REDUCING POSTHARVEST LOSSES IN BIHAR

Bihar PHL Baseline Survey Report

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ADM Institute Bihar Postharvest Loss Prevention Project
Baseline Survey Report

I. Introduction

The ADM Institute Postharvest Loss Prevention project in Bihar (Bihar PHL project) aims to improve postharvest practices and management of grain quality among smallholder farmers in order to improve agricultural incomes, household welfare and food security. Three significant characteristics differentiate this research from previous studies examining postharvest losses in India.

First, sub-optimal postharvest management leads to potential negative outcomes for farmers not only through physical quantity losses but also from value lost due to poor grain quality characteristics. Most studies have focused only on characterizing the physical losses along the postharvest supply chain. This research goes a step further and offers an assessment of the economic value lost to smallholder farmer attributable to postharvest management of grains.

Second, this study incorporates the fact that postharvest losses and the net value receive by farmers for their output do not occur in isolation. Competing forces ranging from the farmers' characteristics, village market conditions that determine incentives for grain quality, government policies affecting the grain market and other contextual factors mediate postharvest practices among farmers as well as their welfare outcomes (Figure 1 provides a simplified schematic of the contextual framework). The data collection methodology for this study reflects this framework.

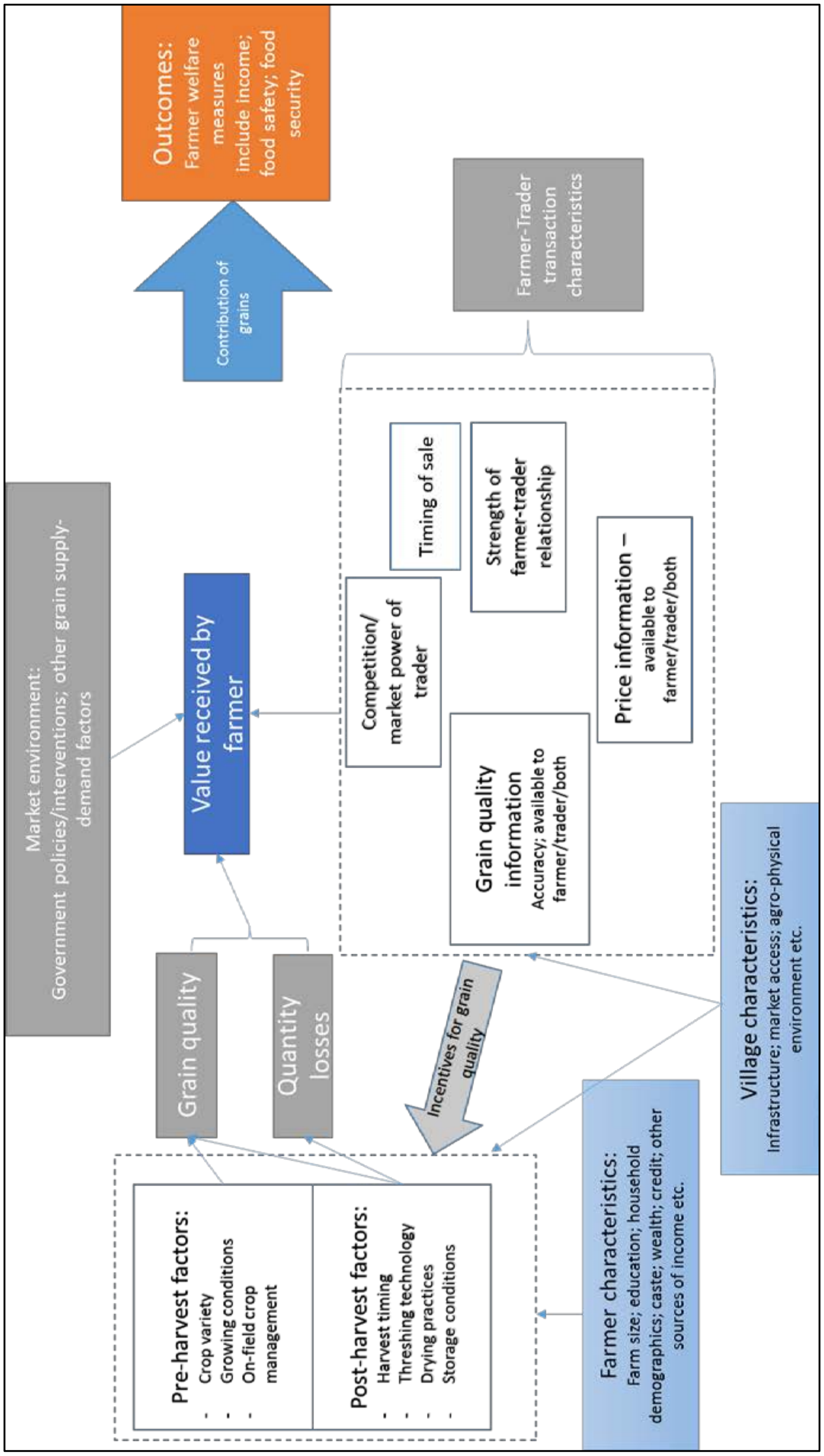
Third, the study is designed to evaluate the impact of various postharvest technology and information interventions on a variety of farmer outcomes. Planned interventions include provision of grain moisture information, hermetically sealed storage bags and improved dryer technologies. A randomized experimental design, in conjunction with extensive information from the baseline and other surveys that allows us to control for confounding factors, will allow us to isolate the impact of each of the interventions separately on smallholder outcomes. More importantly, from a policy perspective, the study design also lets us examine the factors affecting technology adoption among farmers, and how that adoption changes other post-harvest behavior. This approach will help formulate specific programs for postharvest technology and practices that take advantage of driving factors and/or alleviate barriers that may exist.

