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Implementation of Paddy Drying Technology

Introducing small/medium paddy dryers in remote areas

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ACRONYMS AND ABBREVIATIONS

AEZ	Agro-Ecological Zone
BAU	Bangladesh Agricultural University
BDT	Bangladesh Taka
BIDS	Bangladesh Institute of Development Studies
CIG	Common Interest Group
DAE	Department of Agricultural Extension
DG Food	Directorate General of Food
FAO-MMI	Food and Agriculture Organization-Missing Middle Initiative
FGD	Focus Group Discussion
GoB	Government of Bangladesh
IFPRI	International Food Policy Research Institute
IFPRP	Integrated Food Policy Research Program
LPG	Liquid Petroleum Gas
LSD	Local Supply Depot
LSP	Local Service Provider
MFSP	Modern Food Storage Facilities Project
MT	Metric Ton (1,000 kilograms)
PHLIL	USAID Innovation Lab for Reduction of Post-harvest Loss (Post-harvest Loss Innovation Lab)
PMU	Project Management Unit
UIUC	University of Illinois at Urbana-Champaign
UNO	Upazila Nirbahi Officer
USAID	United States Agency for International Development

EXECUTIVE SUMMARY

Grain drying has become increasingly challenging for the Bangladesh food system as postharvest innovations have not kept pace with production growth and an increasing volume of grain is harvested during wet or foggy periods, when conventional open-air drying is problematic. This activity sought to build capacity for mechanical dryer service provision by small-scale entrepreneurs and to demonstrate a model for providing mobile grain drying services through entrepreneurs using a locally manufactured small-scale dryer.

In coordination with Ministry of Food officials, the project selected 20 farmers to train as mechanized drying service providers, provided them with use of small-scale mobile batch dryers, and deployed them in rural areas from which Local Supply Depots (LSDs) source grain. The service providers were active in Bogura and Rangpur Districts in late May 2023, during the closing phases of the Boro harvest season. The pilot revealed nuances of the costs of operation and indicated potential for viable business activities, especially in areas where open-air drying is relatively costly or inadequately available. Additionally, a scoping visit to Naogaon District revealed significant interest in mechanized drying services.

The findings suggest a value to additional observation of the service providers to document capacity utilization over an Aman season and a full Boro season. Such observations would allow confirmation about parameters related to annual capacity utilization which are important determinants of business viability.

I. INTRODUCTION

Background

Bangladesh has made tremendous progress in increasing rice production. However, the rice value chain continues to face difficulties, particularly in paddy drying, which results in losses and poses challenges to public procurement from smallholder farmers. To be safely milled or stored, paddy must be brought to a moisture content of 12% to 14% from a moisture content of 22% or higher, which is typical for grain when it is brought in from field drying (RKB, 2022; and Alam, et al., 2019). Most paddy harvested in Bangladesh is dried on-farm in the open air to some degree prior to either on-farm storage or sales. Once grain reaches a mill, it typically requires additional drying which occurs on drying floors (chatal) in the case of husking mills and semi-automatic mills or in mechanical dryers in automatic mills (Bhuiyan, 2018). Based on data from the 2018 Millers and Traders Survey (IFPRI), 55% of the paddy that was milled in the country was dried on drying floors at husking mills or semi-automatic mills (Table 1). The remaining 45% was dried in machine dryers in automatic mills, after initial open-air drying on the farm. Although automatic mills with large-scale grain dryers account for a growing share of the rice value chain, the bulk of the country's grain harvest is dried on open-air drying floors where grain must be spread at a depth of no more than 5 cm and mixed with rakes for even drying over a duration that may extend to multiple days, depending on the weather.

Table 1: Weighted total paddy processing/drying in 2016-17

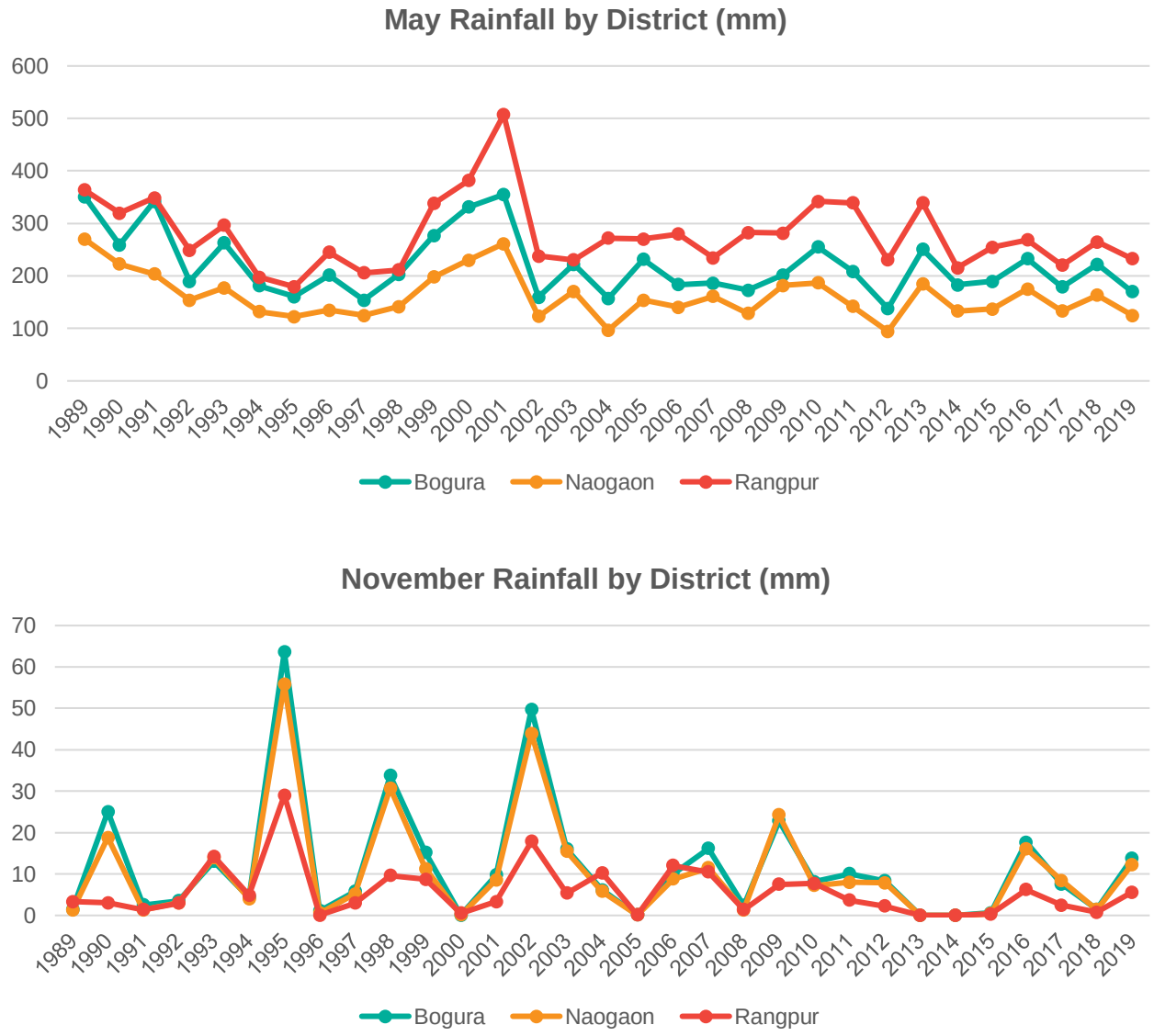
Mill type	Total paddy processed (Million MT)	Paddy dried in open-air on drying floor (chatal) (Million MT)	Paddy dried in open-air on chatal (%)
Automatic mill	11.93	0.06	0.50
Semi-automatic mill	4.34	3.99	91.80
Husking mill	11.07	10.99	99.30
Total	**27.34**	**15.04**	**55.00**

