Post-harvest practices and technology adoption in developing countries

by

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B.Sc., University of Ghana, 2008
M.Phil., University of Ghana, 2012

AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

DOCTOR OF PHILOSOPHY

Department of Agricultural Economics
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Abstract

Study 1: Loss Aversion and Improved Storage Technology Adoption: Evidence from a Field Experiment in Ghana.

Farmers in developing countries commonly sell the majority of their grain immediately after harvest, when prices are lowest. Improvements in technologies that reduce post-harvest losses (PHL) could potentially increase farm incomes by offering a more attractive means for farmers to save their output and sell at higher prices later in the season. This study examines how loss aversion affects the demand for one such technology, hermetically sealed bags, in a maize-growing region in Ghana's Transition zone. Ignoring marketing decisions, loss aversion could potentially increase the willingness-to-pay (WTP) for improved storage technology because loss averse farmers may strongly desire to decrease grain losses. However, the possibility of selling one's stock as a grain-loss averting strategy may flip the relationship between loss aversion and storage demand. If highly loss-averse individuals compensate for potential grain losses by immediate sales, improved storage technologies may not provide additional benefits. Using a Becker-Degroot-Marschak (BDM) auction for 386 farmers, the study finds support for the latter. Loss aversion is negatively related to WTP for hermetic bags, and this relationship is entirely driven by farmers whose grains sales occur soon after harvest. Nevertheless, despite limited previous experience with the bags and little access, a majority of farmers value hermetic storage bags at levels at or above market price prevailing in other parts of Ghana.

Study 2: Perceptions of Food Safety Risk, Post-harvest Practices and Intertemporal Staple Crop Allocation: Evidence from Maize in Nepal.

Improving food safety is essential for improving food security: i.e. access to sufficient and healthy food. Unsafe food contains hazardous agents or contaminants (e.g. mycotoxins) that can increase people's risk of chronic diseases; and may have considerable economic implications for developing-country markets due to losses for rejected marketable surpluses and lower prices for inferior quality crops. This study addresses two research questions: Do perceptions of food safety risk alter intertemporal allocation of staple crops? If so, is the change in the intertemporal allocation through the better post-harvest practices? Using a two-round panel data of 320 maize farmers in Nepal, this study finds that farm households who perceive themselves to have better awareness of food safety risks tend to store produced maize longer than the other households. However, there are no statistical differences in post-harvest practices between the households with higher perceived-awareness and the others. The findings imply that providing farmers with food safety information may enhance storage behavior for optimal intertemporal maize allocation. This requires strengthening the research-extension link to provide agricultural extension officers and farmers information on better post-harvest management and the provision of feedback for improved future research.

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Kansas State University; it's been amazing studying here!

Dedication

To Family

Chapter 1 - Introduction

1.1 Background and Motivation

The FAO (2017) report that to meet the growing food demand in 2050, the agricultural sector must produce about 50 % more food than it did in 2012: in sub-Saharan Africa (SSA) and South Asia (SA), agricultural output must double by 2050 to match this increased demand. Over the past decade, there have been concerns about global food systems particularly due to the 2006 to 2008 food price hike effects that still linger in many low-income countries. For example, in lower-income SSA countries, ongoing contributing factors include persistently low productivity, difficulties associated with climate change adaptation, financial difficulties (inability to handle the burden of high food or fuel prices or a credit squeeze), and increased dependence on food aid (The World Bank, 2011). The report also highlights an often forgotten, yet key factor that exacerbates food insecurity: postharvest losses (PHL).

While the causes of PHL vary, its magnitude is estimated at 32 percent globally although the actual scale is uncertain and very much dependent on country-specific conditions (Kaminski and Christiaensen 2014; FAO 2011). About 63 % of total PHL of grains among smallholder farmers in SSA is storage related (The World Bank, 2011). Despite the uncertainty about the estimated scale, PHL poses a global food security threat, especially in developing countries.

Thus, reducing PHL could increase the supply of available food and strengthen global food security (FAO, 2017). Farmers store harvested crops for varying durations for purposes of household consumption, subsequent season production, and for deferred sale: i.e. intertemporal allocation. However, poor quality storage technologies and lapses in post-harvest practices may expose crops to insect/pest infestation and likely to result in contamination. Crops may become contaminated with mycotoxins due to poor production and harvesting practices, through poor post-harvest handling (e.g. inadequate drying, poor sorting and poor storage), and during processing. Since maize is an important staple crop in many developing countries, even relatively low levels of mycotoxin exposure may have significant health consequences (Shephard, 2008) as well as implications for post-harvest losses.

The interconnectedness of post-harvest activities and the varying degrees of efficiency in their performance are likely to support the growth of aflatoxins. In many developing countries, compliance with minimum food safety standards is generally low; and mycotoxin testing is mainly by visual inspection which only detects severe cases and quite imperfectly (Sheahan and Barrett, 2017).

Due to its pervasiveness, most traditional storage technologies used to counter PHL still lack in many ways. Previous analysis of postharvest loss reduction technologies in SSA suggests that their introduction and use can potentially increase farmers' income (Gitonga et al., 2013; Shimamoto et al., 2018) as returns to improved storage technologies are higher than traditional ones, although benefits particularly accrue in the long run (Gitonga et al., 2013; Kimenju and De Groote, 2010).

1.2 Purpose and Objectives

This disseration draws evidence from two developing countries (Ghana and Nepal), where maize is an important staple crop, to examine issues regarding post-harvest practices and improved agricultural storage technology demand. Since behavioral biases are key features of agriculture and the decision to adopt technology, outlined benefits of improved agricultural technologies may not be realized if farmers do not adopt due to their individual behavioral preferences as well as risks associated with the technology. In effect, the first study in this dissertation focuses on an examination of farmers' loss aversion and improved storage technology adoption in Ghana while the second study examines farmers' perceived awareness of food safety risks, post-harvest practices, and intertemporal crop allocation in Nepal. The respective research questions are as follows:

1. Do farmers' loss aversion affect their willingness to pay (WTP) for hermetic storage bags in Ghana? and

2. Do farmers' perceived awareness of food safety risks alter intertemporal allocation of staple crops? If yes, is this change due to post-harvest practices?

For Study 1, we hypothesize that loss averse farmers have higher WTP for an improved storage technology with higher mitigating capacity against PHL. Thus, such farmers will invest in better storage, e.g. hermetic storage bags, to safeguard their crops from storage related losses. For Study 2, we hypothesize that farmers' perceived awareness of food safety risks is correlated with prolonged maize storage for intertemporal allocation (either for consumption or sale to take advantage of price arbitrage).

1.3 Approach

For Study 1, 386 farmers were randomly sampled across 32 randomly selected communities in Ghana's Transition Agroecological Zone (major maize producing area) to respond to a household survey. Further, using a lottery game, we obtained farmers' loss aversion outcomes with which we computed loss aversion parameters. Subsequently, we conducted an incentivized auction (which avoids hypothetical bias) to obtain farmers' willingness to pay outcomes for the hermetic storage bag using the Becker, Degroot, and Marschak (1964) experimental auction approach (the BDM mechanism). We later examined the relationship between farmers' loss aversion and their WTP for the bag using a Tobit framework.

For study 2, we use a two-round panel data from the Post-Harvest Loss Innovation Lab (PHLIL) Mycotoxin Awareness Household Survey conducted in 20 Feed the Future Zones of Influence (FTF ZOI) in Nepal. The data comprises a random survey of 320 respondents from four randomly selected districts in the 2018 farming season which is analyzed using ordinary least square (OLS), fixed effects (FE), and correlated random effects (CRE) Tobit models.

1.4 Contribution

Study 1 offers two conceptual insights. First, if farmers' dominant strategy is to sell grains immediately after harvest, then their physical loss reference point is zero. In that case, investment in storage technologies represents a certain loss, implying a negative correlation with WTP. Further, loss aversion in such cases may constrain investment in profitable storage technology. We find that loss aversion has a significantly negative correlation with farmers' WTP for hermetic storage bags and this relationship is driven by a reference-dependent preference of sell immediately after harvest.

Study 2 is among the first to look at the relationship between perceived food safety awareness and length of maize storage by maize farmers in a developing country context. We find that farmers' perceived awareness of food safety risks is positively correlated with duration of maize storage but not with post-harvest practices. The findings imply that enhancing farmers' awareness of food safety issues is likely to enhance storage behavior which will have further implications for optimal intertemporal grain allocation.

1.5 Organization

The remainder of this dissersation comprises four chapters. Chapter 2 presents the study on loss aversion and improved storage technology adoption with evidence from a field experiment in Ghana. Chapter 3 draws evidence from Nepal to examine farmers' perception of food safety risks, post-harvest practices and intertemporal staple crop allocation. Chapter 4 presents concluding remarks and some recommendations for both policy and future research.

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Chapter 2 - Loss Aversion and Improved Storage Technology Adoption: Evidence from a Field Experiment in Ghana

2.1 Introduction

Postharvest loss (PHL) in sub-Saharan Africa (SSA) is reported to be equivalent to the annual caloric requirement of 48 million people, estimated at USD 4 billion for grains alone, and equal to SSA's annual cereal imports: about 37 percent or 120-170 kg/year per capita (Sheahan and Barrett, 2017; The World Bank, 2011). Although there is uncertainty about the actual scale of those estimates, it is clear that PHL poses a challenge to food availability especially among poor (Affognon et al., 2015). In rural populations in SSA, where food production is the main source of income and food purchases constitute a large share of expenditures, PHL reduction is essential to attaining part of the Sustainable Development Goal (SDG) of substantially reducing global food loss by 2030 (Sheahan and Barrett, 2017). While rapid population growth and rising incomes are opening up major markets (previously small or non-existent) for African farmers in areas once considered isolated, urban-based food demand is also rising exponentially, exerting major pressure on African food systems to invest in supply chains (Jayne et al., 2018). Nevertheless, efforts to prioritize PHL interventions in SSA have not yielded compelling widespread PHL reductions (Affognon et al., 2015; The World Bank, 2011). This may be due to the low adoption of storage technologies capable of mitigating such losses.