Summary

The first phase of baseline data collection has been completed across the study area. The data analyzed here come from the first set of 16 villages from the baseline survey (four villages from each district) for which validation and digitization has been completed. These data comprise a quarter of the households in the sample: 800 households. These processes are underway for the remaining two-thirds of the sample (2400 households). We find:

1. The majority of our sample are poor, very small-scale farmers with less than 0.5 ha of farmland (52%). It also includes a large fraction (37%) of landless farmers. These statistics are consistent with the population of rural Bihar as a whole.
2. For landless and farmers with under 0.5 ha of land, the majority of grain and pulse storage is for own consumption. For farmers with over 0.5 ha, they both hold grain for home consumption and to wait for a higher price.
3. Most farmers are aware of common PHL methods such as threshing, drying, storage in jute bags, milling and so on, but most have not used them. Larger farmers are more likely to use mechanized technologies such as mechanical threshing and costlier storage alternatives such as jute bags with plastic layer.
4. Self-estimates for storage losses are low, ranging from 1 to 2%. These data should be taken with caution since it was clear farmers were not always including all losses due to mold or loss of moisture from excessive drying. Further, since much of the storage is for home consumption, reducing these small losses could increase grain available for home consumption.
5. Farmers receive below minimum support price for their crops, and thus minimum support prices do not appear to be binding. Explicit quality discounts range from 4 to 9% of the price offered by traders. Traders' most important quality preference for maize and rice is lower moisture content and that for wheat and lentil is fewer brokens. In as much as post-harvest technologies could improve quality as well as quantity, improved practices could substantially improve farm incomes.

Figure 1 Schematic representation of contextual framework



Outline of the rest of the report

- II. Sampling and Survey Design
- III. Household Demographics
- IV. Post-Harvest Technologies and Practices
  - i. Awareness and use
  - ii. Storage Practices
- V. Market Characteristics and Value

II. Sampling and Survey Design

The study covers four districts in Bihar – Samastipur, Begusarai, Bhagalpur and Banka[1]. In each district we selected two blocks, and from each block we randomly selected 8 villages. As a result we have a total of 64 villages in the sample. Within each village we then randomly selected 50 agricultural households[2]. In keeping with the conceptual framework portrayed in Figure 1, the baseline survey collected data on key variables at three levels: village, household and village traders. Researchers from the University of Illinois trained and managed a data collection team comprising two research coordinators (RCs) – each covering two districts – and 16 field investigators (FIs) with each FI handling four villages.

The village-level survey instruments, as the term suggests, were designed to capture macro information for each village. The household surveys provide in-depth information on the demographic, livelihoods, assets, agricultural practices, marketing and other key variables pertaining to the farmer household. The baseline trader survey provides a census of all traders operating in the sample villages. Village traders are an important part of the grain value chain in India. The farmer-trader relationship and the incentives that traders offer is a key component motivating a farmer's decision to invest in new technology. Table 1 provides a summary of the various survey modules and an overview of the key informational components that each module provides.

[1] In early 2016 the study area has been expanded to include the district of East Champaran. The total sample of villages is now 80, including the 16 villages in the new district.
[2] Any household that has an income source from agricultural related activities (including agricultural labor) is defined as an agricultural household for the purpose of this study.

Table 1 Overview of Survey Modules

SURVEY MODULE	OVERVIEW
I. Village level data collection	The village level modules provide a wealth of data on the social and economic structures, agro-ecological environment, availability of infrastructure and an overview of the current state of agricultural technology for each of the 64 villages, including information on: – Demographic mix – Public and private infrastructure in the village – Technology, crop mix and agricultural markets – Natural resources, including use, seasonality and governance – Community governance and conflict These characteristics will be useful in identifying macro characteristics that are likely to mediate the adoption and usage of postharvest technology by farmers in the later stages of this project.
a. List of lists	In the first step FIs generated lists of social groups, infrastructure, institutions operating, various natural and bio-physical resources, crops and livestock varieties, markets and market actors etc. present in each village through detailed discussions with village residents. These lists help codify all elements of the village about which more information is collected in subsequent modules
b. Village level module	Further details of social, agro-physical, institutional and agricultural marketing information at the village level collected through interaction with multiple groups of farmers, administrators and other key informants at the village level
c. Agricultural unit, surface water unit, and other common lands survey	These modules focus on the utilization, quality, dependability, and management of land and water resources at the village level. In the List of lists process village land is demarcated into easily identifiable units of agricultural, common or forest land. Water sources are listed.
I. Household survey	Household baseline survey information includes: – household food security, expenditure and assets – livelihood sources – labor market interaction, including migration – natural resource use – production and inputs (farm level) for crops and livestock – storage behavior by crop destination; credit behavior and access – Market channel, quality and price
I. Trader Survey	Trader data include: – (stated) Quality premia paid by traders – (stated) Quality premia received by traders from end users – Prices paid by traders – Quality measures used – Credit provided by traders – Credit access by traders

VI. Household Sample Characteristics

Table 2 provides descriptive statistics for a number of household characteristics. The average household in our sample is characterized by low levels of educational attainment, relatively high poverty, and low on household assets and resources. For instance, the education levels of the household head are relatively poor with the mean years of education being less than four. The average per capita expenditure (derived from the mean annual expenditure and household size) is less than Rs. 50 per day per capita. Nearly half of the households have at least one household member who migrates seasonally in search of work.