Source: IFPRI, 2018 Millers and Traders Survey.

The Boro harvest—the largest in terms of total output—comes in April and May, coinciding with periods of high humidity and unreliable weather making open-air drying problematic (Shelley, et al., 2016; Aktar, et al., 2016; and Weather and Climate, 2022). As Figure 1 shows for selected districts, rainfall levels are rather high during the Boro harvest, but comparatively low in November when the Aman harvest occurs. Over the last decades the share of the paddy produced during the Boro season has steadily increased (Al Mamun MA, et al, 2021), meaning that the difficulties associated with open-air drying in wet weather affect a larger and larger share of national production. Moreover, in regions such as Rangpur and Bogura districts, rising land values and labor costs have combined to make open-air drying a costly process. Grain drying has become increasingly challenging for the Bangladesh food system as postharvest innovations have not kept pace with production growth and an increasing volume of grain is harvested during wet periods. These constraints on drying have clear implications for postharvest losses, market development, as well as implementation of public procurement policies at harvest (Alam and Saha, 2021). Open-air drying is also associated with quality losses due to excessive respiration and fungal growth if weather is damp, contamination from foreign agents, and uneven heating which contributes to cracking. The practice also creates a processing bottleneck that slows milling throughput and can restrict market activity with negative consequences for farmers trying to sell grain.

Given the prevalence of open-air drying, identification of drying technologies and delivery mechanisms that are appropriate for farmers and other value chain actors in Bangladesh could enhance the food system. The BAU-STR dryer represents a potential tool for providing smallholder farmers in rural Bangladesh with paddy drying services. The BAU-STR dryer was developed at the Bangladesh Agricultural University with support from the USAID Innovation Lab for the Reduction of Post-Harvest Loss (PHLIL). This small-batch, locally manufactured, mobile dryer can be operated on farms or at service hubs. The BAU-STR dryer can dry one-half metric ton of paddy rice in 3-5 hours, bringing the moisture content from 22% to 12%, making it suitable for storage and milling. The dryer relies on heat provided by either rice husk briquettes or Liquid Petroleum Gas (LPG) and requires electricity to power a small, locally manufactured blower (Alam, 2019).

Figure 1: Average monthly rainfall by district



Source: National Center for Atmospheric Research Staff (Eds). "The Climate Data Guide: CRU TS Gridded precipitation and other meteorological variables since 1901." Retrieved from https://climatedataguide.ucar.edu/climate-data/cru-ts-gridded-precipitation-and-other-meteorological-variables-1901.

There are numerous technical options for providing mechanized grain drying, ranging from small-scale systems for household use to large-scale dryers at automatic mills (Alam, Bala and Bhuiyan, 2010; Mareeswaran and Dillibabu, 2028; Saha et al, 2021). Given the large share of paddy that is

currently stored on-farm and the large volume of grain that continues to be processed through husking mills as well as the need to meet moisture limits for storage in LSDs and private facilities, provision of drying services in rural communities may contribute to addressing postharvest bottlenecks. The model for providing rural drying services has not yet been fully developed, despite the availability of different technical options.

Objectives

This activity aimed to demonstrate a model for providing rural drying services using locally available small-scale, mobile grain dryers managed by private service providers, including farmers' and youth organizations, during one harvest season.[1] By training, supporting and monitoring these service providers, the project sought to determine whether this model holds promise.

The specific objectives of this activity were:

- To demonstrate a model for providing drying services using locally available small-scale, mobile grain dryers managed by private service providers and farmers' and youth organizations during one harvest season;
- To train, support, and monitor these service providers in their use of the mobile dryer;
- To determine the viability of the proposed service provider model; and
- To conduct reconnaissance survey for scoping the prospects of scaling the activities in Naogaon District.

[1] The original intent described in the inception report was to conduct these activities at the 2022 Aman season harvest, 2022. Administrative delays prohibited fielding the program at that time. As a result, the activities targeted the 2023 Boro season. In general, weather patterns suggest greater need for mechanical drying for the Boro harvest than the Aman harvest.

II. METHODOLOGY AND APPROACH

This activity introduced mechanized paddy drying technology in remote rural areas in Bangladesh through field testing a dryer service provision model. The activity trained service providers to provide grain drying services to farmers using small-scale dryers. Led onsite by experts from the Bangladesh Agricultural University (BAU), the activity included selection and training for service providers, installation of dryers and service providers with technical support, monitoring and evaluation of service provider performance and data collection from value chain actors including management of Local Supply Depots (LSDs).

Selection of service providers

The activity was conducted in Bogura and Rangpur Districts. In each of these districts, two Upazilas that are known to be cluster areas of paddy supply to LSDs were selected purposively and in consultation with LSD officials. Bogura Sadar and Sherpur Upzillas of Bogura District and Pirganj and Badarganj Upazillas of Rangpur District were selected. In each of the four Upazilas, five service providers were selected in consultation with the Ministry of Food officials, District Controller of Food, District and Upazila Agriculture Officers. Each of these entrepreneurs was a farmer who had registered to deliver paddy to the LSD.

In February 2023, a team from BAU visited the selected areas to identify key value chain stakeholders and to select 20 service providers to receive training in the use of the dryers and in associated business practices. The criteria used to select service providers included: (1) engagement in post-harvest activities such as transportation of paddy; (2) registration as a potential supplier of paddy to an LSD; (3) entrepreneurial experience with other agricultural machines; (4) access to a reliable power source to operate a dryer. These service providers were selected in consultation with the District Controller of Food, and District and Upazila Agriculture Officers. Participants from Pirgonj and Badarganj in Rangpur District were from farmers groups associated with the FAO-MMI program, including young farmers.

Appendix 1 Table A1.1 provides the roster of farmer/service providers selected for the program.

