belfast) – session held that was organized by Dr. Harvey, featuring Innovation Lab research, that included PHLIL, Nutrition Innovation Lab, Livestock Systems Innovation Lab, Food Processing and Post-Harvest Handling Innovation Lab and the International Center for Insect Physiology and Ecology

In addition to contributions to core PHLIL publications, additional PHL-related publications were finalized and published:

Leslie, J., & Morris, J. (December 2020). Perspective: Talking about Mycotoxins. *Frontiers in Sustainable Food Systems* 3(109): 1-6.

Director Dr. Jagger Harvey is Guest Editor for a special issue of Foods (impact factor 4.092) entitled “Safeguarding the Global Food Supply: Advances in Mycotoxin Prevention, Surveillance and Mitigation.”

XI. Other Topics

None.

XII. Issues and How They Are Being Addressed

A major preoccupation of the ME and the program was shifting operational strategy during the COVID-19 pandemic. The ME and program partners invested substantial time in adaptations to plans, ensuring safety and that the program met or exceeded all Feed the Future indicator targets for the year.

Another major challenge associated with this report was the unrest in Tigray, Ethiopia. As the report was being finalized, unrest unfolded on 3 November and partners were out of communication as efforts to finalize the report were underway.

The closure of the border between Ghana and Nigeria posed a significant impediment to import of ZeroFly Hermetic bags. The project team expects arrival of the bags in late 2020.

XIII. Future Directions

The PHLI team is focused on finishing strong with sustainable outcomes and innovations scaling towards resilient development outcomes in its final year (and beyond).

Appendix A: Success Stories

The BAU STR Dryer: Engaging national policymakers, local businesses and farmers in post-harvest loss reduction

Rice is a staple food in Bangladesh and daily serves as both a nutritional and cultural necessity. Approximately 13 million farmers are involved in rice production in Bangladesh, accounting for 75 percent of land use and 12.68 percent contribution of agricultural sector in the GDP of the country.

Drying of paddy rice in Bangladesh traditionally happens in field and on farm, leaving it open to contamination from pests, dirt and dangerous fungal toxins. Post-harvest loss at the farm level is estimated to be about 14%, with drying and storage losses representing key contributors.

To address this challenge, the PHLIL Bangladesh team developed the BAU-STR dryer, modified from Vietnam, which is a small-batch dryer that is mobile and can be operated on farm. It provides an effective drying technology alternative to traditional sun drying in terms of rate and efficiency. The adaptations to the BAU-STR dryer were effective in improving its efficiency, cost and mobility,



and removing its reliance on the national electric grid. The dryer has been validated for rice, wheat, and maize. The dryer was also recently added to the Bangladeshi Government's ag machinery subsidy program, enabling the scope of significant portion of sale to a targeted number of 5,000 dryers to more farmers, millers and service providers in the next five years.

In Bangladesh, the BAU-STR dryer has been successfully adapted, validated, piloted and deployed in forty villages across six districts. Though the blower was previously imported from Vietnam, a small electric company in Bangladesh manufactured a 17 kilogram blower designed and supervised by the PHLIL Bangladesh. The original blower was 20 kilograms, slightly too heavy to accommodate women farmers and post-harvest processors. Now the BAU-STR dryer is entirely locally manufactured and repaired.

In Bangladesh, the BAU-STR dryer has been successfully adapted, validated, piloted

The BAU-STR dryer can dry one-half metric ton of paddy rice in 3 to 5 hours and bring moisture content from 22 percent, which is often the result from field drying, to a safe 12 percent, reducing the risk of mycotoxin accumulation from contaminating fungi. The dryer can be powered by rice husk briquettes; and the BAU research team worked to successfully modify the burning unit to use Liquid Petroleum Gas as fuel, which will help farmers in regions where rice briquettes are not available.

In partnership with the Bangladesh Department of Agricultural Extension's (DAE) Integrated Agricultural Approach for Ensuring Nutrition and Food Security project, 184 farmer organizations in six districts each received a BAU-STR dryer in 2019.

BAU invested in building the capacity of local fabricators, including Agromech, Bhai Bhai Engineering and Kamal Machine Tools, to manufacture the dryers at scale for distribution to farmer organizations and other interested buyers. New designs for a 12-ton recirculating batch grain dryer are in development by BAU to cater to the needs of small-scale private rice millers, effectively improving their capacity to accept wet grain sold by smallholder farmers and remain commercially viable.