Table 2 Summary statistics of household characteristics

Variable	Mean	Std. dev.
Age of household head	46.46	14.32
Education (years) of household head	3.76	4.66
Household size	4.38	2.28
Number of livelihood sources	2.57	1.49
Annual cash expenditure (rupees)	75570.30	212714.08
Household has at least one migrant member	0.49	0.50
Household assets (number):		
Rooms (Mud)	1.47	0.99
Rooms (Cement)	0.79	1.36
Water tank	0.02	0.17
Private toilet	0.22	0.50
Television	0.15	0.37
Bullock cart	0.01	0.08
Bicycle	0.90	0.61
Private 2-wheeler	0.13	0.35
Private 4-wheeler	0.01	0.19
Generator	0.01	0.07
Commercial vehicle	0.02	0.16
Number of sim cards	1.31	1.03
Operational holdings (number)	2.33	2.90
Operational holdings area (ha)	0.64	4.61
Agricultural assets (number):		
Plough	0.09	0.29
Bullocks	0.14	0.50
Tractors	0.03	0.32
Threshers	0.01	0.12
Sprayers	0.28	2.89

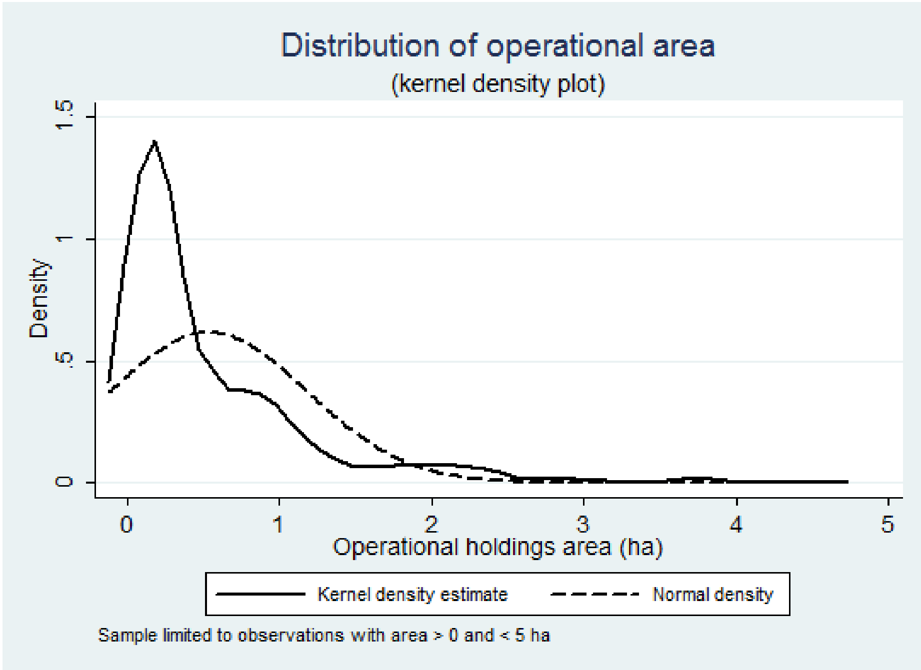
Breeding bulls	0.00	0.08
Dug wells	0.02	0.16
Bore wells	0.30	1.43
Power tiller	0.00	0.11
Pump set	0.33	1.30
Irrigation pipe	0.32	1.24
Observations	800	

Households in the sample show low ownership of various household assets that are widely used as proxies for household wealth. For instance only about 22% of the sample have a private toilet, and even less (about 15%) have a television. A similar picture emerges with respect to ownership of agricultural assets as well. The number of productive agricultural assets per household, such as ploughs, bullocks and others are fairly low.

However these averages mask the wide variation across the households in the sample. For instance while the average landholding size is 0.64 hectares (ha), the standard deviation of 4.61 is indicative of the large variation across the sample. Not only is there large variation in the distribution of farm sizes, it is also highly skewed. Figure 2 plots the density of this distribution, limiting the sample to those households who cultivate at least some land, and with a right cut-off of 5 hectares[3]. The distribution is heavily skewed to the left indicating a large presence of farmers with marginal landholding sizes.

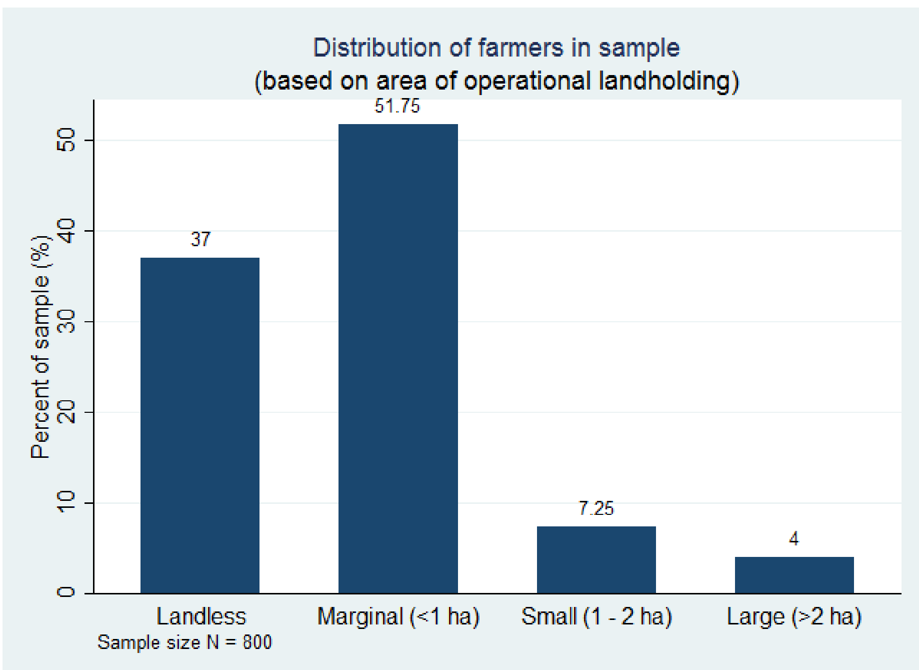
[3] The sample is truncated on the right only to improve readability of the graph

Figure 2 Density plot of the farm-size distribution



In addition to the above, Figure 3 divides the sample into various land size classes based on classification cut-offs widely used by the agricultural administration in India. Nearly 90% of the sample is either landless (i.e. households that work as agricultural labor on other farms) or has less than 1 ha.