Additional scoping site

While these activities were concentrated in Bogura and Rangpur Districts, Naogaon District was recognized as a potential location for future work given its significance as a rice surplus area with grain drying bottlenecks and major clusters of rice milling industries. Therefore, Niamatpur Upazila of Naogaon District was selected for a reconnaissance visit for scoping future activities related to the development of drying services.

Training service providers

On March 21, 2023, experts from BAU trained service providers in the use of the BAU-STR dryer onsite at BAU campus. The training program was aimed to equip participants with the necessary knowledge and skills to effectively operate and maintain BAU-STR dryers as a small business operation. All 20 farmers from the four upazilas participated in the training, with one representative from each Upazila Local Storage Depot (LSD) also attending. The four LSD representatives, listed in Appendix 1 Table A1.2, were nominated by the District Food Officers.

The BAU-STR Dryer training program was conducted in the Department of Farm Power and Machinery at Bangladesh Agricultural University. The training sessions were designed to cover various aspects of operating and maintaining the BAU-STR dryer, including:

1. **Introduction to BAU-STR dryer:** The participants were introduced to the features, components, and functionality of BAU-STR dryer. They gained a clear understanding of how the dryer can improve the drying process for paddy, maize, and other crops.
2. **Dryer installation:** A significant aspect of the training program focused on the installation of BAU-STR dryer. Participants were guided through the installation process, including site selection, electrical and LPG connections, and proper positioning of the dryer for optimal performance.
3. **Dryer operation:** The participants learned the proper procedures for setting, starting, operating, and stopping the BAU-STR dryer. They were trained in setting the appropriate temperature, airflow, and other relevant parameters to achieve optimal drying results.
4. **Maintenance and troubleshooting:** The training program emphasized the importance of regular maintenance to ensure the efficient functioning of the dryer. Participants were taught how to conduct routine inspections, clean the equipment, and address common issues that may arise during operation.
5. **Safety precautions:** Safety measures were discussed to ensure that participants understood the potential hazards associated with operating the dryer.
6. **Moisture meter operation:** The training program included a subject on moisture meter operation. The participants were educated on the importance of accurately measuring the moisture content in paddy. They learned how to use moisture meters effectively and interpret the results to determine the optimal drying time.
7. **Basic business practices:** Trainees were instructed in the costs of operating the dryer, appropriate fees to charge and record keeping practices.

Images from this training are provided in Appendix 2.

After the training, each service provider was given rights to use one BAU-STR dryer in order to provide drying services for a fee in their localities. Service providers were advised to charge between BDT1.0/kg and BDT 2.0/kg for drying services. The upper bound is the amount charged at drying platforms and the lower bound is the ex ante estimated operating cost of the dryer. BAU experts continued to provide technical support and monitoring of the dryer use after the training and through the end of the drying season.

Implementing and monitoring grain drying service provision

Twenty BAU-STR dryers and related equipment were made available to the service providers through the LSDs. These dryers remained under control of the LSDs during and beyond the project period as per direction of the DG Food. The LSDs distributed the dryers to the trainees on loan so that they could pilot a model of rural drying service provision, with and the Bangladesh Agricultural University, University of Illinois, and Ministry of Food gathering information on their activities and the dryer performance.

Dyers were delivered to the LSDs on April 11, 2023 shortly after the onset of the Boro harvest in the region. The dryers were presented to the farmer/service providers in ceremonies involving the relevant Upazila Executive Officers and other officials. During dryer distribution in Bogura Honorable

District Commissioner (DC) was present. Elsewhere Upazila Nirbahi Officer (UNO), DAE officials, representatives of BAU, and local government representatives were present. Images from the delivery ceremonies are in Appendix 2.

Delivery dates of the dryers to the service providers in each respective Upazila were as follows:

1. May 7, 2023: Dryers presented to five service providers in Bogura Sadar, Bogura.
2. May 15, 2023: Dryers presented to five service providers in Badarganj, Rangpur.
3. May 15, 2023: Dryers presented to five service providers in Pirgonj, Rangpur.
4. May 21, 2023: Dryers presented to five service providers in Sherpur, Bogura.

A total of 20 dryers, 20 moisture meters, 20 tool boxes and 8 diesel generators were distributed under the direct supervision of District Food Officers. The equipment was deployed to provide services in the Boro harvest, 2023. The locations for deployment of the dryers were purposefully determined to target areas from which LSDs are known to procure paddy. Technical staff from BAU were available to support the service providers as needed and to gather data on performance and activity.

Data collection from farmer/service providers

BAU staff provided technical support to farmer/service providers and monitored use of the dryers after the service providers received them and until the local grain harvest had been dried. Monitoring activities allowed staff to collect data on technical performance and business aspects of dryer use. These data were to include information on dryer operation and reduction of postharvest loss, business viability (use, revenue and profit), and impact on grain quality. Additionally, the clientele using the mechanical drying services provided feedback to the operators and project staff.

The timing of distribution of dryers combined with a somewhat early onset of the Boro harvest and favorable weather conditions for sun drying in the localities of interest meant that most of the Boro harvest had already been sun-dried by the time the service providers were locally operational. The low volume of drying activity limited the collection of data for all the Upazilas covered. In Bogura Sadar, where dryers were delivered to farmer/service providers on May 7, four of the five recipients recorded business activity. However, in Sherpur Bogura, driers were not received until May 21 due to scheduling issues and none of the recipients reported providing any drying services as the harvest had already been fully dried. In Rangpur, researchers were able to monitor and gather data on mechanical dryer operations in Badarganj, but an absence of wet paddy remaining in Pirgong prohibited data collection on mechanical dryer operations in that Upazila. BAU staff in consultation with University of Illinois investigators also secured information from farmers, traders and Local Supply Depots (LSDs) concerning the quality and moisture content of grain delivered to them.

Data collection Naogaon scoping

In addition to data collection from farmer/service providers in Bogura and Rangpur Districts a scoping study conducted in Niamotpur Upazila of Naogaon District provided background information relevant to further scaling of mechanical drying services. The scoping study employed a mixed-methods approach, combining both qualitative and quantitative data collection techniques. Extensive field surveys were conducted to gather primary data, which involved face-to-face interviews, and direct observations over the period of January 3 through January 18, 2023. Additionally, secondary data from various reliable sources, including government reports were also utilized to complement the primary data.

The methods for data collection included Rapid Reconnaissance Survey followed by Focus Group Discussion (FGD), and Key Informant Interview (KII). A structured questionnaire was used to collect quantitative data while key informant interviews were conducted over zoom platform and in person. Table 2 summarizes the sample distribution. The data comprises a total of 109 respondents. Among them, the majority are farmers who supply to LSDs (n=45), followed by local service providers (n=21). Additionally, there are 20 farmers who do not sell grain to LSDs, 12 aggregators and 11 representatives of Common Interest Groups (CIG).