In spite of the benefits of new agricultural technologies, their extensive adoption especially in developing countries is often slow. The technology adoption literature identifies various barriers to rapid adoption of agricultural technologies.[1] According to Foster and Rosenzweig (2010), departures from behavioral rules may affect decisions pertaining to technology adoption. The circumstances under which farmers and the poor in developing countries function often lack support systems designed to mitigate potential negative outcomes of risk-taking behavior (The World Development Report, 2013). Because agricultural production involves risks and uncertainty that create losses, the decision to adopt an agricultural technology may be affected by risk aversion and loss aversion (Shimamoto et al., 2018). While risk aversion refers to the aversion to risky outcomes with known distribution, loss aversion refers to one's sensitivity to losses compared to gains. In an analysis of risk preferences and technology adoption, Liu (2013) found that risk aversion or loss aversion delayed farmers adoption of a new cotton variety. Loss aversion may be a particularly important determinant of the demand for improved post harvest technologies, as it directly impacts the valuation of potential losses these technologies are designed to obviate.

This paper addresses the question of whether farmers' loss aversion affects their willingness to pay (WTP) for an improved storage technology (ZeroFly hermetic storage bag). We collected data from 386 farmers across 32 communities in two of Ghana's highest maize producing regions. We obtained farmers' loss aversion parameters from a risky lottery game and obtained farmers' willingness to pay (WTP) as a measure of adoption using the Becker, Degroot, and Marschak (1964) experimental auction approach (the BDM mechanism). We explore the existence of farmers' behavioral biases toward the adoption of hermetic storage bags due to their potential

[1] These include: household liquidity constraints, credit market constraints and incomplete insurance (Feder et al., 1985; Foster and Rosenzweig, 2010; Karlan et al., 2012); familiarity with technology and respondents' desirability of product attributes (De Groote et al., 2011); and heterogeneity in financial and nonfinancial returns to the technology (Foster and Rosenzweig, 2010; Suri, 2009). Furthermore, adoption of new technologies has been constrained by inadequate incentives associated with farm tenure arrangements, insufficient human capital, chaotic supply of complementary inputs (e.g. seed, water, and chemicals), inappropriate transportation infrastructure, and aversion to risk (Feder et al., 1985).

similarities to insurance products, which would suggest that more loss averse farmers would have higher WTP for hermetic storage bags due to their capability to mitigate storage related PHL. Despite the appeal of the basic hypothesis that more loss averse farmers will more highly value grain-loss mitigating technologies like hermetic storage bags, the story is complicated by potential non-technological avenues by which farmers can reduce grain losses. Farmers may not only be making a decision between improved and status quo storage technologies, but also using other coping mechanisms, such as selling crops immediately, to limit or avoid losses.

We offer two main conceptual insights. First, if farmers' dominant strategy is to sell grains immediately after harvest, then their physical loss reference point is zero. In that case, investment in storage technologies represents a certain loss, implying a negative correlation with WTP. Further, loss aversion in such cases may constrain investment in profitable storage technology.

We find that loss aversion is in fact negatively correlated with farmers' WTP for hermetic storage bags. To explore whether that relationship is driven by a reference point of selling immediately, we examined farmers' decision on time of sale during the previous growing season. If their default strategy is to sell immediately to cope with PHL, then storage losses would be zero (or negligible) and investment in hermetic storage bags would be treated as a net storage, which would depress demand for a hermetic storage bag. We find support for that theory. The negative relationship between farmers' loss aversion and their WTP for hermetic storage bags is driven primarily by those who sell immediately. For those who store to take advantage of intertemporal price arbitrage, we find no relationship between loss aversion and demand for storage technology.

In addition to providing evidence on the relationship between demand for storage technology and loss aversion, we also make two important contributions to the literature on PHL in developing country settings. First, we use an incentive-compatible auction to show that demand for hermetic storage bags is high. Well over half the sample (61%) were willing to pay at least the market price, and almost two-thirds were willing to pay above the market price. Combined with our finding that 97% of farmers report that the bags are not available for purchase, our results suggest low adoption of these technologies in Ghana faces strong supply-side constraints. That finding is in constrast to Masters and Alvarez (2018), who find low WTP for a different hermetic storage bag in Malawi. Second, we solicit subjective estimates on the effectiveness of different storage bags across different time periods and different potential conditions. Consistent with the high demand, we find that farmers perceive hermetic storage bags to offer superior grain protection agianst PHL relative to other storage technologies in both favorable and unfavorable conditions.

This study is among the first that have studied the relationship between farmers' loss aversion and their demand for improved storage technologies using experimental auctions in a developing country context. We demonstrate that while demand is likely not the limiting factor for adoption, behavioral biases such as loss aversion may be part of the reason why agricultural storage technologies are not exploited despite their capacity to mitigate against storage losses. Aker and Dillon, (2017) show that WTP for an improved storage technology (Purdue Improved Crop Storage (PICS) bags) among both cowpea traders and farmers in Niger is low with high geographic variation in uptake. They demonstrate that the different adoption levels represent distinct equilibria, with relatively lower supply of PICS bags in low-adoption areas because of traders' beliefs about farmers' demand for the product. Masters and Alvarez (2018) estimated WTP for PICS bags among low-income farmers in Malawi and found that WTP for one bag was well below the market price with no significant association between farmers' WTP and their attendance at bag-use demonstrations, aflatoxin knowledge, education, and wealth. In another study, Aggarwal et al. (2018) experimentally show that farmers in Kenya who joined group-based savings clubs had a higher likelihood to store maize for consumption or sale at least one month after harvest when prices are higher. Omotilewa et al. (2018) build on this to test if there is a link between improved storage technology, next season storage decisions, and input adoption decisions for smallholder farmers in Uganda. They indicate that smallholder farmers, who received an improved storage technology, stored maize for a longer period and reported a substantial drop in storage losses. The aforementioned studies, however, do not examine the effect that respondents' behavioral preferences (e.g. aversion to losses or risks) might have on their WTP for the products presented during the experimental auction.

In what follows, we present a background to this study in Section 2.2 and a discussion of the study's methods in Section 2.3. We then present the results and their discussion in Section 2.4, limitations is Section 2.5, and provide a summary in Section 2.6.

2.2 Background and Theory

2.2.1 Maize Production

Maize (*Zea mays*) is an important food crop in Ghana, accounting for 50-60% of total cereal production, and more than 45% of the agricultural cash income for the majority of farmers (Ragasa et al., 2014). Its production (output and value) is second to cocoa, the main export crop, and it contributes significantly to consumer diets as well as for the production of feed in the poultry and fish sub-sectors. Maize is grown across the country, but mainly in the forest and transition or middle belt (about 80% of total production) and the savannah zones (about 16%) and the remaining from the southern plains in Ghana (MoFA, 2015).

The crop calendar varies among the different agro-ecological zones, which is characterized by two growing seasons, and is predominantly rain-fed. Within the forest, transition, and southern savannah zones, sowing begins in March/April and harvesting is from July to August/September whereas sowing begins in June and harvesting is from August to October in the northern savannah zones. The second season is from August/September to January. Maize production in Ghana faces several challenges from cultivation to harvest. Due to limited use of improved seeds, fertilizers, mechanization, and crop management, smallholder farmers produce less than 1.5 ton/ha for maize compared to at least the 5 ton/ha achieved on similar soils and weather conditions in developed economies (Opit et al., 2014).

2.2.2 Nature of PHL System for Maize

The postharvest and marketing system consists of interconnected activities from harvest of crops to final consumption (The World Bank, 2011). According to the FAO (2011), food losses happen at five main stages between farmers' fields and consumers' tables. These are: (i) during harvesting (e.g. mechanical damage or spillage); (ii) during postharvest handling, such as drying, winnowing, packing, and storage; (iii) during processing; (iv) during distribution and marketing; and (v) during consumption (when quality food is discarded). The efficiency by which activities in these stages are performed depends on their specific contexts including not only economic, social (e.g., cultural aspects, gender), technical, and business considerations, but also wider considerations related to the overall enabling environment (i.e. availability of facilitating services and infrastructure, strong institutions, and macroeconomic aspects) (The World Bank, 2011). While most of PHL occurs during the stages (iv) and (v) in developed countries, PHL is most likely to occur during stages (i) to (iii) in SSA.

Opit et al. (2014) report that PHL of maize in the Ghana's Middle belt is about 30%, with a higher proportion occurring during the major season due to drying challenges resulting from the short dry spell prior to the minor growing season. The authors further state that poor handling of the maize in the field, delayed harvesting during the minor season, inadequate drying of the corn ear on bare ground and on inappropriate materials attract heavy pest infestation right from the field. An assessment of data over several years by Pens Food Bank in Ejura show that major season PHL are largely due to molds while minor season losses are mostly due to insects. The following is a description of some postharvest activities observed during the field data collection, emphasizing different factors that may influence PHL in the aforementioned stages.

2.2.2.1 Maize Harvesting

The short transition time between harvesting in the major season and preparation for the minor season may compel farmers to harvest when grain moisture content is high and more susceptible to mold growth. Farmers with large farm sizes or whose farms are distant from their homes may hire the services of tractors or motorized carting vehicles (i.e. locally called *aboboyaa*) to transport their harvested maize to their homes. These modes of transportation, although better than head load, bicycle, or animal-drawn carts, may lead to PHL as grains may be exposed to insects, birds, and unsuitable weather conditions or may fall off due to bumpy nature of road surfaces.

2.2.2.2 Shelling

Shelling is a manual activity which entails the removal of the sheathing leaves before removing kernels on the cob. In most households, women and children assume the responsibility of shelling although adult male household members also engage in shelling. During the harvest period, tractor operators also offer maize dehusking and shelling at central points in some communities at a fee of GHS 10 per 100 kg bag of maize.

2.2.2.3 Drying

Farmers across the study area rely on sunshine and atmospheric air to dry their harvested maize. Thus, unfavorable weather conditions (e.g. rainfall or cloudy days) during or after harvest adversely affect product condition, and may result in mold growth and eventually increase postharvest losses. Conversations with farmers revealed their awareness that adequate drying of grain is key to limiting loss from mold which may cause illness aside producing off-flavors when maize is consumed.

In most instances, maize is transported immediately upon harvest to homes for drying although some farmers may leave matured maize in the field for some time before harvesting. Transported maize harvests (shelled or unshelled) are usually dried on swept compounds within the house or on the street (for farmers whose homes are close to tarred roads). Mostly, pieces of wood or shovels are used to turn the grains for exposure to sunlight and atmospheric air while others walk or ride bicycles through shelled maize for the same purpose. Some farmers also dry harvested maize on tarps laid on the uncemented floors in their compounds or on the streets. In some areas, farmers heap the maize at one point and use bowls to scoop and throw the grains unto the tarp as a form of aeration. Some farmers also dry the grains on elevated wooden platforms similar to those used in drying cocoa beans: this was typical for cocoa farmers who are also maize farmers. They however reported that they dry the maize on tarps on the floor if they have cocoa beans on the wooded platforms.