Figure 3 Classification of farmers by landholding size

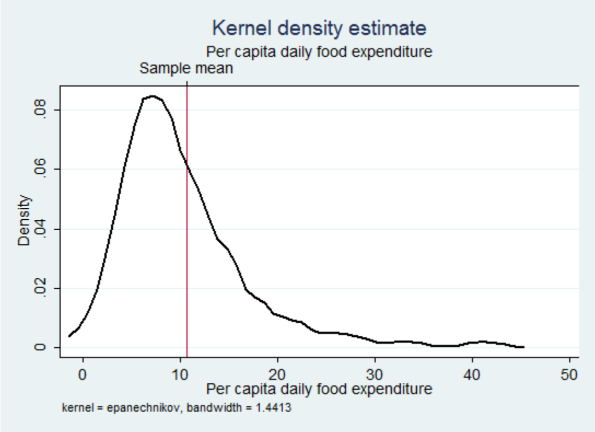


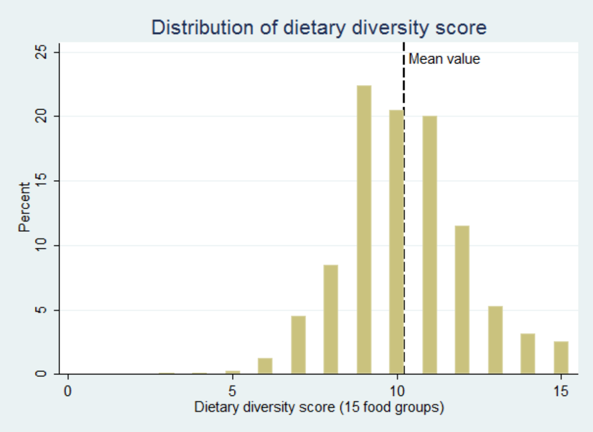
This distribution of landholdings in the sample closely aligns with the data on overall distribution in Bihar available from other sources. Official agricultural statistics indicate that about 91% of farmers in Bihar have holdings in the range 0 to 1 ha and the average landholding size is about 0.4 ha (Agricultural Statistics at a Glance, Government of India, 2014). This is indicative of the representative nature of our sample, and adds to the validity of our data quality.

These distributional aspects of the data also have a key implication for any agricultural technology intervention in general, and for postharvest technology in the particular context of this study. We need to take into account the fact that there exist wide variations across farmers' resources and characteristics that are likely to mediate the effect of agricultural interventions on farmer welfare outcomes. The baseline data allows to examine these patterns in a variety of indicators of household welfare, agricultural practices, as well as postharvest aspects in Bihar.

Indicators of household welfare show a similarly skewed distribution. For instance, Figure 4 shows the distribution of daily per capita cash expenditure on food and the dietary diversity score – two commonly used measures of food security. Both of these distributions are indicative of the wide range of welfare outcomes that the households in the sample experience.

Figure 4 Household welfare indicators - (i) per capita food expenditure (ii) dietary diversity score

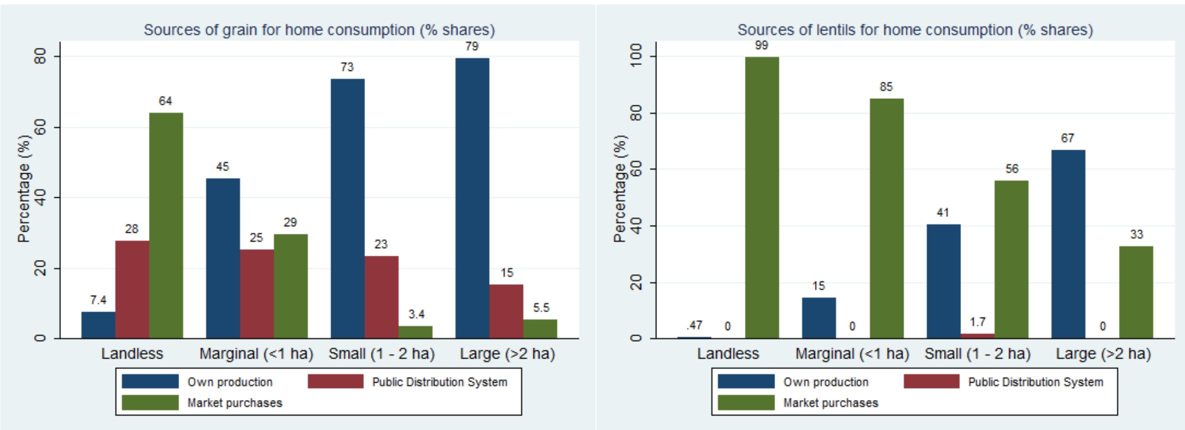




Another important indicator related to food security of the household is the extent to which the family depends upon own production for its food supply. Many agricultural households, apart from buying food from the market, store part of their harvest for their food consumption later. Storage duration for such purposes can be fairly long; over 12 months on average. This grain use and storage time has implications for the type of storage technology and methods used. Suboptimal storage methods can impact food security due to quantity losses as well as through deterioration of quality. Among the sample of households in this study we find that, on average, about a household depends on its own production of grains for about 35% of its grain consumption. The dependence on own production is lower for lentils at around 13% on average (Table 3).