Table 2: Naogaon district scoping research sample

Respondent type	Sample size
Farmers supplying to LSD	45
Local service providers	21
Farmers not supplying LSD	20
Aggregators	12
CIG representatives	11
Total	**109**

Source: Authors.

III. FINDINGS FROM TRAINED FARMER/SERVICE PROVIDERS

Farmer/service provider activities

Two factors significantly restricted the data that could be collected from the trained farmer/service providers concerning the fielding of the dryers in the Boro season 2023. First, the somewhat early onset of harvest and sunny weather combined with the timing of dryer distribution left many of the farmer/service providers with little or no potential clientele in their home villages. Second, while all the service providers were registered to supply to local LSDs, authorization to supply was restricted to those registered suppliers who were selected by lottery. The registration process using a mobile app was easily accessed by the users. However, although all of the trained farmer/service providers had registered on the app and many of them had been selected to supply to LSDs in previous years, none of them were selected in the lottery for Boro 2023. As a result, none of these individuals supplied paddy to an LSD. The service providers therefore could not report on direct experience supplying to the LSD.

Information on the technical performance of farmer/service providers that operated dryers during the study period is given in Table 3.

Table 3: Technical performance of dryer service providers

Upazila	Number of active service providers	Dates of operation	Average batches per day	Average initial moisture content	Average final moisture content	Average drying time (hours)	Fuel use (kg/hr)
Bogura Sadar	4	09/05/23-27/05/23	1.33	23.3%	13.3%	4.0	1.09
Badarganj Rangpur	3	25/05/23-28/05/23	2.0	28.8%	12.0%	5.2	1.3
No service provider activity was possible in Pirgonj or Sherpur Upazilas due to absence of wet paddy. The maximum observed final moisture content across all baches dried was 14.02%.							

Source: Authors.

About 55% of users of the drying services reported an intent to sell the dried grain in the local market while the remaining 45% indicated an intent to store the grain in their homes. Farmers intending to sell the grain in the market reported that use of the dryer enabled them to be confident that their grain was sufficiently dried to be sold. The average moisture content of grain dried in the BAU-STR dryer across all upazilas in the study was 12.6%. Spot checks in the market and LSD reports indicated that grain being sold was generally under the 14% moisture content threshold, whether it had been dried mechanically or not. However, farmers using the mechanical dryer reported that the mechanized service enabled them to achieve this quality in a timely manner, which was of value to them. All users responded that they would like the option to use mechanical drying services in the future. Even in locations where piloting commercial use of the dryers was not possible, the demonstration of the dryer performance served to stimulate interest in using mechanical drying services in the future. All the drying service providers and the users identified benefits of the dryer in terms of saved cost, time, and grain quality.

Financial analysis of farmer/service provider operations

Previous financial analysis based on controlled conditions suggested that the BAU-STR dryer could offer drying services at below the cost of open air drying and therefore held promise as part of a small-scale commercial drying operation (PHLIL, 2022; Saha et al 2017; Saha et al, 2018; Saha et al, 2020). The experience of the farmer/service providers in this study provides a set of parameters based on actual field experience that can be used to assess the financial viability of this service provider model.

Financial analysis uses the cost parameters shown in Table 4. The commercial alternative to mechanical drying is open air sun drying on private drying floors. The charge for these services in the study area in 2023 was BDT 2/kg. Therefore, the financial analysis of the BAU-STR dryer uses BDT 2/kg as a reference price for the value of drying services. Other fixed parameters in Table 4 relate to the cost of inputs for the dryer: electricity, LPG fuel and labor. The operation of the dryer does not require continuous attention. The wage is therefore applied to only 25% of the duration of the dryer's operating time, implying a labor cost of BDT 25/hr of dryer operation, using a wage rate of BDT 100/hr, which is above the observed rural wage rate.

Table 4: Price parameters for financial analysis

Item	Price parameter
Drying floor service charge (BDT/kg)	2.00
Hours labor use/hour dryer operation	0.25
Dryer operator wage (BDT/hr)	100.00
Electricity BDT/kwh	7.49
LPG BDT/kg	95.00
Dryer batch (Kg)	500

Source: Authors.

The volume of grain throughput is a critical determinant of the profitability of a drying activity. Table 5 presents the estimated throughput given four sets of observations and projections. The first column represents lab setting results based on previous research using the BAU-STR dryer (PHLIL, 2022). The second column is based on the average observations across Rangpur and Bogura Districts. Because field observations differed between Bogura and Rangpur, data and related projections for each of these districts are presented separately in columns 3 and 4. In the following tables, "Lab Setting" refers to data published in PHLIL 2022. Values under "Combined Pilot" are based on averages of data from all observed dryer activity by project trainees. "Bogura Pilot" and "Rangpur Pilot" refer to the average values from project participants who were active in those areas. As the table shows, the dryers were consistently used at their 500kg/batch capacity in lab and in field settings. However, trainee service providers had fewer batches per day and different time requirements for dryer operations than the lab setting. The relatively low number of batches per day reflects lower market activity while the differences in drying time can be attributed to differences in initial moisture content of grain as well as ambient conditions and furnace management. In order to estimate annual throughput for these data, we assume 75 days of use per year (45 in Boro and 30 in Aman) and project the annual number of drying batches that would be expected if the daily observations were representative of a norm. This exercise suggests throughput of about half the lab-based estimate and probably underestimates the annual throughput that service providers could achieve since the observations of batches per day were made after the peak of the season.

Table 5: Throughput

	Lab setting	Combined pilot	Bogura pilot	Rangpur pilot
Batch size (kg paddy)	500	500	500	500
Batches/day operation	2.88	1.50	1.33	2.00
Hours/batch	5.00	4.50	4.00	5.20
Estimated Days/yr operation	75	75	75	75
Projected Throughput: batches/year	216	113	100	150
Projected Throughput: kg/year	108,000	56,250	49,875	75,000

Source: PHLIL (2022) and field observations.

The analysis of business viability uses fixed and variable cost estimates provided in Tables 6 and 7. The fixed costs of the dryer in the field site are lower than those in the lab setting because of the current Government of Bangladesh policy of providing a 50% subsidy on the dryer. As Table 7 shows, the annual variable costs are much greater than the annualized fixed costs and are dominated by the cost of LPG fuel. With the exception of the annual charge for the service contract, the variable costs vary with throughput and with the duration required for drying. As both drying time and throughput are estimated to be lower in the field sites than in the lab setting, variable costs per year are smaller for the trainee service providers than was estimated in the lab setting.

Table 6: Fixed costs

	Lab setting	Combined pilot	Bogura pilot	Rangpur pilot
Dryer price (BDT)	75,000	60,000	60,000	60,000
Interest rate	0.09	0.09	0.09	0.09
Life span of equipment: years	5	5	5	5
Fixed cost: BDT/year	**19,282**	**15,426**	**15,426**	**15,426**

Source: PHLIL (2022) and field observations.