The dryer has been covered in the national media and highlighted in a Nature Magazine editorial. Recently, the Secretary of the Ministry of Agriculture, Md. Nasiruzzaman, stated that the BAU-STR dryer has proven to be an effective technology in reducing post-harvest loss for grains in Bangladesh and needs to be expanded and introduced to more farmers. The Government of the People's Republic of Bangladesh has approved a mega project worth about 360 million USD for popularizing appropriate agricultural machinery where drying machineries will be disseminated to the farmers on subsidy along with other need-based agricultural machines. The government is also giving 70% subsidy on the machines in *haor* (low-lying areas) and coastal areas, and 50% to farmers in other areas of Bangladesh. Such government-led efforts will help Bangladesh attain food security through mechanization.

“Application of appropriate agricultural machinery in Bangladesh is urgently necessary in all stages of agricultural activities.” *Mr. Md. Nasiruzzaman, Secretary, Ministry of Agriculture, Bangladesh*

Ethiopian Graduate Students Paving the Way for new Leadership in Post-Harvest Management Field

Two students of rural Ethiopian descent have emerged from graduate student status to co-PI's in the PHLIL Ethiopian team research labs. Five years of hard work coupled with an interest in securing the harvest for citizens of their home country, we present to you Dr. Aynadis Molla Asemu and Samuel Alemayehu Lapiso.

Dr. Aynadis Molla grew up in a village of South Gondar, Ethiopia where she witnessed farmers' post-harvest crop losses each year just 10 km outside of her home. As a young girl she saw how the occurrence of market losses were drastically impacting farmers' ability to maximize their potential sales. She was also acutely aware that there are very few women in Ethiopia earning tertiary degrees, particularly in STEM-related fields.

Aynadis began her doctoral studies at PHLIL partner institution Bahir Dar University (BDU) in 2015 after having spent 10 years in graduate research and lecturer roles in the field of Chemical and Food Engineering. She crossed paths with the coordinator of the Post-Harvest Loss project at BDU where she quickly became interested in becoming one of the first female researchers involved in the drying and storage experiments of PHLIL's lab. Aynadis excelled as a graduate student and researcher in PHLIL and even led many of the drying experiments with the solar bubble and solar cabinet dryers.



Another successful PHLIL graduate student, Mr. Samuel Alemayehu, grew up in rural southern Ethiopia. Samuel's interest in science and experience as an Assistant Professor led him to Mekelle University's Ph.D in Plant Breeding and Seed Systems program in 2016. Samuel's research on both sesame and chickpeas was inspired by reports of mycotoxin contamination, negative health effects of unsafe food, and lack of knowledge about proper storage structures and techniques. Through research, Samuel now hopes to find safe storage technologies which would help ensure food security for Ethiopia's population.

Being promoted to co-PI of a large multi-faceted international agricultural research project as a graduate student is rare anywhere in the world. But Aynadis and Samuel have challenged that standard and forged a ground-breaking path for the PHLIL Ethiopia team. Initially shadowing the team PI's, they each eventually took on a crucial leadership role in the lab's research.

Dr. Molla and Mr. Alemayehu now serve as Assistant Professors at their respective institutions and co-PI's of the PHLIL Ethiopia labs. Aynadis remarks that she feels a great sense of pride to be able to now train farmers, predominantly women, on best practices in protecting their harvest. Aynadis and Samuel, along with additional graduates from the PHLIL Ethiopia program, have become role

models and represent a promising next generation of scientific discovery for food security in Ethiopia.

Prior to the PHL Innovation Lab's existence in Ethiopia, post-harvest loss studies were nearly non-existent at Mekelle and Bahir Dar Universities. Due to the team's success, and that of these future scientists, the program has taken shape to now include course development, teaching, extension training, technology dissemination, and leadership in post-harvest loss reduction initiatives for Ethiopia. The field of post-harvest loss reduction is still very much emerging as a food security strategy and research agenda in Ethiopia. PHLIL has enabled the necessary training and capacity building for continued research and growth in post-harvest loss reduction research.

Additional Ph.D graduates and soon-to-be graduates from Ethiopia include Dr. Karta Kalsa (2019, Post-Harvest Technology, Bahir Dar University), Mr. Muez Berhe (2021, Plant Science, Mekelle University), and Dr. Admasu Fanta (2020, Post-Harvest Technology, Bahir Dar University). Dr. Kalsa now works for the Ethiopian Institute of Agricultural Research as a senior researcher of seed technology. Muez Behre hopes to continue work with post-harvest loss team members, devoting himself to scaling up proven storage technologies and his research findings to various stakeholders after graduating; and Dr. Fanta is now a lecturer at Bahir Dar University.