Table 3 Food supply share by source for grain and lentil

Source	Share of supply from source (%)	
	Grains	Lentils
Own production	34.73	13.34
Public Distribution System	25.54	0.13
Open Market	39.32	86.12



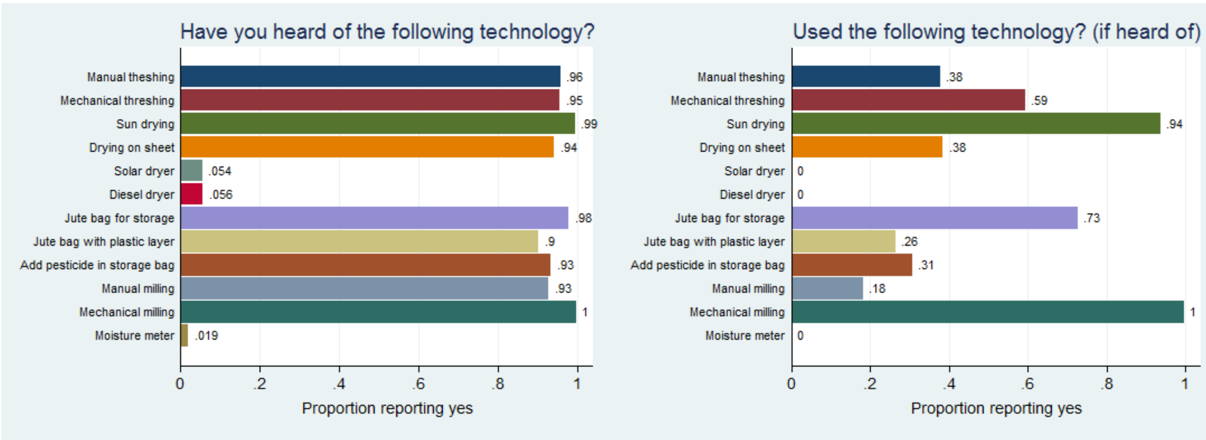
VII. Postharvest Technology and Practices

i. Awareness and use of technology among farmers

The baseline survey collected information on farmers' awareness of various postharvest technologies and practices. Many farmers report "yes" when asked if they have heard about these technologies for commonly used methods (Figure 5). Not many farmers are aware of more advanced options such as solar or diesel dryers, and moisture meters.

Most of the farmers who have heard of these technologies have not actually used them. For instance while nearly 95% of farmers are aware of mechanical threshers, less than 60% of them have used them in the past. A similar pattern is visible with respect to use of tarpaulin sheets for drying (38% report usage), storing grains in jute bag with a plastic layer within (26% report usage) and others.

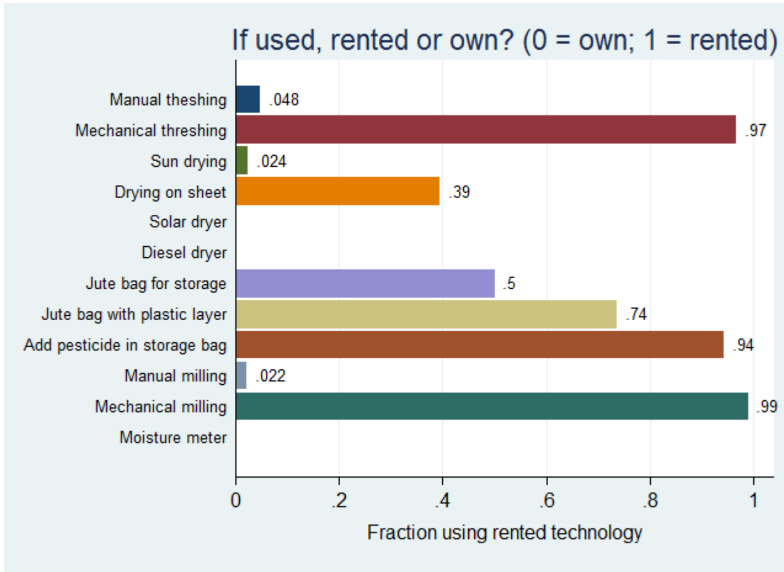
Figure 5 Awareness and use of postharvest technology



Two other important features emerge from the farmers' response to the questions on postharvest technologies. The first is the dependence on rental or custom hiring for accessing many of the mechanized technologies (Figure 6). Nearly all mechanical threshing and milling activity is through hiring. The importance of the custom hiring markets for expanding access to agricultural technology in rural markets has been established in many developing country contexts. Here, we find that this is a key feature not only for input and production technologies (such as tractors, seeders etc.), but also for postharvest technology. Interestingly, many farmers also utilize rented sources for storage as well, with farmers renting jute or plastic bags for storage.

A second key feature is the variation in usage patterns across classes of farmers as seen for some of the technological practices in Figure 7. As one would expect larger farmers tend to use more mechanized technology (mechanical threshers, for example) or costlier alternatives (jute bag with plastic layer inside). However this relationship is not clearly linear. For instance a larger fraction of small farmers (i.e., those having one to two ha of land) use more expensive methods compared to the corresponding proportion of large farmers. A possible reason underlying this observation may be the following: the value gained due to better quality and lower losses due to better postharvest technology is likely to contribute a larger share of the revenue for a small farmer compared to a large farmer. Further analysis of the technology adoption patterns from the intervention in the next phases of this study will help examine this hypothesis in greater detail.

Figure 6 Own or rented access to technology by farmers



Also noteworthy is the fact that landless agricultural labor also exhibit some use of postharvest technologies. This is explained by the fact that many of them are paid in the form of grain for their labor at the time of harvest. They process, store and consume or sell this grain when required. Many agricultural technology studies tend to ignore the agricultural labor segment of the population. Thus, the impact of technological interventions on their outcomes (either directly or indirectly) is often unclear. By taking a representative sample across all agricultural households in the villages this study would help shed more light on this particularly vulnerable class of the rural population.

We also find variation across postharvest technologies and practices employed across the main grain crops – rice, wheat and maize, and lentils (Figure 8). Threshing operations are almost always carried out by mechanical means for wheat (~98%) while manual threshing is the preferred method for rice (about 89%) and lentils (about 80%). Both manual and mechanical threshing methods are widely prevalent among maize farmers (about 45% and 60% respectively).

Across the four crop categories simple sun-drying is the most commonly reported drying practice by farmers. However sun-drying on tarpaulin sheets is widely used for lentils (about 68%), while use of this method is comparatively lower for the other grains (ranging from 34% for wheat to 45% for maize). A possible explanation for this use pattern is the fact that lentil volumes are generally much smaller compared to the harvested quantities of cereal grains. Therefore drying on tarpaulin sheets is more affordable for lentils relative to the other crops.