Table 7: Variable costs

	Lab setting	Combined pilot	Bogura pilot	Rangpur pilot
Hours/batch (hours)	5.0	4.5	4.0	5.2
Batches/year (count)	216	113	100	150
Labor BDT/yr	**27,000**	**12,656**	**9,975**	**19,500**
LPG kg/hr	0.82	1.20	1.10	1.30
LPG kg/yr	886	608	439	1,014
LPG BDT/yr	**84,132**	**57,713**	**41,696**	**96,330**
Electricity kw/hr	0.75	0.75	0.75	0.75
Electricity kwh/yr	806	378	298	582
Electricity BDT/yr	**6,035**	**2,829**	**2,229**	**4,358**
Service Contract BDT/yr	**1,500**	**1,500**	**1,500**	**1,500**

Variable Cost/Yr	**118,667**	**74,697**	**55,400**	**121,688**

Source: PHLIL (2022) and field observations.

Table 8 combines the information from tables 5 through 7 in a financial summary. The data collected from trainee service providers suggest higher costs per kilogram of paddy for mechanical drying than the lab setting indicated. Nonetheless, in both districts the cost of drying with the service providers was well below the cost on commercial drying floors (BDT 2/kg). While the absolute profits per machine are lower than lab data suggested due to the lower forecasted annual throughput, the trainee service provider experiences in Bogura and Rangpur indicate that the dryers are viable for small-scale commercial activities.

Table 8: Financial summary

	Lab setting	Combined pilot	Bogura pilot	Rangpur pilot
Projected Total Revenue/Yr (BDT)	216,000	112,500	99,750	150,000
Variable Cost/Yr (BDT)	118,667	74,697	55,400	121,688
Fixed Cost/Yr (BDT)	19,282	15,426	15,426	15,426
Total Cost/Yr (BDT)	137,948	90,123	70,825	137,114
Projected Annual Profit (BDT)	78,052	22,377	28,925	12,886
Total Cost/kg (BDT)	**1.28**	**1.60**	**1.42**	**1.83**

Source: PHLIL (2022) and field observations.

Note: Total revenue is based on charge of BDT 2/kg paddy.

The results in Table 8 reflect the conditions that existed in the project sites in May of 2023. The financial viability of a dryer-based enterprise will depend on environmental and market conditions that will vary over space and time. Two factors that significantly affect unit costs and business viability are the number of batches that are dried per year and the amount of LPG fuel required per batch. LPG usage will be affected by drying time which is itself influenced by the moisture content of paddy and weather conditions and by the management of the operator. The number of batches run will reflect market conditions and weather, among other factors that may be beyond the control of the service provider. Table 9 presents cost of machine drying paddy (BDT/kg) assuming different volumes of throughput (batches per year), different average drying times, and a range of rates of LPG use. The minimum throughput considered is 50 batches per year, which would be equivalent to just over one batch daily through the 45 days around the Boro season harvest. The upper limit on throughput is set at 200 batches, equivalent to 2.67 batches per day through the 75 days of the combined Boro and Aman season harvests. Observed drying times range from 3.8 hours to 5.2 hours. The average drying time for an operator is unlikely to fall outside of the 4 to 5 hour range and the tables consider the range of 3.5 to 5.5 hours. Observed LPG usage ranges from 0.75kg/hr to 1.3kg/hr. Table 9 considers rates of 0.8, 1.0, and 1.3 kg/hr.

Table 9: Farmer/service provider costs under alternative scenarios

9(a) Total cost (BDT/kg) by batches/yr and drying time at LPG use rate of 0.8 kg/hr					
Drying time/batch (hours)	**Batches/yr**				
	50	**75**	**100**	**150**	**200**
5.5	1.85	1.62	1.51	1.4	1.34

5	1.74	1.52	1.4	1.29	1.24
4.5	1.64	1.41	1.3	1.18	1.13
4	1.53	1.3	1.19	1.08	1.02
3.5	1.43	1.2	1.09	0.98	0.91
9(b) Total cost (BDT/kg) by batches/yr and drying time at LPG use rate of 1.0/hr					
Drying time/batch (hours)	**Batches/yr**				
	50	**75**	**100**	**150**	**200**
5.5	2.06	1.83	1.72	1.61	1.55
5	1.93	1.71	1.59	1.48	1.43
4.5	1.81	1.58	1.47	1.36	1.3
4	1.68	1.46	1.34	1.23	1.17
3.5	1.56	1.33	1.22	1.1	1.05
9(c) Total cost (BDT/kg) by batches/yr and drying time at LPG rate of 1.3kg/hr					
Drying time/batch (hours)	**Batches/yr**				
	50	**75**	**100**	**150**	**200**
5.5	2.37	2.15	2.03	1.92	1.86
5	2.22	1.99	1.88	1.77	1.71
4.5	2.06	1.84	1.73	1.61	1.56
4	1.91	1.68	1.57	1.46	1.4
3.5	1.76	1.53	1.42	1.3	1.25

Source: Authors.

Since the reference price for operators is BDT 2/kg in Rangpur and Bogura Districts, any scenario in Table 9 for which the total cost for production is under BDT 2.0 can be considered profitable. Panel 9 (a) in table 9 shows that if the LPG use rate is kept to 0.8 kg/hr, the service providers can be profitable even at throughput of only 50 batches per year and long drying times. Similarly, if the LPG use rate is 1.0 kg/hr, the enterprise is profitable at the minimum throughput, except in the highly unlikely event of the average drying time reaching 5.5 hours. Panel 10c shows that if the LPG use rate is up to 1.3 kg/hr, as observed among users in Rangpur, the costs exceed BDT 2.0/kg when the throughput is at 50 batches per year. At this low level of fuel efficiency, service providers will need throughput of at least 75 batches per year to be minimally profitable at normal drying times (5 hours or less per batch). The limited observations in Rangpur and Bogura suggest that throughput of 75 batches is well within the feasible range, as it implies fewer than 2 batches per day through the Boro harvest period, or only one batch per day across Boro and Aman seasons.

The experience of trained farmer/service providers in this project suggests that the BAU-STR dryer can be the basis for a viable rural commercial drying activity. The service providers operated the equipment at costs that were lower than the alternative of using open-air drying floors, while offering faster drying services that are robust to weather conditions. Scenario analysis suggested that under

a range of possible conditions, the service provider model would likely offer lower cost drying than the alternative in these districts.

IV. FINDINGS FROM SCOPING STUDY

The scoping study in Niamotpur Upazila of Naogaon District employed a mixed-methods approach, combining both qualitative and quantitative data collection techniques involving face-to-face interviews, and direct observations. Additionally, secondary data from various reliable sources, including governmental reports were also utilized to complement the primary data. Instruments used to structure the interviews are provided in Appendix 3.