To avoid selling price penalties, maize sold must be well dried and have good quality. This is a key quality check by maize buyers/aggregators who “measure” maize moisture content by biting kernels or throwing or shaking grains in their palms while listening to the sound they make. An aggregator at Teacherkrom in Ejura-Sekyedumase Municipality in the study area demonstrated that a clear crisp sound indicated well dried grains. This mode of measuring moisture content seems popular among farmers and traders. There are some incidents of postharvest losses during drying of the grains as not all grains were collected from the streets after drying. For example, some grains fell in gutters, were eaten by sheep and goats, or blown away by the wind. The quality of the grains was compromised since they collect dust as cars drove past on the streets and humans or livestock walked through. Thus, successful drying alone does not eliminate PHL, as insects, rodents, and birds may attack well-dried grain after harvest by invading storage facilities (The World Bank, 2011).

2.2.2.4 Winnowing

Winnowing and cleaning of maize is done right before sale or storage of maize and is a manual process that entails pouring shelled and dried grains into an empty container usually placed on the floor. The pouring of grain is done from an elevated height and in the direction of the wind to ensure the blowing out of chaff. Though widely used, this practice is not absolutely effective in removing organic matter and other foreign particles such as sand from the winnowed maize. Due to little or no premium for good quality maize, there is an incentive to leave foreign matter especially at the bottom of sacks as a strategy to maximize profits from sales (The World Bank, 2011). During site visits, no equipments designed for winnowing any type of grains was identified except for traditional means.

2.2.2.5 Packing of Maize

Small producers personally packed their maize into sacks to sell to aggregators usually accompanied by packers who charged between GHS 8 and GHS 10 per 100 kg bag. This is approximately 4% to 6% of the price of a 100 kg bag of maize which ranges from GHS 180 to about GHS 250 depending on time of sale. The cost for packing maize is borne by the farmer and packer activities are common in households or neighborhoods with large amounts of harvested maize. The packing process entails collecting the maize from the floor/tarp/wooden platform into an aluminum or plastic container, winnowing, and then pouring the chaff separated grains into 100 kg bags. The lack of standard weighing scales gave aggregators an advantage as they ensured that the bags were filled to the brim (producers complained about this). Some bags into which grains are packed were not durable and punctured with the slightest pressure during packing.

2.2.3 Farmers' Storage Decision

The increased use of improved maize varieties and fertilizer is likely to increase overall maize yields leading to maize influx on the market and reduced maize prices during the harvest period. At the household level, increased yields without sustainable storage systems or technologies may increase storage related PHL (i.e. quality or quantity of stored grains may be compromised by insect or aflaxtoxin infestation). This may have implications for undernutrition and reduced revenue.

To address this storage related PHL problem, farmers must decide between storage technologies (e.g. status quo and hermetic bags) that will maximize their expected returns subject to total quantity of maize available for storage and any cash constraint on technology expenditure. That is, farmers would adopt a technology that would insure their harvest against PHL. With an improved storage technology, farmers can effectively store maize to smoothen consumption, reduce food expenditure and take advantage of intertemporal price arbitrage through lean period sales (Omotilewa et al., 2018).

Farmers constrained by the prospect of losing much grains, such that they will be unable to attain subsistence needs, may make decisions that diverge from those who want to maximize profits from selling later to take advantage of higher prices (Smale et al., 1995). Thus, loss averse farmers may sell immediately after harvest to avoid storage losses even when market prices are at their lowest. Farmers may also diversify their portfolio by choosing a combination of storage technologies/practices to maximize their expected income by varying time of sale and amount sold within each period. Under a dynamic context, farmers who value future utility of information may choose to adopt the hermetic bag to store maize for later use: consumption or delay sale to take full advantage of lean season price arbitrage (Smale et al., 1995).

2.3 Data and Empirical Strategy

2.3.1 Description of Experiment and Data Collection

The use of experimental auctions for evaluating demand for new technologies is increasing in developing countries. For example, experimental auctions have been used to highlight heterogeneous valuation of biofortified foods (De Groote et al., 2011), laser land leveling (Lybbert et al., 2013), as well as health related products such as insecticide treated bednets (Hoffmann, Barrett, and Just, 2009).

A widely used auction that compares participants' bids to a randomly drawn price is the Becker-DeGroot-Marschak (1964) auction approach (often called the BDM mechanism). This is an incentive compatible auction in which individual participants bid for a product; if their final submitted bid is at least equal to a randomly selected price, then the participant buys the product at that price otherwise there is no purchase. This nature of the BDM mechanism offers participants have an incentive to bid according to the true preferences they would show in a commercial market (Lusk and Shogren, 2008). This study aims to contribute to the literature by using the BDM mechanism to explore the heterogeneity/tradeoffs associated with maize farmers' valuation of new hermetic storage bags.

The research was conducted in the Ejura-Sekyedumase and Techiman municipalities of the Ashanti and Brong-Ahafo regions respectively (see Figure 2.1). Both regions are among the top three maize producing regions in Ghana[2]. From each municipality, we randomly selected sixteen communities[3] that met the criteria of having a population of at least fifteen households who are maize producers. Our proposed sample size was 406 households. However, twenty observations were lost due to an operating system corruption on one of the data collection devices during the data collection exercise leaving a sample of 386 households.

The data collection exercise was conducted in July 2018 over a period of fifteen days and coincided with the time for maize harvesting and preparation for the second growing season. The data was collected in 32 communities where we randomly selected fifteen households each to respond to the survey.

First, we collected data on household demographics, economic activities, assets, farm characteristics, access to credit and agricultural extension services, exposure to shocks, and maize storage facilities used. Secondly, we conducted loss aversion and willingness to pay experiments with the household representatives as respondents. For each experiment, a respondent was assigned an enumerator to privately guide them through the exercise and collect their responses. This was done to avoid information spillage and possible collusion among respondents. Respondents were randomly assigned an information treatment prior to conducting the willingness to pay experiment.

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[2] Brong-Ahafo and Ashanti are respectively the first and third highest maize producing regions.
[3] According to the Ghana Statistical Service, a community could comprise a single household.

Figure 2.1: Map of Ghana Showing Agro-Ecological Zones and Regions

Source: Osei and Stein (2017).[4]
Note: Ghana had ten regions during the fieldwork. In 2019 six more regions were added.

[4] Osei, F.B., and Stein, A. (2017). Spatio-temporal analysis of small-area intestinal parasites infections in Ghana. Sci. Rep. *7*, 12217

Loss aversion has been used to explain many economic phenomena that are difficult to understand under the assumption of reference-point independence (Booij and van de Kuilen, 2009; Gaechter et al., 2010). Loss aversion has been linked to negativity bias which explains that people may be more pessimistic and thus will pay more attention to negative information than positive information (Harinck et al., 2012) and can occur in both riskless and risky choices (Tversky and Kahneman, 1991). Under riskless choices, loss aversion may be elicited as the ratio of willingness to accept to willingness to pay for a product.[5]

In this experiment, respondents' loss aversion was measured in a risky choice setting using a simple lottery for which they decide whether to accept or reject six different lotteries. Each of the lotteries presents a fixed winning price of GHS 6 and a losing price that ranges from GHS 2 to GHS 7 (see Table A2 in appendix for the decision sheet of the lottery choice task). A win or loss for each lottery is determined by the flip of a coin (heads indicate a loss while tails indicate a win). Following Gaechter et al. (2010), we measure loss aversion as a ratio of gains to losses.[6] The gains represent the fixed winning price of GHS 6 (the outcome of tails in the coin flip) while the losses refer to the final lottery choice accepted by a respondent (as a result of heads in the coin flip). The loss aversion experiment was conducted to elicit preferences for any of the choice tasks; no lottery is selected for actual payment. Upon obtaining the loss aversion outcome from the lottery choice tasks, we calculated the loss aversion parameter for each respondent using the gain-loss ratio (G/L) method following the method of (Tversky and Kahneman, 1991): assessing gain-loss ratios in the 50/50 coin-toss gamble paradigm. Gain-loss ratios higher than one mean that

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[5] See for example Gaechter et al. (2010)

[6] See for example Liu (2013), Tanaka et al. (2010), and Abdellaoui (2000) for alternative loss aversion elicitation approaches.

gains need to be larger than losses to balance the gamble and is indicative of loss aversion (Harinck et al., 2012).

Prior to conducting the willingness to pay experiment, a respondent was randomly assigned an information treatment by flipping a fair coin. Treatment 1[7] (outcome of heads) offered respondent a description of grain losses that the ZeroFly hermetic storage bag may help to prevent whereas treatment two described gains the bag may allow. We handle the treatment framing with caution in the analysis due to an unexplained imbalance in the frequency of assignment of each treatment.[8]

The price of the bag ranged from GHS 1 to GHS 10, and respondents' WTP was asked at each price in incremental levels of one unit (i.e. GHS 1). Upon completion of the experiment (following the Becker-DeGroot-Marschak (1964)), we revealed the random price at which they could purchase the bag.[9] Each respondent was also offered a GHS 10 participation fee from which those whose maximum willingness to pay was at least equal to the preselected price of the ZeroFly hermetic storage bags could make a purchase. The participation fee amount was only revealed after the BDM auction was conducted, so they were not aware that the fee was equivalent to the highest bid. See Table A3 in the appendix for the BDM auction sheet used.

[7] Treatment 1: Prevents 100% post-harvest losses due to insect damage for up to 24 months; no repeated intervention required; no vulnerability to insect damage; no toxicity risks for food consumers and other handlers.
Treatment 2: Allows up to 60% saving on fumigation and chemical application costs; efficient for insect control; allows large-scale stacking; easily transportable (saves cost of new sacks to transport maize to the market).
[8] While each treatment should have occurred with equal probability, treatment one was assigned significantly more often than treatment two.
[9] The stepwise implementation of the BDM mechanism follows that of (Lybbert et al., 2013).