Figure 7 Technology use across farmer classes

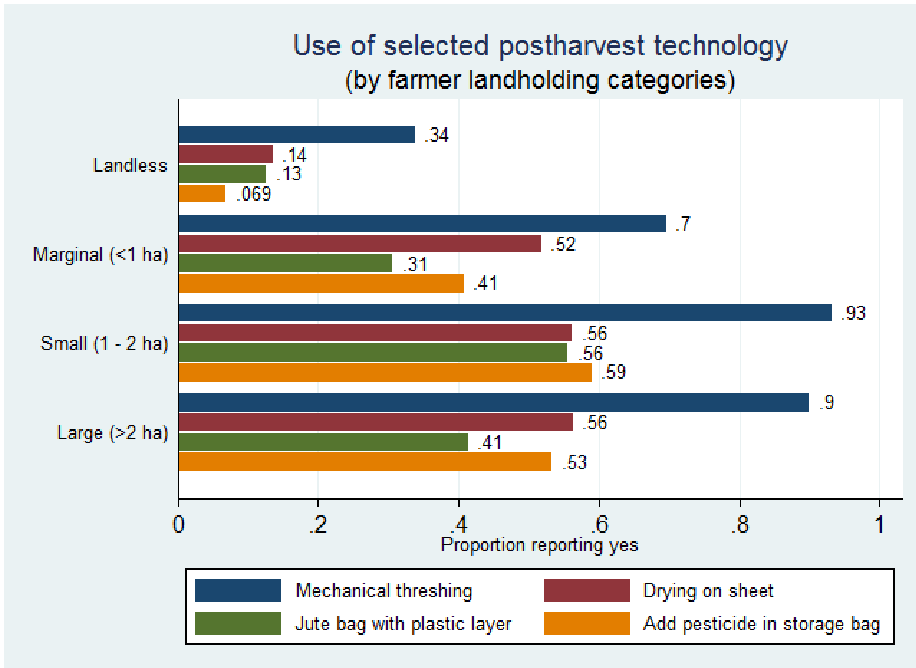
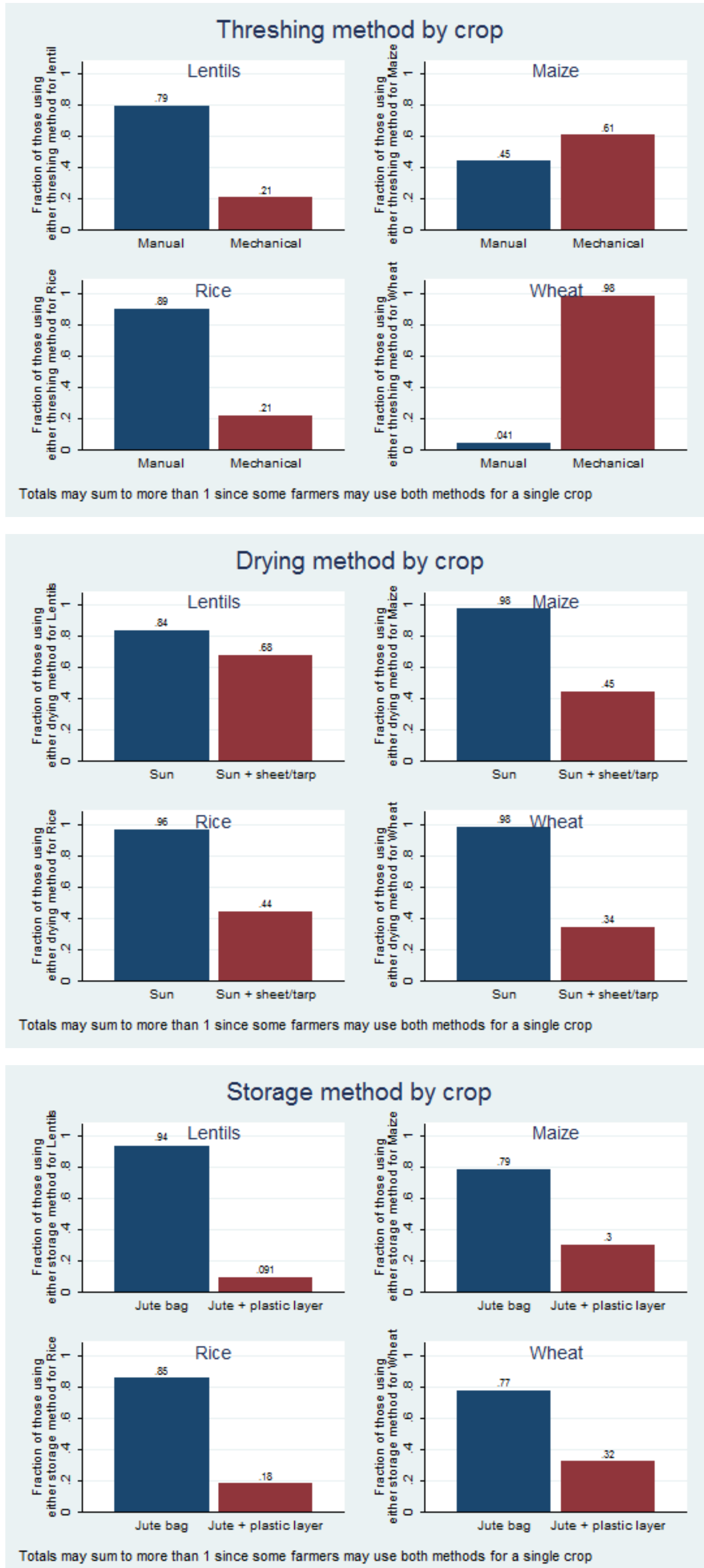