Agricultural context

Niamatpur Upazila, situated in the Barind Tract, is composed of AEZ-26 and AEZ-25. The predominant crop in this region is rice, with approximately 29,000 hectares of land dedicated to cultivating Aman rice during the monsoon season, 21,000 hectares for Boro rice during the winter season, and about 8,000 hectares for Aus rice during the summer season. Additionally, other crops such as wheat cover around 3,800 hectares, mustard covers 3,530 hectares, potatoes cover 1,400 hectares, leafy vegetables span 1,000 hectares, and pulses occupy 100 hectares of land. This constitutes a region of substantial agricultural productivity. Niamatpur Upazila plays a vital role in the food supply chain, producing an annual yield of approximately 140,000 metric tons of food. This production contributes to meeting the demand for sustenance across various parts of the country.

In Niamatpur the Local Supply Depots (LSDs) collected 0.0939 lakh metric tons (MT) of paddy during the 2022-23 period. Table 10 summarizes sales of paddy to LSDs by the informants contacted in this research. The farmers selling to the LSD report a range of sales volumes from 25 to 100 maunds of 40 kg, with an average of 51 maunds, about 2000 kilograms. Local service providers (LSPs) tend to operate at slightly larger volumes, averaging 80 maunds (3200 kg). Common Interest Group (CIG) members, show a pattern similar to other farmers delivering to the LSD.

Table 10: Paddy sold to the LSD

	Sales volume (maunds of 40 kg)		
Description	High	Low	Average
Farmers supplying to LSD (n=45)	100	25	51
Local service providers (n=21)	200	50	80
Farmers not supplying LSD (n=21)	0	0	0
Aggregators (n=12)	0	0	0
CIG representatives (n=11)	100	25	48

Source: Based on Focus Group Discussions, Niamatpur Upazila, Naogaon district, January 2023.

Table 11 presents data on the number of times paddy was sold to the LSD during the last season. Farmers, LSPs, and CIG members are somewhat uniform in terms of average number of exchanges with the LSD. In general, these actors sell just once or perhaps twice per season, but in all groups, a small number of actors sell at high frequency.

Table 11: Frequency of paddy sales to LSD

	Frequency of sales to LSD		
Description	**Maximum**	**Minimum**	**Average**
Farmers supplying to LSD (n=45)	5	1	2
Local service providers (n=21)	5	1	3
Farmers not supplying LSD (n=21)	0	0	0
Aggregators (n=12)	0	0	0
CIG representatives (n=11)	7	1	2.4

Source: Based on Focus Group Discussions, Niamatpur Upazila, Naogaon district, January 2023.

Knowledge about moisture content

Respondents and informants tended to have little understanding of the importance of managing moisture content in grains. As Table 12 shows, among the farmers selling to the LSD, the minority (6 respondents) demonstrated knowledge about moisture content, while the majority (39) lacked awareness in this topic. Similarly, among LSPs, only 4 individuals possessed knowledge about moisture content, with 17 individuals indicating a lack of knowledge on the subject. While most respondents had little knowledge about moisture management or its importance, they all applied the traditional method to assess the moisture content by biting the paddy.

Table 12: Knowledge about moisture content

	Knowledge about moisture content	
Description	**Yes**	**No**
Farmers supplying to LSD (n=45)	6	39
Local service providers (n=21)	4	17
Farmers not supplying LSD (n=21)	0	21
Aggregators (n=12)	0	12
CIG representatives (n=11)	1	10

Source: Based on Focus Group Discussions, Niamatpur Upazila, Naogaon district, January 2023.

The local LSD reported that no penalty is imposed for selling paddy at above the 14% moisture content threshold.

Postharvest operations: Transportation of paddy to LSD and drying

Mini-trucks and trailers are commonly used for transporting paddy to the LSD. Mini-trucks are small commercial vehicles that are well-suited for transporting smaller loads of paddy over shorter distances. On the other hand, trailers are mainly power tiller or tractor mounted vehicles specifically designed for transporting in village roads. They have a higher carrying capacity and are commonly used when larger quantities of paddy need to be transported and in off-road conditions. Table 13 provides the transportation costs (BDT/maund) reported during the scoping visit. The considerable range in transportation expenses (BDT 5/maund to BDT 60/maund) relates to factors such as distance to the market, road condition, type of transportation used, and volume of paddy transported.

Table 13: Transportation cost

	Transportation cost (BDT/maund)	
Description	**Maximum**	**Minimum**
Farmers supplying to LSD (n=45)	60	5
Local service providers (n=21)	50	10
Farmers not supplying LSD (n=21)	0	0
Aggregators (n=12)	0	0
CIG representatives (n=11)	30	20

Source: Based on Focus Group Discussions, Niamatpur Upazila, Naogaon district, January 2023.

The data presented in Table 14 reveals the average cost for open-air sun drying of paddy. All categories of informants in Naogaon District relied on open-air sun drying and reported no access to mechanical dryers. Across all groups the reported cost of open-air sun drying was roughly uniform, ranging from 24 to 27 BDT/maund.

Table 14: Average cost of open-air drying (chatal)

Description	Average cost of open-air drying (BDT/maund)
Farmers supplying to LSD (n=45)	26
Local service providers (n=21)	26
Farmers not supplying LSD (n=21)	27
Aggregators (n=12)	26
CIG representatives (n=11)	24

Source: Based on Focus Group Discussions, Niamatpur Upazila, Naogaon district, January 2023.

While all respondents relied on open-air drying, they reported clear willingness to use a mechanical dryer if one were available (Table 15). Moreover, they reported a willingness to pay some amount for such a service (Table 16). Many farmers in focus group discussion indicated a preference for the speed, uniformity, and reliability of drying with a machine rather than on the drying floor. The preferred location for the dryer is within the home village itself to enhance convenience, accessibility, and familiarity while reducing transportation costs.

Table 15: Willing to use mechanical dryer

	Willing to use mechanical dryer	
Description	**Yes**	**No**
Farmers supplying to LSD (n=45)	45	0
Local service providers (n=21)	21	0
Farmers not supplying LSD (n=21)	19	2
Aggregators (n=12)	10	2
CIG representatives (n=11)	9	2

Source: Based on Focus Group Discussions, Niamatpur Upazila, Naogaon district, January 2023.

While farmers indicated an interest in mechanized drying services, the relatively low cost for open-air drying of drying floors in Naogaon (BDT26/40kg) compared to Rangpur and Bogura may restrict the price that can be charged for machine drying services in that district. The lower fees on drying floors in Naogaon may reflect different market conditions concerning land or labor costs or lower levels of rainfall in Naogaon in April in May as compared to Rangpur and Bogura (Figure 1).

Table 16: Willingness to pay for mechanical drying

	Willing to pay for mechanical drying service	
Description	**Yes**	**No**
Farmers supplying to LSD (n=45)	45	0
Local service providers (n=21)	21	0
Farmers not supplying LSD (n=21)	19	2
Aggregators (n=12)	10	2
CIG representatives (n=11)	9	2

Source: Based on Focus Group Discussions, Niamatpur Upazila, Naogaon district, January 2023.