2.3.2 Descriptive Statistics by Treatment

Table 2.1 presents the summary statistics on key variables disaggregated by the information treatment received by the respondent during the survey. For both treatments, we report the means and standard deviations for the listed variables and present the ex-ante difference in means between the treatment groups and their respective t-statistics in the last two columns. All the respondents sampled for this study were maize farmers: the majority of the respondents (about 99%) engage in farming as their main occupation while the remaining 1% are employed in the non-farm sector but operate a farm as a side activity. The majority of the respondents were male (70%) and the average age being 42 years. The average years of formal education is low (5 years) while the number of years of farming experience is greater than 18 years. About 79% of the respondents are married and the average household size about 8 persons.

On average, total farm sizes are about eight acres of which an average of four acres is allocated to maize production with about 2801 kg of maize harvested. The average yield of maize is about 559 kg/acre. This mean is below the national average (830 kg/acre) (MOFA, 2017). The average marketable surplus and total maize sale within the sample are 2540 kg and GHS 3545 respectively. About 33% (125) of the respondents borrowed money during the production season under review. The majority (94% or 117) of these farmers borrowed toward enhancing agricultural productivity (land preparation, fertilizer purchase) while only 6% (eight) respondents did not exclusively use the borrowed money for an agricultural related activity (use money for children's school fees).

The most prevalent storage medium used by respondents is jute/plastic sack followed by metallic or plastic drums and then hermetic storage bags. Overall, 97% of the respondents use plastic sacks: a light textured woven sack which is readily available on the market at GHS 2 or

GHS 3 per 100 kg bag.[10] Unlike baskets/pots/jars (which less than 1% of respondents use), jute/plastic sacks offer better portability of stored grain and better insect protection. However, there may be some level of exposure to PHL since it lacks an airtight or insecticide treated feature which may limit the activities of insects within the bag. To compensate for the no insecticide treated feature of plastic sacks, about 18% of the farmers either spray grains before storage or use insecticide pellets during storage which may be harmful when consumed and may present respiratory problems since storage rooms double as bedrooms for some farmers. The cost of these pellets ranges from GHS 8 to GHS 12 per can and the farmers anecdotally noted they normally use pellets to store maize meant for home consumption. Only 3% of the respondents reported ever using a hermetic storage bag.

We asked farmers to rate the performance of the four grain storage media based percent grain survival under best and worst cases and over three and six month periods. Generally, farmers perceive hermetic storage bags to offer the best protection for maize over the two time periods and scenarios: about 96% and 94% maize survival under best environmental conditions for three and six months postharvest respectively, and about 70% and 61% under worst environmental conditions for the same periods. Most farmers based their perceptions on information received from agricultural extension agents or demonstration sessions they previously attended. The majority of the respondents perceive maize survival to be higher with jute/plastic sack under best and worst conditions and across the two time periods compared to baskets/pots/jars or metal/plastic drums.

Using the best and worst case survival estimates, we illustrate respondents' perceived maize survival for the various storage technologies over the full range of probabilities of a worst

[10] The most popular bag among producers and aggregators is the "Makola Woman" a 100 kg bag.

condition occurring. We observed that farmers' expected maize survival with hermetic storage bags dominates all other storage technologies even with a 100% probability of a worst environmental condition over both three and six months after harvest (see Figures A1, A2 and A4 in Appendix A).

Table A1 (in Appendix A) presents summary statistics by time of sale of marketable surplus (i.e. no maize sold after two months, some maize sold after two months, and all maize sold after two months). Across the three groups, majority of the farmers are male household heads with mean age and mean farming experience of at least 41 years and 18 years respectively. Farmers who sold some of their marketable surplus within two months have the highest mean household size, size of maize farm, amount of maize harvested, maize revenue, and off-farm income. Also, perceived average maize survival is highest for farmers who sold some maize both within and after two months of harvest (over three and six month durations under best or worst case conditions using baskets/pots/jars and metal/plastic drums). In best and worst case scenarios, three and six months' difference in perceived average maize survival using jute/plastic sacks is highest among farmers who sold all their maize after two months. Farmers in this category always store grain and may have a more precise perceived maize survival for this technology. Similarly, they report the highest perceived average maize survival for hermetic storage bags except for the worst case scenario.

Table 2.1: Demographic and Socio-Economic Characteristics of Respondents

Variable	Treatment 1 (N=241)		Treatment 2 (N=145)		Difference in means	
	Mean	Std. Dev	Mean	Std. Dev	Coeff.	t stat
Farmer/Household characteristics						
Male (%)	69.29	46.22	71.03	45.52	-0.0174	-0.36
Age (years)	41.95	14.39	42.26	13.60	-0.3091	-0.21
Education (years)	5.32	4.86	5.32	4.65	0.0402	-0.09
Farming experience (years)	18.53	13.15	18.80	13.01	-0.2689	-0.20
Married (%)	80.08	40.02	77.93	41.61	0.0215	-0.50
Profession “farmer” (%)	98.76	11.11	98.62	11.70	0.0013	-0.11
Total HH size (numbers)	8.15	4.62	8.64	5.49	-0.4620	-0.88
Production characteristics						
Total farm size (acres)	8.23	6.74	8.17	7.96	0.0648	-0.09
Maize farm (acres)	4.62	4.75	4.69	5.34	-0.1475	-0.28
Maize harvested (kg)	2782.37	3836.48	2830.69	5480.81	-131.3121	-0.29
Maize consumed (kg)	266.96	312.40	250.75	216.59	16.2180	-0.55
Maize yield (kg/acre)	577.16	364.19	527.51	358.19	49.6466	-1.31
Marketable surplus (kg)	2515.40	3736.17	2579.94	5378.60	-64.5425	-0.14
Total maize sale (GHS)	3321.52	7237.02	3916.79	12712.40	-651.9087	-0.60
Off-farm income (GHS)	317.77	2140.98	242.55	958.28	75.2201	-0.40
Credit (1=borrowed money)	0.34	0.47	0.31	0.46	0.0291	0.58
Maize Storage						
Basket/pot/jar (%)	0.00	0.00	0.69	8.33	-0.0069	-1.29
Metal/plastic drums (%)	2.49	15.61	1.39	11.74	0.0110	-0.73
Jute/plastic sacks (%)	97.10	16.83	97.22	16.49	-0.0013	-0.07
Hermetic storage bag (%)	0.41	6.44	0.69	8.33	-0.0028	-0.37
Stored with chemicals (%)	19.92	40.02	14.58	35.42	0.0533	-1.32
Hermetic bag ever used (%)	3.73	19.00	2.76	16.44	0.0098	-0.51
Hermetic bag still in use (%)	2.07	14.28	2.07	14.28	0.0001	0.00
Hermetic bag availability (%)	2.90	16.83	3.47	18.37	-0.0057	-0.31
Storage perception						
Baskets/pots/jars						
Best case						
- 3 month survival (%)	65.88	26.61	67.35	21.86	-1.4733	-0.56
- 6 month survival (%)	50.99	31.69	52.50	29.39	-1.5049	-0.46
Worst case						
- 3 month survival (%)	38.87	34.72	42.09	32.48	-3.2188	-0.90
- 6 month survival (%)	30.35	34.46	32.66	34.33	-2.3148	-0.64

Table 2.1 Continued

Variable	Treatment 1 (N=241)		Treatment 2 (N=145)		Difference in means	
	Mean	Std. Dev.	Mean	Std. Dev.	Coeff.	t stats
Metal/plastic drums						
Best case						
- 3 month survival (%)	63.55	27.09	65.76	23.40	-2.2048	-0.81
- 6 month survival (%)	48.82	32.61	51.89	29.36	-3.0730	-0.93
Worst case						
- 3 month survival (%)	37.46	34.54	38.60	32.11	-1.1390	-0.32
- 6 month survival (%)	29.76	34.77	30.22	33.11	-0.4668	-0.13
Jute/plastic sacks						
Best case						
- 3 month survival (%)	85.04	18.08	84.07	17.20	0.9663	-0.52
- 6 month survival (%)	74.87	24.16	71.76	25.17	3.1107	-1.21
Worst case						
- 3 month survival (%)	52.34	36.90	55.81	34.98	-3.4735	-0.91
- 6 month survival (%)	43.72	38.43	43.55	38.84	0.1723	-0.04
Hermetic storage bag						
Best case						
- 3 month survival (%)	95.98	14.64	96.02	14.85	-0.0456	-0.03
- 6 month survival (%)	93.76	15.49	93.41	18.02	0.3414	-0.20
Worst case						
- 3 month survival (%)	68.80	36.12	71.18	37.28	-2.3840	-0.62
- 6 month survival (%)	59.46	41.40	62.98	41.97	-3.5180	-0.80
Location (Municipality)						
(1=Ejura-Sekyedumasi, 0=Techiman)	0.51	0.50	0.54	0.50	0.3030	0.58

Notes: Exchange rate at the time of interview was GHS 1 = US$ 0.22.

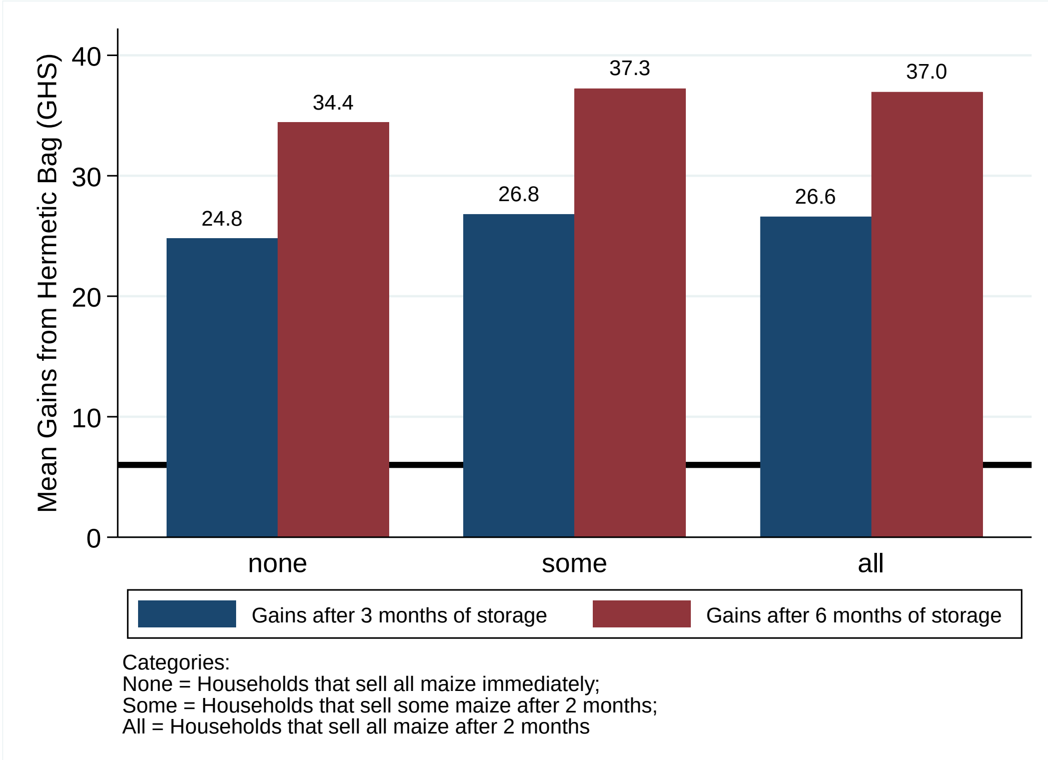
2.3.3 Gains from Hermetic Storage Bag Use

The data show that farmers perceive hermetic storage bags to be superior to all other technologies with respect to grain preservation. Specifically, over both three-month and six-month post-harvest periods and under the worst hypothetical environmental conditions, respondents predict that maize survival rate is higher with hermetic storage relative to jute/plastic sacks, baskets/pots/jars, and metal/plastic drums. In this sub-section, we combine data on maize production with respondents' predicted preservation to calculate an estimated predicted returns to hermetic bag use for each household.