Figure 8 Threshing, drying and storage methods by crop



ii. Storage behavior

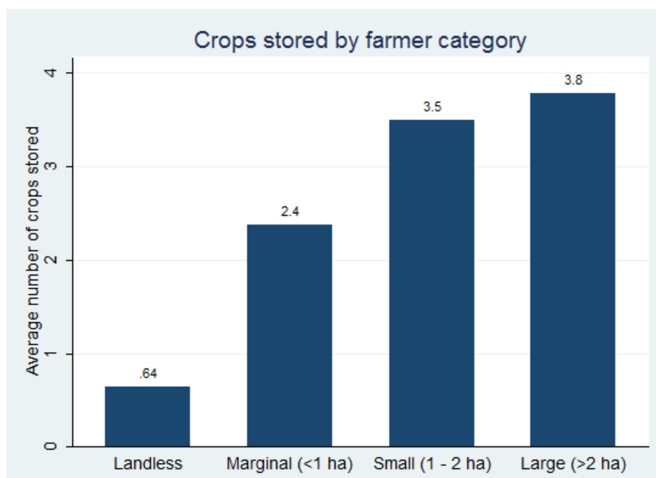
Given that storage technology is one of the key points for the planned intervention in this study, we take a closer look at the storage behavior among farmers in the study sample. Most agricultural households in Bihar generally grow multiple crops, and farmers make a decision on how to allocate available storage resources across the crops that they harvest. This decision is driven by multiple factors including cost of storage, reason for storage (for home use, or for sale later), losses that are likely to occur etc. The information available from the baseline survey can help us explore some of these variables affecting farmers' storage behavior.

In terms of prevalence of storage behavior among the farmers in the study we find that about 30% do not store any crops. However among those who do store crops, majority of the farmers store more than one crop – just over 18% store two, and more than 25% store three crops (Table 4). The number of crops stored increase with the operational landholding size of the farmers in the sample (Figure 9).

Table 4 Number of crops stored

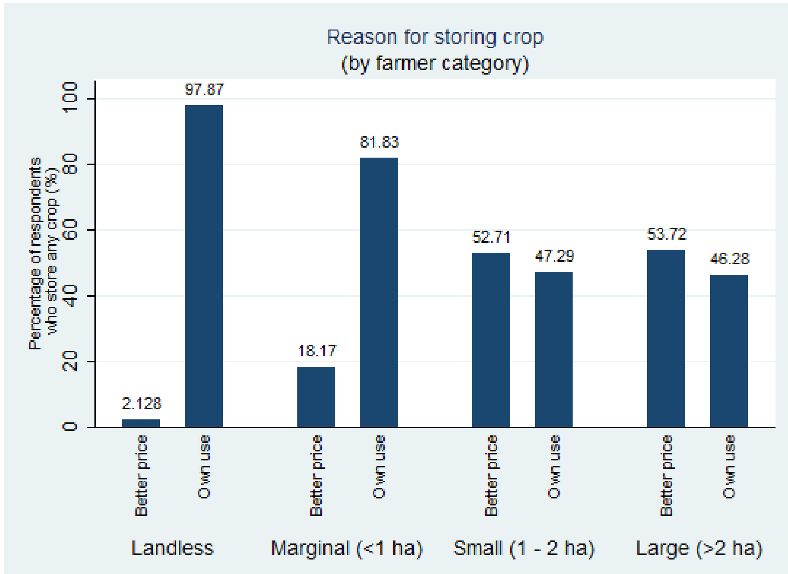
No. of crops stored	Share (%) of households
0	33.9%
1	7.6%
2	18.4%
3	25.4%
More than 3	14.8%

Figure 9 Number of crops stored across farmer categories



Here too, interestingly, landless agricultural labor also exhibit crop storage behavior, storing 0.64 crops on average. The reason for storage also varies markedly with the farmer size (Figure 10). Landless labor and marginal farmers overwhelmingly store for their own use later. However a large share of small and large farmers (nearly 50% in each case) store in order to wait for a better price to sell later.

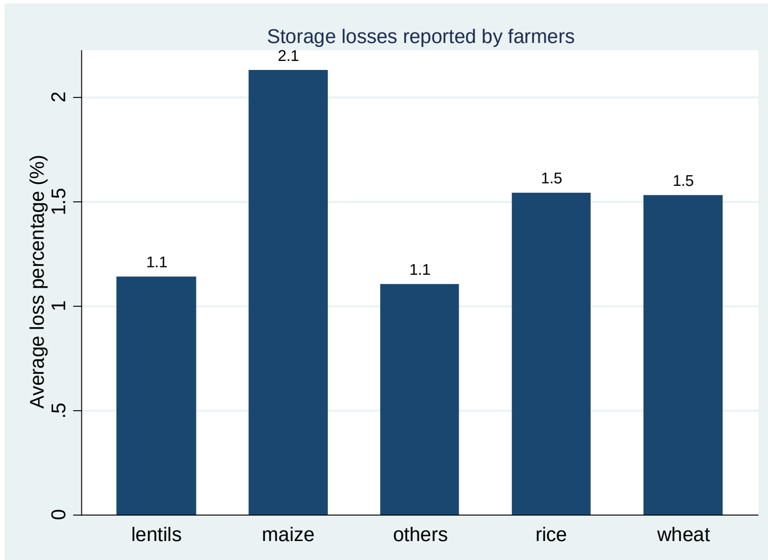
Figure 10 Reason for storing crops reported by farmer