V. CONCLUSIONS AND RECOMMENDATIONS

This project sought to explore the proof of concept that small-scale dryers could be deployed in rural Bangladesh through private service providers as a way of addressing the grain drying bottleneck in the value chain. The model of dryer service provision was piloted in Bogura and Rangpur Districts and a scoping mission was launched to assess the relevant conditions in Naogaon District.

The project identified, recruited and trained farmers to act as mechanical drying service providers in the catchments of selected LSDs in Bogura and Rangpur Districts. Participants were recruited in consultation with local Food Ministry officials. All the recruited participants were farmers and those from Rangpur included young farmers affiliated with organized farmer groups. The participants successfully completed training and were presented with drying equipment (BAU-STR Dryers) in May 2023. The timing of the Boro harvest and weather conditions limited the opportunities for the trained service providers to operate during the study period. Nonetheless, monitoring of the trainee service providers indicated that:

1. Drying activities of the trainee service providers demonstrated strong potential for profitable application of the dryers in the areas they were distributed.

2. Drying activities by the trainee service providers suggested somewhat higher variable costs than previous studies suggested.

3. Achieving high throughput and managing fuel use and costs will be important for successful commercial service providers.

4. High throughput can probably be best secured by stationing the dryer activities at the village level to serve households that intend to store grain at home as well as those selling in local markets and elsewhere.

5. The current subsidy for the investment in the BAU-STR dryers is important for the viability of the private service provider model in the short run. Removing the subsidy would effectively double the fixed costs for the technology and significantly affect profits. However, as operators gain experience, one can anticipate increased efficiencies that would make the subsidies less critical over time. For example, reducing fuel usage from the levels observed among novice operators in this study to the recommended level of 0.8kg/hr would more than offset loss of the existing subsidy.

The dryers secured through this project have been temporarily stationed with the trained farmer/service providers. Since these service providers were only active for a small part of the 2023 Boro harvest season, it would be valuable to gain more observations from them during the next Aman and Boro harvests. Allowing these individuals to continue to operate the dryers over the next two harvest seasons while monitoring their performance would provide greater confidence in estimates of annual throughput and other details to inform efforts to address the grain drying challenges in Bangladesh.

The interactions in Naogaon reinforced the importance of finding solutions to the grain drying in rural Bangladesh. The study demonstrated broad interest in mechanical drying to support farmers and to facilitate LSD operations. In comparison to Bogura, the cost of open-air drying was observed to be relatively low (BDT 26/Maund = BDT 0.65/kg). As the cost of mechanical drying falls between BDT1/kg and BDT2/kg depending on conditions, it could be more difficult to establish a drying enterprise using this technology in Naogaon. However, the farmers in focus groups identified advantages to mechanical drying, including robustness to weather, speed, and consistency which

could make it attractive even if it may be more expensive than alternative methods in some contexts.

Based on these findings, there appears to be strong potential for viable service provider businesses using small mechanical dryers, like the BAU-STR dryer, in rural Bangladesh. This type of enterprise may have an important role to play alongside other mechanical drying technologies including larger scale circulating and batch dryers.

APPENDIX 1: PARTICIPANTS IN DRYER SERVICE PROVIDER TRAINING

Table A1.1: Farmer/service providers selected for training

Sl. No.	Name of farmer	District	Upazila	Village	Mobile number	NID No.
1	Md. Sahajahan Ali	Bogura	Bogura Sadar	Chalk Dhanai	01732401505	690310228
2	Md. Abu Taher (Babu)	Bogura	Bogura Sadar	Rozakpur	01772937093	5054465314
3	Md. Rafiqul Islam	Bogura	Bogura Sadar	Chingaspur	01713790670	5504848648
4	Md. Asir Uddin	Bogura	Bogura Sadar	Fapor	01726497289	550565945
5	Sri Poritosh Chandra Debnath	Bogura	Bogura Sadar	Gholagari	01721208015	4156803152
6	Md. Iqbal Hossain	Bogura	Sherpur	Uchrong	01734505913	1018877069906
7	Md. Abu Sayed	Bogura	Sherpur	Shibpur	01721752977	9148791552
8	Md. Mostak Ahmed	Bogura	Sherpur	Bangra	01736462147	1018828131086
9	Md. Solaiman Ali	Bogura	Sherpur	Khamarkandi	01746794305	1018838735272
10	Sohidul Islam	Bogura	Sherpur	Subli	01731243146	1018847000030
11	Md. Biplob Islam	Rangpur	Badarganj	S. Bawchondi Feski Para	01756643104	8510363000191
12	Doyal Chandra Roy	Rangpur	Badarganj	Purba Rajarampur	01317185333	8510375240798
13	Md. Asif Farhan	Rangpur	Badarganj	Osmanpur Khamarer Danga	01615186616	5562398353
14	Sheikh Abu Naser	Rangpur	Badarganj	Sheikh Para	01713709495	8510325207039
15	Md. Ismail Hossain	Rangpur	Badarganj	Uttor Ramnathpur	01770369965	8510388275918
16	Md. Moksudar Rahman	Rangpur	Pirgonj	Kazirpara	01751302287	8517688552659
17	Md. Afsar Ali	Rangpur	Pirgonj	Boro Dorgah	01723607423	8517622445376
18	Md. Nurul Islam	Rangpur	Pirgonj	Khetaber Para	01719545760	851765647878808
19	Md. A. Kader Mamun	Rangpur	Pirgonj	Kasimpur Bagher ba-zar	01725671317	8517658575769
20	Md. Mosiur Rahman	Rangpur	Pirgonj	Thakurdas Laxmipur	01712828560	8517656498682

Table A1.2: LSD officials participating in dryer service provider training

Sl. No.	Name	Designation	Upazila
1	Md. Kudrat-E-Azam Sumon	Assistant food Inspector	Sherpur, Bogura
2	ABM Kibria	Food Inspector	Sadar, Bogura
3	Md. Harun-or-Rashid	Deputy food Inspector	Pirgonj, Rangpur
4	Mohammad Ali	Assistant food Inspector	Badargonj, Rangpur

APPENDIX 2: IMAGES

Figure A2.1: Training on BAU-STR dryer for the selected farmer/service providers, March 21, 2023

Figure A2.2: Presentation of BAU-STR dryers to farmer/service providers in (a) Bogura Sadar (b) Sherpur, Bogura (c) Pirgonj, Rangpur (d) Badarganj, Rangpur: May 7-25, 2023

(a) (b) (c) (d)

APPENDIX 3: SCOPING VISIT INSTRUMENTS AND DATA

IFPRI-BIDS-University of Illinois joint venture

University of Illinois, USA and Bangladesh Agricultural University (BAU)

Respondent Number.....