"I feel extremely responsible for the loss of crops in my country, so I need to do more research to work with farmers to reduce these losses. As an engineer I need to develop different types of dryers, considering free (solar) energy by developing new designs to deliver to farmers. I want to be an expert in my field of study and a problem solver for the people of Ethiopia." Dr. Aynadis Molla Asemu, Bahir Dar University

Photo above: Dr. Aynadis Molla Asemu with the Solar Bubble Dryer at Bahir Dar University

Gender Course Quickly Shifts to Online Format in light of Global Pandemic

With the halt of international travel due to the COVID-19 pandemic, many international research projects have found creative solutions to continuing operations. Dr. Anna Snider of AgReach at the University of Illinois was preparing to teach a course on conducting gender technology assessments at the University for Development Studies (UDS) in PHLIL focus country Ghana. When the pandemic lingered Dr. Snider did not relent and instead worked hard to prepare an online course delivered in August 2020.

The University for Development Studies is a public university dedicated to the rural development of Northern Ghana and the entire country. The university emphasizes practically-oriented research and field-based training aiming to reduce poverty and accelerate national development. Training UDS faculty and staff was identified as a relevant strategy for reaching smallholder farmers in the north as the PHLIL Ghana team aims to study the market demand and scaling of hermetic storage through a gender lens. One of the team's priorities is to determine how post-harvest technologies can be scaled with equitable access.

In a normal year, Dr. Snider would have prepared to teach her day-long seminar, "Assessing Post-Harvest Technologies through a Gender Lens," in person to a group of faculty, staff, and undergraduate students at UDS. Anna typically structures her course to involve advance homework and readings as well as group work and discussions on the day of the seminar. The course closely follows the Gender Technology Assessments developed by the USAID-funded Integrating Gender and Nutrition within Agricultural Extension Services (INGENAES) project. Gender Technology Assessments consider the differential impacts of technologies on women and men, the equitability in access to the technologies, and the impact on gender roles that result from uptake of the technology.

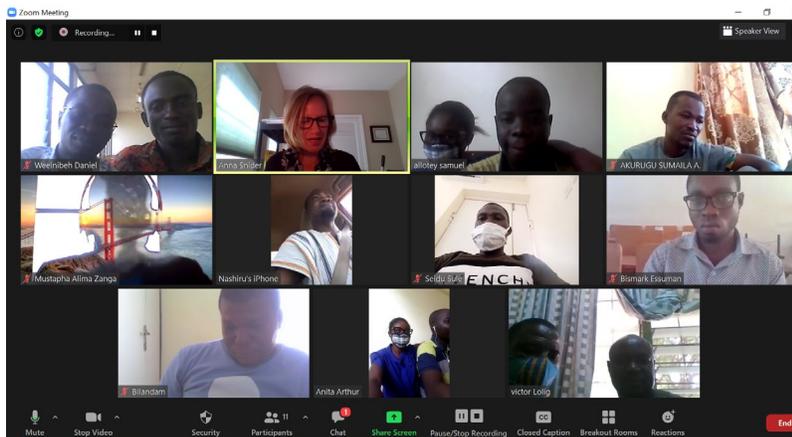
Moving to an online format produced challenges: for one, variable internet service was a constant challenge for participants. Furthermore, UDS would not be able to invite undergraduate students as originally anticipated given that courses had not yet resumed on campus by August. Additionally, Anna likes to ensure the active participation of both women and men in the class. UDS has more male than female faculty, but teaching the course remotely gave her less control over the gender breakdown of the participants. Finally, it meant splitting the day-long seminar into a 3-day course to avoid video conference fatigue. Ultimately, 15-20 UDS faculty and staff tuned in to the sessions over the course of the seminar, including the Head of the Faculty of Agribusiness and Applied Economics at UDS.

In Dr. Snider's first session, faculty and graduate students discussed the theory of gender dynamics and why it is important to consider in the agriculture sector. Day two consisted of taking a deeper look at the INGENAES Gender Assessments, walking the class through the worksheets and process so that they might soon be able to incorporate these into their own courses and research. Finally on day three, Anna presented a fictitious case study of a post-harvest technology being introduced into a community. The cohort used the INGENAES worksheets to align with the case study.

Participants commented that the course helped them to put their knowledge of gender theories into a more practical and operational frame. Moving forward, 2 graduate students and 2 faculty will

conduct fieldwork to inform the gender technology assessments of three post-harvest technologies recommended by the lab as well as contribute to a journal article on the impact of post-harvest technologies on food security.

Anna comments that the class is ultimately at its best when delivered in person. Students can converse and discuss case studies more efficiently. She can ensure that materials are properly disbursed. Though at times imperfect, the online format was the most properly suitable way to continue to drive momentum for incorporating gender equity into the post-harvest loss research and innovation scaling.



Dr. Snider teaching students via zoom during the 3-day seminar which took place in July/August 2020



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