Based on farmers' perceived maize survival, we computed predicted returns to using hermetic storage bags relative to jute/plastic sacks. Our basic strategy is to take a household's perceived difference in the survival of 100 kg of maize between hermetic bags and jute/plastic sacks over three and six months, and multiply that by the average maize price at those times. Specifically, we winsorize the household's retained marketable surplus at 100 kg (the bag's capacity) and multiply that by the perceived survival rate difference under the worst hypothetical conditions to obtain the perceived gains in marketable surplus from hermetic bag use. We then find the value of the storage improvement by multiplying perceived gains in marketable surplus by the per kilogram price of maize three and six months after harvest.

Figure 2.2 shows a graph of perceived value of gains to hermetic bag use compared to using jute/plastic sacks over of time sale of maize. The average returns to hermetic bag use is higher after six months of harvest compared to the three-month post-harvest period. The value of perceived gains is also larger for farmers who sell all or sell some maize two months post-harvest compared to those who sell immediately after harvest. For both time of sale comparisons, the difference is approximately GHS 2 and GHS 3 over the three and six month respective periods. Furthermore, the value of predicted gains to hermetic bag use exceeds the difference in cost of hermetic bag and jute/plastic sack (GHS 6). The computed value of predicted gains excludes any gains from storage for consumption purposes.

Figure 2.2: Predicted Gains from Hermetic Storage Bags by Sales at Harvest



Source: Author's compilation from survey.
Notes: The black line indicates the difference between cost of hermetic bag and jute/plastic sack: GHS 6.

2.3.4 Empirical Model

This study focuses on estimating the determinants of demand for hermetic storage bags in Ghana, with a specific focus on the role of loss aversion. First, we assess the framing effect of information about the bags on their WTP. To do this, we check the differences in the impact of receiving information about potential losses that the bag prevents compared to potential gains the bag offers (the random assignment of treatment information presents a counterfactual scenario for comparison). We then examine the effect of farmers' loss aversion, obtained through a lottery experiment, on their WTP for the bag and check the effect of an interaction between loss aversion and information treatment.

Furthermore, because farmers'storage decision may influence the value of the technology, we examine the effect of time of sale of marketable surplus maize on their WTP for the bag. We categorize farmers based on whether a household sells all maize immediately after harvest; sells some maize immediately and the rest after two months of harvest; or sells all maize after two months of harvest. We also interact farmers' loss aversion parameter with the time at which they sell maize to analyze the potential changes in the effect of loss aversion within those groups on the value of hermetic storage bags.

From the outlined model of farmers' storage decision, the basic 'engineering' model of storage suggests a postive relationship between loss aversion and WTP: loss averse farmers will treat hermetic storage bags as a product that mitigates storage related PHL and will assign relatively higher value to them. However, there may be a reference dependence preference for time of maize sale which could confound the *a priori* expectation of a positive loss aversion-WTP relationship.

We recognize the existence of censoring in the respondents' bids. In experimental auctions, bids are often censored at the lowest possible bid (i.e. zero) to account for the fact that respondents who dislike the auctioned product cannot submit negative bids (Banerji et al., 2013; Morawetz et al., 2011). Similarly, if respondents' bids do not exceed the market price of the product, although they may value it more highly, then bids are censored from above (Morawetz et al., 2011). In this study, left censoring is not a major issue due to the relatively small number of respondents (approximately 2%) with zero WTP. Also, traditional market price censoring is not salient due to low availability of hermetic storage bags in the study area. However, we note that right censoring induced by the maximum price in the BDM auction is potentially problematic.

Accounting for right censoring using the right-censored Tobit model produced robust results that are not qualitatively different from the left-censored Tobit model.

The WTP$_i$ of farmer i for the technology regressed on the type of treatment they received (loss prevention or gain preserving qualities of the technology) may be specified as:

$$WTP_i = \beta_0 + \beta_1 treat_i + v_i, \tag{1}$$

where v_i is the error term for farmer i's WTP for the technology, $treat_i$ is the treatment information about the technology, and v_i represents the standard errors.

The most general model, which includes other explanatory variables such as farmer characteristics and behavioral parameters and their interactions is specified as:

$$WTP_i = \beta_0 + \beta_1 treat_i + \beta_2 Lossav_i + \beta_3 treat_i * Lossav_i + \beta_4 sold\ some_i + \beta_5 sold\ all_i + \beta_6 Lossav_i * sold\ some_i + \beta_7 Lossav_i * sold\ all_i + X'\gamma + v_i \tag{2}$$

where $Lossav_i$ is farmer i's loss aversion measure; $sold\ some_i$ is a dummy for whether farmer *i* sold some maize after two months of harvest and $sold\ all_i$ is a dummy for whether farmer *i* sold all maize after two months of harvest. The omitted category constitutes farmers who sold no maize after two months of harvest. β_3 represents the interaction coefficient between farmer i's loss aversion parameter and the treatment information they received. β_6 is the interaction coefficient between loss aversion and dummy of whether farmer *i* sold some maize after two months of harvest whereas β_7 represents the interaction coefficient between loss aversion and whether farmer *i* sold all maize after two months of harvest. X is a vector of control variables including farmer's sex, education, farming experience, income, household size, and perceived storage loss reduction from using hermetic storage bags compared to plastic/jute sacks.

2.4 Results and Discussion

2.4.1 Loss Aversion

Table 2.2 shows the acceptance rates of the lottery experiment and their implied loss aversion parameters. About 41% of the sample rejected all lotteries regardless of the non-negative expected value from first five choices whereas 5% of the respondents accepted all lotteries which have non-negative expected gains but rejected lottery 6 which has a negative expected value. Overall, about 30% of the respondents accepted all lotteries including lottery six which has a negative expected value: indicating they are the least loss averse.

We further calculate loss aversion parameters using the gain-loss ratio method of Tversky and Kahneman (1991) and Gaechter et al. (2010) from Section 2.3. Columns 1 to 4 of Table 2.2 show alternative elicited loss aversion parameters based on different assumptions about the probability weights and diminishing sensitivity. Abdellaoui (2000) notes that it is essential to recognize that people weight probabilities and these weights may differ for gains and losses and presents a non-parametric assumption which accounts for respondents' probability weights and the diminishing sensitivities of their choice. We imposed these assumptions on the gains and losses and recalculated the loss aversion parameters using the gain-loss ratio method to verify any possible heterogeneous impacts on the implied loss aversion. The loss aversion measure reported in the regression results are based on column 1 (no weights), through and the results are not sensitive to different assumptions of probability weights and diminishing sensitivity for gains and losses.

Table 2.2: Acceptance Rates of Different Lotteries and Implied Loss Aversion[11]

Lottery choice category (loss game)	%	Implied loss	Implied loss aversion under different assumptions of probability weights and diminishing sensitivity for gains and losses			
			(1) ω = 1 β = 1 δ = 1	(2) ω = 1 β = 0.95 δ = 0.92	(3) ω = 0.86 β = 1 δ = 1	(4) ω = 0.86 β = 0.95 δ = 0.92
Reject all lotteries	40.93	0	6.00	5.49	5.16	4.72
Accept lottery 1, reject lotteries 2 - 6	9.84	GHS 2	3.00	2.90	2.58	2.49
Accept lotteries 1 & 2, reject lotteries 3 - 6	5.44	GHS 3	2.00	2.00[a]	1.72	1.72[b]
Accept lottery 1 to 3, reject lotteries 4 to 6	3.63	GHS 4	1.50	1.53	1.29	1.32
Accept lottery 1 to 4, reject lotteries 5 & 6	4.40	GHS 5	1.20	1.25	1.03	1.07
Accept lottery 1 to 5, reject lottery 6	5.44	GHS 6	1.00	1.06	0.86	0.91
Accept all lotteries	30.31	GHS 7	0.86	0.92	0.74	0.79

Notes: (1) benchmark parameters: no probability weighting, and no diminishing sensitivity. (2) no probability weighting, but diminishing sensitivity. (3) Probability weighting, but no diminishing sensitivity. (4) Probability weighting and diminishing sensitivity. Parameters on diminishing sensitivity taken from Booij and van de Kuilen (2009); parameters on ω taken from Abdellaoui (2000). Exchange rate at the time of interview was GHS1 = US$0.22.
a and b are 1.9966 and 1.71708 respectively.

2.4.2 WTP for Hermetic Storage Bags

We obtained farmers' WTP for hermetic storage bags using experimental auctions. The use of hermetic storage bags is low: of the respondents, 3% have ever used while 2% still use hermetic storage bags. As shown in the descriptive statistics section, majority of farmers who have ever used or still use hermetic storage bags are willing to pay higher than the market price to obtain the bags. Also, about 83% of the respondents are willing to pay at least a 33% premium above the market price (GHS 3) for jute/plastic sacks (the most used storage technology). This indicates that hermetic storage bags would be adopted if their availability was more widespread (only 3% reported having access). This supports findings by Aker and Dillon (2017), who report inefficient

[11] See, for example, Gaechter et al. (2010) for similar analysis

demand translation despite the introduction and widespread distibution of hermetic storage bags in Niger.