District	Upazila	LSD Name	Date and Time	GPS Coordinate
				Lat:
				Long:

We are gathering information to understand more challenges people face managing their and especially whether drying is a concern for selling or storing paddy. We would like to ask a few questions to learn about your experiences.

1. Demographic characteristics of respondent
    a. Name of the respondent:
    b. Mobile number of the respondent:
    c. Address:
    d. Gender: e. Age:

We realize your time is important and we will keep this brief. However, may we call you at this number with follow-up questions? Yes/No (please tick)

2. Role or position in local storage depot (LSD)(paddy selling)

3. For Paddy sellers (farmer/aggregator):
    a. Paddy sale (Boro 2021):
        i. How much paddy you sold to the LSD in Boro 2021 season? (maund=40 kg)
        ii. Where was the source of this paddy (Village/Union)?
        iii. What was the paddy variety/varieties?
        iv. What was the market price of this type of paddy (BDT/kg or maund)?
        v. How many times you sold paddy at LSD in Boro 2021 season?
        vi. Does LSD check physical quality of paddy? What quality/qualities they check?
        vii. How do you measure the moisture content at home/shop thus you can sell at LSD? (biting/rubbing on floor by hand/moisture meter/others)
        viii. Did you know the moisture content of your paddy? (yes/no- if yes, then what was the moisture content?)
        ix. What is the accepted moisture content level of paddy for sell at LSD?
        x. If the moisture content is above the limit, how/where do you sell it?
            1. If sell at LSD, is any penalty imposed by LSD? What is the rate of penalty?

xi. Did you ever get a lower/higher paddy price at LSD compared to others because of moisture content of paddy?
xii. Have you ever been unable to sell paddy at LSD because of moisture content?
xiii. What did you do or what would you do with paddy that was rejected by LSD for moisture content (a. Bring back to home, b. Sell to other aggregators/traders, c. Sell to LSD at lower price, d. Sell to rice mill, e. Others)
xiv. How did you bring the paddy to LSD?(head load/bullock cart/by-cycle/rickshaw van/auto/trolley(pt/tractor)/mini-truck/truck/others)
xv. What was the transportation cost for bring the paddy to LSD? (BDT/maund)
xvi. If loading unloading labor was needed at LSD, who paid for this? how much?
xvii. What was the total other costs you faced to sale the paddy to the LSD? (BDT/maund)
xviii. Where else do you sell paddy? (from home/other union market/other)
xix. Which of these sales locations is most important for you? (home/union market/other)

b. Post-Harvest management
   i. How did you dry your paddy? (under sun/dryer/others)
   ii. If you paid for drying, how much did it cost?
   iii. How do you store paddy (jute sack/motka/dole/auri/gola/plastic drum/others)

c. Willingness to Pay for mobile dryer
   i. Would you be interested in using a machine that can dry a half ton of paddy in 4-5 hours even in rainy days? (yes/no)
   ii. Would you pay Tk 1/kg for the drying service? (yes/no)
   iii. If no, what is the maximum price you are willing to pay for machine drying services?
   iv. What would be your preferred location of the dryer? (At Govt. LSD/near to LSD/in town/at your home village)

4. Is there anything you would like to tell us about your experience of selling paddy or drying it?

Thank you for taking the time to talk with us. We hope you will let us call you with a few more questions so that we can better understand grain-drying issues here.

Scoping Activities for Mobile Grain Drying for Public Paddy Procurement in Bangladesh

IFPRI-BIDS-University of Illinois joint venture

University of Illinois, USA and Bangladesh Agricultural University (BAU)

Respondent Number.....

District	Upazila	LSD Name	Date and Time	GPS Coordinate
				Lat:
				Long:

We are gathering information to understand more challenges people face managing their and especially whether drying is a concern for selling or storing paddy. We would like to ask a few questions to learn about your experiences.

1. Demographic characteristics of respondent
    a. Name of the respondent:
    b. Mobile number of the respondent:
    c. Gender: e. Age:

We realize your time is important and we will keep this brief. However, may we call you at this number with follow-up questions? Yes/No (please tick)

2. Role or position in local storage depot (LSD) (LSD employee(position))
3. For Paddy Buyer (LSD management):
    a. Paddy purchase (Boro 2021)
        i. What was the target of paddy purchase by the LSD? (ton/maund)
        ii. What was the tenure of paddy purchase?
        iii. What was the purchase price of paddy? (BDT/kg or maund)
        iv. Do purchase price vary on varieties/coarse/fine/color/cleanliness? If so, how does LSD fix the purchase price?
        v. Do the LSD buy paddy from outside of the LSD? (Yes/No)
        vi. (If yes), from where do the LSD buy paddy (a. village market, b. town market, c. farmers home, d. Others)
        vii. Do you check the moisture content of the paddy before purchase? (Yes/No)
            1. (if yes) How do you judge moisture content? (biting/visual inspection/moisture meter/others)
            2. (If yes) Do you offer a lower price to the seller for having higher moisture content? What is the price difference (BDT/kg or maund)?
            3. Do you ever refuse to buy paddy based on moisture content?
            4. On an average day in Boro 2021, how many deliveries were rejected for moisture?

5. On an average day in Boro 2021, what percentages of deliveries were rejected for moisture?

viii. How do you measure the weight of paddy?

ix. Who pay for the loading and unloading labor charge? (seller/buyer)

x. What was the labor charge? (BDT/bag (30/50/75 kg))

xi. Is there any limit to purchase paddy from a single farmer/aggregator? if yes, what are the limits?

xii. How do you pay money to seller? (cash/cheque/bank transfer/mobile banking/others)

b. Paddy drying service for the farmers

i. Do you think paddy drying by machine would be beneficial for the farmers selling paddy to the LSD? (yes/no)

ii. Would it be beneficial for the LSD to install dryer machine that can dry a half ton of paddy in 4-5 hours even in rainy days? (yes/no)

iii. Would it be useful if drying service providers were nearby?

iv. What would be the acceptable cost of machine drying? (BDT/kg or maund)

v. What would be the preferred location of drying service? (At Gove. LSD/ town/village/paddy market/others)

4. Is there anything you would like to tell us about your experience buying paddy or drying it?
5. Would you please share any documents related to Boro 2021 season's target, volume purchased, buying price, rejected percentage of paddy for higher moisture content etc. (season/monthly/yearly report)

Thank you for taking the time to talk with us. We hope you will let us call you with a few more questions so that we can better understand grain purchase issues here.

Table A3.3: Scoping survey: Demographics

	Sex		Sales volume (maunds of 40 kg)			
Description	**Male**	**Female**	**Maximum**	**Minimum**	**Average**	**SD**
Farmer Supplying LSD	44	1	70	22	44	10.75
Local service provider	21	0	60	30	47	8.53
Farmer not supplying LSD	21	0	70	27	47	11.79
Aggregator	12	0	63	35	44	8.68
CIG	9	2	62	28	43	10.49

Source: Authors.

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