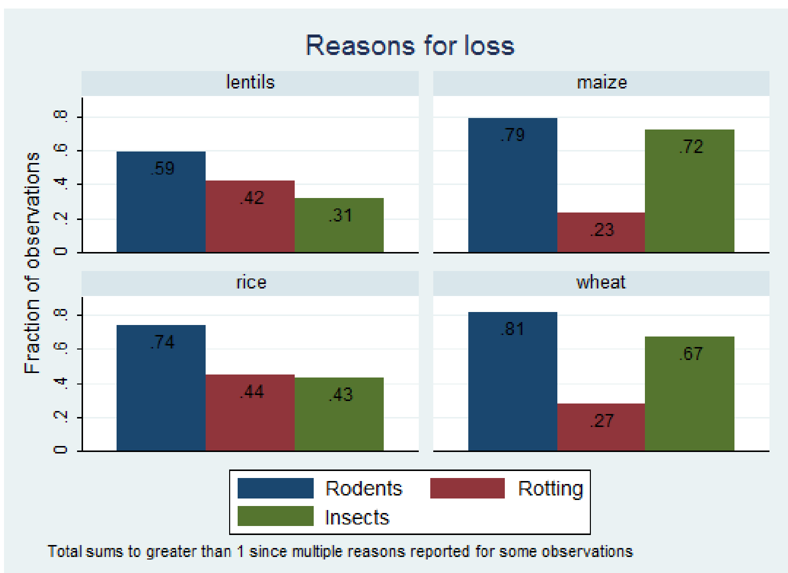


The storage methods and technology used as well as the quality of storage conditions has implications for grain stored for both sets of reasons. Grain that is stored for own use under poor conditions can affect food security conditions of the farmers' households. Improper moisture level and fungal activity induced by that can result in poor quality grain being used for home consumption which in extreme cases can result in presence of aflatoxin or mycotoxins. Poor storage can also reduce the value that the grain fetches in the market resulting in losses for the farmer.

Next stages in the study will measure grain quality characteristics for a sub-sample of farmers at each stage of the postharvest process. In the baseline survey farmers report their estimate of physical quantity loss during storage and the main reasons for those losses. The highest reported loss during storage is for maize at about 2.1% loss (Figure 11). Across the crops the most commonly reported source for storage loss is rodents. Closely following this, many farmers also report pests and insects as reason for storage losses. While these physical losses reported are generally low, in the next section we look at some of implications of grain quality for potential market value of the crop.

Figure 11 Reported storage losses (%) across crops





VIII. Market Characteristics and Grain Value

Each sample village, on average, engaged in market transactions at more than five different market locations. These markets vary in their frequency of operation (permanent/weekly/seasonal) and distance to the village. Of particular interest to this study is the presence of traders for grains and lentils.

On average we find that each village has more than two traders present for grains and lentils. To measure the market power of traders in a village we measure the Herfindahl Hirschman Index (HHI) for each village. The HHI is calculated as the sum of the squared market shares of each trader, and runs from 0-1. The US Justice Department considers a market to be highly concentrated if the HHI is above 0.25. In these cases, buyers have high market power. The average HHI is higher than 0.25 for each crop in our sample of villages, which implies that traders have very high market power (Table 5).

Table 5 Grain trader presence in villages

	Mean	Std. Deviation
Traders Per Village	2.35	.977
Wheat Traders	2.30	.948
HHI	.716	.261
Rice Traders	1.41	.974
HHI	.633	.400
Maize Traders	2.18	1.05
HHI	.710	.280
Lentil Traders	1.22	1.17
HHI	.492	.427

Traders report the price that they pay to farmers (purchase price) and the price which they receive when they sell to end-users (sale price). Notably, the average purchase and sale prices are below the 2015-2016 Minimum Support Price for maize (1325 Rs./Quintal) and rice (1450 Rs./Quintal for grade A, 1400 Rs./Quintal for Common).

We also see that traders penalize farmers for poor quality grain[4] (Table 6). On average this penalty ranges from more 4 % of the usual purchase price in the case of lentils to more than 9 % in the case of wheat. This constitutes a significant loss for the farmer. Potentially a large percentage of this value loss could be avoided by better postharvest management.

[4] The penalties reported do not include traders and end users who will simply refuse sale if quality is low (wheat: 7 traders and 8 end users; maize: 7 traders and 7 end users; rice: 1 trader and 2 end users; lentil: 0 traders and 2 end users). Including this complete loss in sale makes the loss in value for poor post-harvest quality significantly higher.

Table 6 Price variation for quality

Crop	Price	Mean (Rs per quintal)	Standard Deviation
Wheat	*When purchasing from farmers*		
	Price	1167.10	116.76
	Penalty for poor quality	88.1	27.65
	Penalty as % price	**7.58**	**2.32**
	When selling up the value-chain		
	Price	1262.43	114.16
	Penalty for poor quality	59.09	27.48
	Penalty as % price	**4.77**	**2.34**
Maize	*When purchasing from farmers*		
	Price	1001.96	70.19
	Penalty for poor quality	89.63	31.78
	Penalty as % price	**9.04**	**3.36**
	When selling up the value-chain		
	Price	1118.28	86.19
	Penalty for poor quality	59.16	22.01
	Penalty as % price	**5.41**	**2.27**
Rice	*When purchasing from farmers*		
	Price	948.86	135.79
	Penalty for poor quality	83.91	25.59
	Penalty as % price	**8.81**	**2.28**
	When selling up the value-chain		
	Price	1068.21	150.24
	Penalty for poor quality	55.43	19.96
	Penalty as % price	**5.24**	**1.90**
Lentil	*When purchasing from farmers*		
	Price	4226.23	909.01
	Penalty for poor quality	168.36	59.42
	Penalty as % price	**4.00**	**1.18**
	When selling up the value-chain		
	Price	4436.89	936.52
	Penalty for poor quality	88.28	54.47
	Penalty as % price	**2.04**	**1.28**

Another feature of the grain market in Bihar that is discernable from the above table is that the quality penalty that the traders face when they sell further up the value chain is lower than what traders impose on farmers. For instance, traders impose a quality penalty of more than 7% when they buy wheat from farmers. However when they sell this wheat to their buyers the penalty that the traders' face is less than 5% on average. A part of this margin could potentially be shifted to the farmer if accurate information on the quality of their grain is available to the farmer at the time of their market transaction with the trader.