Table 2.3 shows that about 61% of the respondents are willing to purchase hermetic storage bags at least at the market price of GHS 9 per bag. Moreover, about a third of the respondents are willing to pay an 11% premium above the market price of GHS 9 per hermetic storage bag. However, the average WTP for hermetic storage bags is generally below the market price across municipalities and over the information treatment received.[12] For example, without considering treatment type, the mean WTP for hermetic storage bags is 14% and 16% below the local market price in Ejura-Sekyedumasi and Techiman respectively. The demand for hermetic storage bags across these two areas is similar and is not highly dependent on any idiosyncratic local factors. It is important to note that censoring of elicited prices at GHS 10 in the respondents' bids is a possible contributor to pushing down the mean WTP figures. Overall, respondents who received the "loss information" treatment have higher mean WTP for hermetic storage bags compared to respondents who received the "gains information" treatment. There is, however, no statistically significant difference between treatments type received across the two municipalities.

Table 2.3: Willingness-to-Pay for Hermetic Storage Bags (GHS/bag)

	Ejura-Sekyedumasi		Techiman		Pooled Sample
	Treat. 1	Treat. 2	Treat. 1	Treat. 2	
Mean WTP	7.71	7.65	7.65	7.30	7.61
St. Dev	3.23	3.31	3.27	3.39	3.28
% farmers at least at market price	62.91	63.30	60.68	60.61	61.14
N	124	79	117	66	386

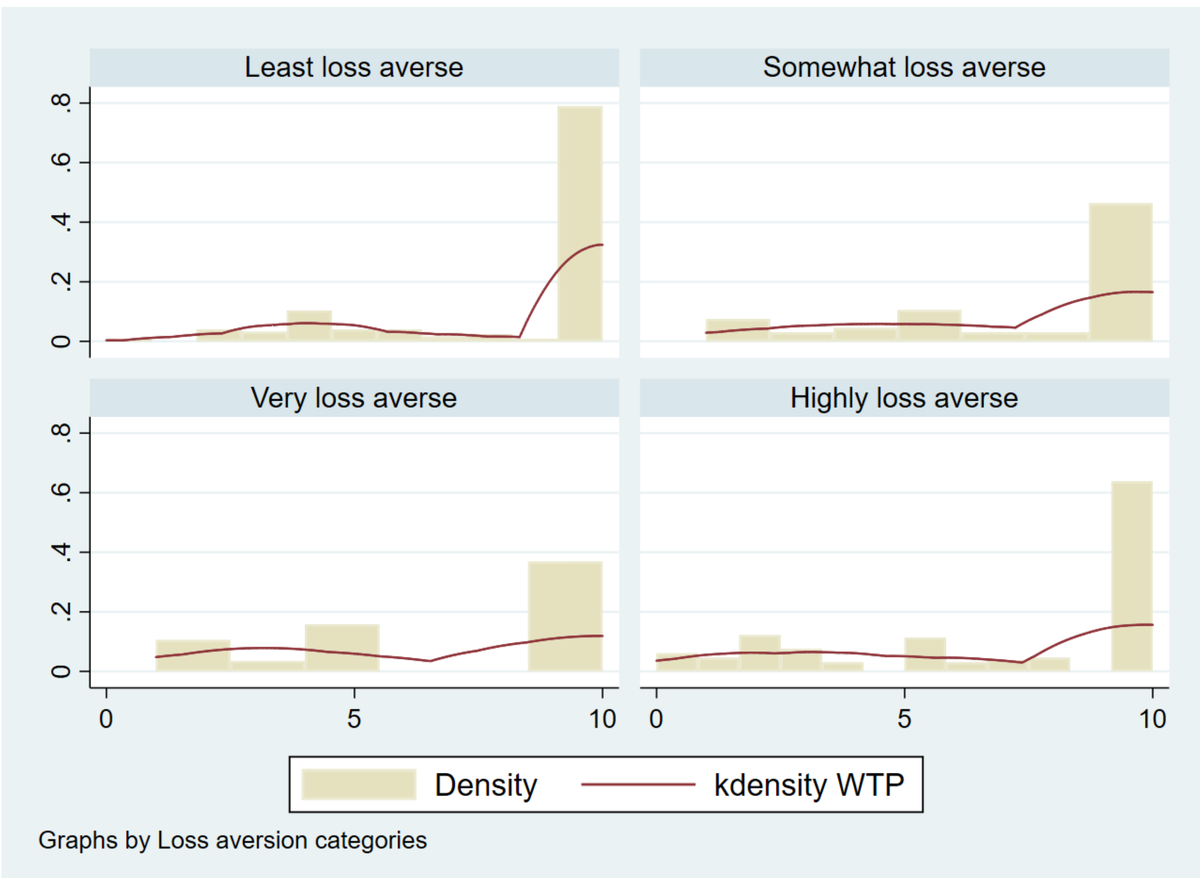
Notes**:** Market price of ZeroFly hermetic storage bag is GHS 9 and GHS 1 = US$ 0.22.

[12] Mean WTP is GHS 7.68 and GHS 7.52 for Ejura-Sekyedumasi and Techiman respectively (without considering treatment type)

2.4.3 Willingness-to-Pay and Farmers' Loss Aversion

We categorize farmers' loss aversion parameters into four components: least loss averse, somewhat loss averse, very loss averse, and highly loss averse. The data show that farmers' WTP for hermetic storage bags at least at the market price of GHS 9 is highest for those who are least loss averse followed by those who are highly loss averse (see Figure 2.3). The WTP characteristics of the farmers classified as somewhat loss averse as well as those who are very loss averse are similar; and the distribution of their demand is skewed towards the highest WTP price of GHS 10.

Figure 2.3: Relationship Between Farmers' WTP and Loss Aversion Categories

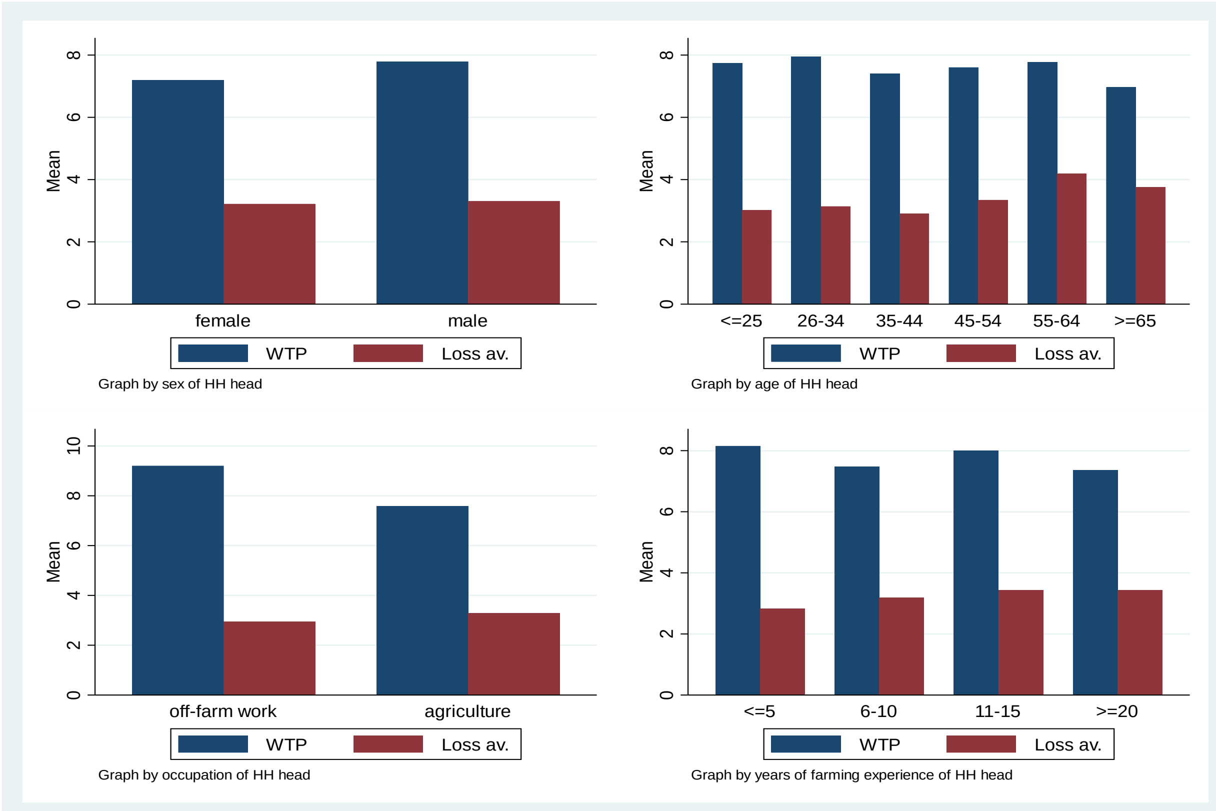


Source: Author's computation from household survey

2.4.4 WTP and Loss Aversion Comparison by Socio-Economic Variables

Figures 2.4 illustrates the relationship between farmers' demographic factors and WTP as well as loss aversion over the distribution. While WTP is higher for male household heads compared to their female counterparts, we observe that on average loss aversion is similar for the two groups. When disaggregated by farmers' age, WTP hovers between GHS 7 (for farmers at least 65 years old) and GHS 8 (for relatively younger farmers: 26 to 34 years old); which is lower than the GHS 9 market price for the hermetic storage bags. Also, farmers whose main occupation is off-farm work have higher WTP of the bags and are less loss averse compared to those whose main occupation is farming. The data shows that WTP measures are similar for farmers with up to five years farming experience and those with between 11 to 15 years of experience while farmers with 6-10 years farming experience are similar to those with at least 20 years farming experience. We notice that more experienced farmers are characterized with higher loss aversion. Since bivariate correlations may be weak, we present results of regression analysis to ascertain these relationships in the next subsection.

Figure 2.4: Comparison of WTP and Loss Aversion by Farmer Characteristics



Source: Author's computation from household survey

2.4.5 Factors Influencing WTP for Hermetic Storage Bags

We begin with a simple model (column 1 in Table 2.4) to determine the effect of the information treatment on farmers' WTP. We observe that the loss framing treatment had a small and very imprecise positive effect on WTP. That is, farmers who received loss prevention information about the hermetic storage bags have a GHS 0.19 higher WTP for the bags. We handle the information treatment with caution due to an imbalance between the loss and gains framing percentages (about 62% and 38% respectively) possibly due to enumerator error.

The results in column 2 show that farmers' loss aversion significantly reduces their WTP (by GHS 0.27). This result is contrary to the notion that loss aversion could potentially increase WTP for improved storage technology since loss averse farmers may strongly desire to reduce storage losses. Combining treatment, loss aversion, and their interaction in a single model (column 3) did not meaningfully change their respective individual relationships. The interaction term shows that increases in loss aversion do not change the treatment effect.

From our data collection exercise, farmers provided information on the time of sale of their marketable surplus: percentage of maize sold within two months of harvest or beyond that duration. Anecdotal evidence from our interactions with the respondents showed that some farmers sell marketable surplus immediately (within two months of harvest) as a coping strategy against potential storage related PHL. We run a separate regression to identify the relationship between farmers' WTP for hermetic storage bags and the time at which they sold their maize. The results show that farmers who store for a longer period (at least after two months of harvest) have significantly higher WTP for hermetic storage bags compared to those who sold within two months of harvest.

In Column 4, we add time of sale variables and observe that on average, farmers who sold all their marketable surplus after two months of harvest have a significantly (GHS 1.3) higher WTP compared to farmers who sold all marketable surplus immediately. The evidence here is that there is higher demand for better storage among farmers who store for longer durations compared to those who sell immediately to avoid potential storage losses. Also, the possibility of spreading marketable surplus before and after two months of harvest may lower the incentive to invest in the storage technology.

A meta-analysis of PHL in SSA by Affognon et al. (2015) shows that factors affecting adoption of storage technologies include farmers' education, contact with extension agent, access to credit, income, and market orientation (commercial or production for home consumption). In Column 5, we add control variables to the model for Column 4 and observe an increase in the magnitude of the estimates while the significant effects remain the same. The results however show that an additional year of education and farm size are negatively correlated with WTP for improved storage bags whereas male household heads are more likely to be willing to purchase this improved storage technology.

In Column 6, we add interactions between loss aversion and the timing of sale variables: selling no maize, some maize, or all maize after two months of harvest. The results show a persistent significantly negative correlation between loss aversion and WTP but no significant differences between selling some or all maize after two months and the benchmark of selling immediately. Though the difference is marginally insignificant, the patter is clear: the negative relationship between loss aversion and WTP for the storage bags is driven primarily by farmers who sold immediately. That is the expected pattern if farmers' default strategy is to sell immediately to avoid storage losses: they will have no incentive to invest in hermetic storage bags since storage losses would be zero or negligible. In this case, purchasing a hermetic storage bag is a certain loss in and of itself. We conjecture that for farmers who sell immediately, loss aversion may even be a behavioral constraint to switching to the new storage technology if the new technology changes the optimal selling time strategy.

Additionally, we run several variants of the aforementioned models and find no changes in the relationship between loss aversion and WTP for hermetic storage bags (see Tables A4 to A7 in Appendix A).

Table 2.4: Regression Results on Factors Affecting WTP

Variables	(1)	(2)	(3)	(4)	(5)	(6)
Loss treatment	0.1864		0.9566	0.1510	0.1877	0.2183
	(0.3539)		(0.5343)*	(0.3474)	(0.3379)	(0.3392)
Loss aversion		-0.2663	-0.1290	-0.2923	-0.2705	-0.3695
		(0.0726)***	(0.1243)	(0.0707)***	(0.0721)***	(0.1535)**
Loss treatment and loss aversion			-0.2199			
			(0.1524)			
Some maize sold after 2 months				-0.3315	-0.2924	-0.5503
				(0.4319)	(0.4365)	(0.6830)
All maize sold after 2 months				1.2720	1.4218	0.5367
				(0.4578)***	(0.4491)***	(0.6751)
Loss aversion X Some maize sold						0.0628
						(0.1866)
Loss aversion X All maize sold						0.2471
						(0.1825)
Education					-0.0743	-0.0727
					(0.0375)**	(0.0373)*
Sex					0.9127	0.9300
					(0.3831)**	(0.3803)**
Household size					0.0438	0.0454
					(0.0322)	(0.0320)
Farm experience					-0.0228	-0.0235
					(0.0143)	(0.0145)
Farm size					-0.0855	-0.0850
					(0.0337)**	(0.0338)**
Income					0.0000	0.0000
					(0.0000)***	(0.0000)***
Perceived gains with hermetic					-0.0050	-0.0053
storage bags (6 months)					(0.0067)	(0.0067)
Constant	7.4656	8.4552	7.8704	8.2750	8.6346	8.5106
	(0.2826)***	(0.2529)***	(0.4450)***	(0.4828)***	(0.6302)***	(0.7156)***
N	386	386	386	386	386	386

Notes: Dependent variable is WTP for hermetic storage bag. Models in all columns are Tobit estimators. Standard error in parenthesis. * p<0.1; ** p<0.05; *** p<0.01.

2.5 Study Limitations

We are mindful of several limitations of our study and draw lessons for future studies. First we note an imbalance in the mode of assigning treatment information about the hermetic storage bags to respondents. The intention was to randomly assign the information treatment but the imbalance may be due to either a misunderstanding of the protocol by enumerators or incorrect recording of the treatment.

Second, we acknowledge some limitation with the loss aversion elicitation procedure; since the gain-loss ratio method we used may not be exhaustive. It would have been useful to conduct at least another experiment to elicit farmers' loss aversion parameters. This would serve as a robustness check for the relationship between farmers' loss aversion and their willingness to invest in a hermetic storage bag. Third, we do not breakdown the interconnected nature of other behavioral biases such as risk aversion and its effect on demand for the hermetic storage bags. Including farmers' risk aversion parameters would help us decompose the result to identify the role of each behavioral bias.

The nature of farming (e.g. cropping system, farm size, and yield) in the study area is similar to other places in Ghana. However, we note that the small sample size may lower the statistical power of the results and may not be representative of the country. Nonetheless, our results present an important first step in investigating the effect of loss aversion on WTP; and provide a potential for expanding the sample as well as including further analyses for better precision and generalizability.

2.6 Summary of Findings

In this study, we examine the effect of farmers' loss aversion on their willingness to pay for improved storage technology capable of mitigating postharvest losses in maize. The results show that there is a high demand for such an improved technology (hermetic storage bag) although supply of the technology is rather low in the study area. On average, the loss aversion measure shows that the majority of farmers in the sample fall in the category of being somewhat, very, or highly loss averse. This notwithstanding, nearly two-thirds of the sample are willing to pay at least the market price GHS 9 for a hermetic storage bag. Also, farmers generally perceive hermetic storage bags to have superior mitigating capacity against PHL compared to other storage technologies (including jute/plastic sack which is the most used storage technology in the area).

Futhermore, we find that farmers' loss aversion negatively correlates with their WTP for the improved storage technology and conjecture that this negative relationship has a reference dependent component (farmers who sell immediately after harvest). We argue that this negative relationship is driven by farmers who sell all their marketable surplus maize immediately after harvest; and this category of farmers may consider investing in such a technology as a loss in itself.

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Chapter 3 - Perceptions of Food Safety Risk, Post-Harvest Practices and Intertemporal Staple Crop Allocation: Evidence from Maize in Nepal

3.1 Introduction

Improving food safety is essential for improving food security, which exists when populations have access to sufficient and healthy food (Unnevehr, 2003). The emergence of global and regional supply chains and the renewed emphasis on compliance with food safety standards have spurred a major paradigm shift regarding how the post-harvest system is perceived (The World Bank, 2011). This post-harvest system does not only comprise a series of individual components but an integrated system linking producers and consumers. In many developing countries, demand for better-quality grain has been rare, and usually, the market has not rewarded farmers' efforts to improve quality (The World Bank, 2011). This trend, however, seems to be changing. For example, in Africa, rapid population growth, rising incomes, and rising urban-based food demand is exerting major pressure on food systems to invest in supply chains (Jayne et al., 2018).

Unsafe food contains hazardous agents or contaminants that can increase people's risk of chronic diseases (Unnevehr, 2003). A particularly dangerous fungal contaminant, aflatoxin (a type of mycotoxin),[13] commonly affects maize and causes illness when consumed in large quantities (Hoffmann et al., 2013). Chronic aflatoxin exposure is carcinogenic, linked to growth retardation in children, and can be lethal (Strosnider et al., 2006; The World Bank, 2011). For instance, in

[13] Mycotoxins (e.g. aflatoxins, deoxynivalenol, fumonisims etc.) are produced by fungi, commonly called mold (Unnevehr, 2003).

Kenya, over 150 deaths were reported in 2004 and 2005 resulting from consumption of aflatoxin-contaminated maize. Additionally, mycotoxin contamination may have considerable economic implications: losses for rejected marketable surpluses and lower prices for inferior quality crops which can constrain developing country export markets.

This study seeks to examine whether farmers' perceived-awareness of food safety information affects grain storage duration (before consumption or sale). The study has two main objectives. First, we estimate whether perceptions of food safety risks alter intertemporal allocation of staple crops. Secondly, we examine if the change in intertemporal allocation resulting from perceptions of food safety risks is due to better post-harvest practices. We hypothesize that farmers' perceived awareness of food safety risks will be correlated with prolonged maize storage for intertemporal allocation (either for consumption or sale to take advantage of price arbitrage).

We use a two-round panel data from the Postharvest Loss Innovation Lab (PHLIL) Mycotoxin Awareness Household Survey conducted in the Feed the Future Zone of Influence (FTF ZOI) in Nepal. Overall, 320 respondents were randomly surveyed from four randomly selected districts: Dang, Salyan, Kailali and Dadeldhura. Both survey rounds occurred in 2018. The baseline survey was conducted within the minor production season (March-April) and the follow-up survey was conducted the major production season (October-November). We observed a resampling rate of about 99%. The main variables of interest are length of maize storage (the outcome variable) and farmers' perceived awareness of food safety risks (the key independent variable). The average duration of maize storage in our sample is 17 weeks while about half of the pooled sample were awareness of food safety risks. We further computed a normalized version of the duration of maize storage variable to account for the huge dissimilarity in maize storage duration due to the interval between maize harvest and interview dates. The data also show that at least 80% of the sample engage in various post-harvest practices prior to storage (i.e. drying harvested maize, sorting harvested maize, and cleaning store before storage).

To our knowledge, this study is among the first to study the relationship between perceived food safety awareness and length of maize storage among small-holder maize farmers in a developing country context. Using ordinary least square (OLS), fixed effects (FE), and correlated random effects (CRE) Tobit models, we find that farmers' perceived awareness of food safety risks is associated with prolonged maize storage for intertemporal allocation. Our finding implies that providing farmers with food safety information is likely to enhance storage behavior which will have further implications for optimal intertemporal grain allocation. A further analysis of the data showed no significant correlation between farmers' perceived food safety awareness and post-harvest practices although pre-storage drying and sorting (but not cleaning of store before storage) significantly correlates to shorter duration of maize storage. We conjecture that the manual process of sorting and the huge reliance on sunshine and atmospheric air for drying delays the commencement of storage and may have implications for non-optimal intertemporal allocation of maize as would be the case with improved means for carrying out these post-harvest practices.

In the following, we provide a literature review in Section 3.2 and a conceptual framework for the study in Section 3.3. We then present a description of the data and study design in Section 3.4, the results in Section 3.5, limitations of the study in Section 3.6, and a summary in Section 3.7.

3.2 Literature Review

3.2.1 Food Contamination Observability and Mitigation

Although many countries now regulate mycotoxins by setting maximum tolerable levels (MTLs) in food, these regulations may still be insufficiently protective if intake of the contaminated food is high (Wu et al., 2013). There is evidence that in areas with high maize consumption, MTLs for aflatoxins may not adequately mitigate the health implications of consuming contaminated food (Shephard, 2008; Wu et al., 2013). In Nepal, the MTL for aflatoxin in food intended for human consumption is 20 μg/kg (Thapaliya et al., 2010). The figure is lower than that of India (i.e. 30 μg/kg), the same as that of the US and Kenya, but higher than that the allowable level in the EU and Australia (5 to 10 μg/kg).

The presence of aflatoxins in food (e.g. maize) may be associated with physical kernel damage, compromised taste, and grain discoloration. However, the apparent limited observability of these associated attributes implies that problems of such asymmetric information may not only affect maize consumption but also maize marketing (Hoffmann et al., 2013). The authors state that while the effects of information asymmetries could potentially be mitigated by repeated buyer-seller interactions and reputation effects, the maize market structure is not aligned to the development of strong reputation effects. Using data from Kenya, the authors find that perceptions about food safety risks are high: 93% of their sample perceive a non-zero probability of falling ill through consumption of purchased maize with 30% assigning at least a 50% probability of becoming sick. Further, although respondents generally used visible attributes to infer maize quality, only a third correctly reported that maize of visually high quality could cause sickness.

Maize kernels may become contaminated with mycotoxins through production and harvesting practices, poor post-harvest handling (e.g. inadequate drying, poor sorting and poor storage), and during processing. Since maize is the second most important staple grain in Nepal, accounting for 15% of total cereal consumption (i.e. 45.5 kg/capita/year) (Pokhrel, 2016), even relatively low levels of aflatoxin exposure may have significant health consequences (Shephard, 2008) as well as implications for post-harvest losses.

3.2.2 Nature of PHL and Incidence of Food Contamination in Nepal

Globally, about one-third of food produced for human consumption, amounting to 1.3 billion tons per year, is lost or wasted from initial agricultural production to final household consumption (FAO, 2011). According to the report, per capita food loss in sub-Saharan Africa (SSA) and South/Southeast Asia ranges from 120-170 kg/year while total per capita food produced is 460 kg/year. Food loss or postharvest loss (PHL) volume is equivalent to the annual caloric requirement of 48 million people, estimated USD 4 billion for grains alone, and equal to SSA's annual cereal imports (Sheahan and Barrett, 2017). This poses threats towards attaining the Sustainable Development Goal (SDG) of substantially reducing global food loss by 2030 (Sheahan and Barrett, 2017) and the provision of food to feed the estimated 9.1 billion global population by 2050.

The FAO (2011) reports that food losses occur at five main stages along the food supply chain: i.e. (i) during harvesting (e.g. mechanical damage or spillage); (ii) during postharvest handling (e.g. such as drying, winnowing, packing, and storage); (iii) during processing; (iv) during distribution and marketing; and (v) during consumption (when food fit for consumption is wasted). Food loss estimates vary significantly depending on the particular stage along the food supply chain. In low-income countries, significant volumes of food is lost during the early to middle stages of the food supply chain while losses are more concentrated in the latter stages in high-income countries (FAO, 2011).

In order to mitigate the PHL problem, it is essential to know the actual scale of losses against which to measure the progress towards targets. However, uncertain PHL estimates and imprecise understanding of the points along the supply chain where losses occur could end in policy errors as well as sub-optimal choices of mitigation approaches (Affognon et al., 2015).

Postharvest losses in grains is not only tied to mechanical damage of outer kernels or spillage but also infestation of mold, insects and other pests. Poor pre-harvest handling, delayed harvesting during the minor season, inadequate drying, drying of corn ear on bare ground or other unsuitable materials facilitate pest infestation (Opit et al., 2014).

Exclusive reliance on sunshine and atmospheric air to dry harvested grains is a major problem associated with postharvest handling among smallholder farmers in many low-income countries. Short drying duration (e.g. four to five days) before storage and the lack of knowledge regarding factors of contamination and lack of better storage techniques and infrastructure further worsen the PHL situation in Nepal (Thapaliya et al., 2010). The summer maize harvesting season coincides with the late monsoon when cobs have a relatively high moisture content ranging from 23 percent to 28 percent (Pokhrel, 2016). Grains should be dried to moisture levels lower than those required to support mold growth during storage (usually below 13%–15%) (The World Bank, 2011). Inadequately dried maize become more susceptible to mold growth and may produce aflatoxins that contaminate the maize. In Nepal, the maximum allowable moisture content is 16% for maize (with no less than 10% insect damage). Thapaliya et al. (2010) report that no aflatoxins were detected in maize samples with 13% moisture content. Aflatoxin production may also occur pre-harvest, particularly when stimulated by drought and high temperatures or during prolonged drying (Pokhrel, 2016) as well as during storage.

3.2.3 Consumption Smoothing in Developing Countries

Rural households in developing countries face many risks; and with agriculture being predominantly rain-fed, rainfall-induced production shocks often translate into income shocks and then to negative consumption shocks (Fafchamps et al., 1998; Gao and Mills, 2018; Kazianga and Udry, 2006). Such households adopt several strategies to shield consumption from these risks, including income smoothing, self-insurance, and social insurance arrangements (Kazianga and Udry, 2006). Further, most households protect their consumption from the full effects of the income shocks, but not to the degree required by either a Pareto efficient allocation of risk (within local communities) or by the permanent income hypothesis (over time) (Kazianga and Udry, 2006).

Using a 15-year panel data, Gao and Mills (2018) find a positive relationship between rainfall and per adult equivalent consumption, while high temperatures are negatively associated with household consumption in rural Ethiopia. The authors provide evidence that formal social safety net transfers mitigate the impact of adverse rainfall shocks on consumption and off-farm employment mitigates the impact of high-temperature shocks. While net grain stock savings is important for smoothing seasonal consumption, Kazianga and Udry (2006) find very little evidence of this in rural Burkina Faso. A much referenced coping strategy for smoothing consumption is livestock holdings or sales. As expected, livestock holdings positively impact consumption in the presence of pronounced seasonality (Gao and Mills, 2018; Islam and Maitra, 2012). However, Fafchamps et al. (1998) and Kazianga and Udry (2006) indicate that livestock transactions have little effect on consumption smoothing in West Africa. While livestock sales compensate for between 15% to 30% of income shortfalls resulting from village-level shocks

(Fafchamps et al., 1998), the extent to which livestock price dynamics affect sale decisions is a source of concern (Kazianga and Udry, 2006).

Several studies on consumption smoothing reach the conclusion that wealthier households have better insurance against income shocks in general and health or illness shocks in particular (see Fafchamps et al., 1998; Islam and Maitra, 2012). This confirms the important role access to credit could play in insuring consumption against income shocks potentially due to production risks among poor households. Using data from rural Bangladesh, Islam and Maitra (2012) report that credit from microfinance institutions play an essential role in the daily life of households and the no collateral requirement for microcredit loans ensure that poor households can access loans more easily. Further, households' access to microcredit or microfinance enhance income diversification and free up other sources of financing that can be used to directly smooth consumption. However, commercial credit facilities in developing countries are often weak and provide inadequate service to the poor (Islam and Maitra, 2012).

But how do households insure against idiosyncratic health shocks? Do these shocks impact consumption smoothing?

3.3 Conceptual Framework

The problem of seasonality is repetitive and characterizes many agricultural production systems: particularly those that are rainfall reliant (as with Nepal). To adapt to this problem, farm households may have to transfer resources inter-temporally either through storage (non-cash transfer) or selling immediately after harvest for later use of cash (cash transfer).

The seasonal nature of crop production is characterized by frictions: difficulty in borrowing against future harvests, use of poor storage methods, and seasonal price variation (Basu and Wong, 2015). These seasonal frictions skew household consumption away from the lean season and limit annual consumption possibilities. Also, upon harvest, households may face food safety risks with stored maize due to pertaining storage conditions likely to expose maize to mycotoxin contamination.

The theoretical framework follows propositions and notations of Basu and Wong (2015). The authors assume consumption of staple food ($\boldsymbol{m}$) and a non-food numeraire good ($\boldsymbol{c}$) over a harvest period ($\boldsymbol{H}$) and a lean period ($\boldsymbol{L}$). They further assume an additively separable utility function in period $\boldsymbol{t}$ as shown in Equation (1).

$$U_t = u_{m,t}(m_t) + u_{c,t}(c_t) \tag{1}$$

where $u_{m,t}$ is twice differentiable and strictly concave with no corner solutions ($\mathrm{i.e.}\, u'_{i,t}(0) = \infty$). During the harvest period a farmer harvests $\boldsymbol{X}$ kg of maize to be allocated to consumption between $\boldsymbol{H}$ and $\boldsymbol{L}$. The allocated asset amount is divided across staple and non-food good within the production season. We denote $\boldsymbol{M_H}$ and $\boldsymbol{M_L}$ as amounts of endowment in the harvest and lean periods respectively. The price of the numeraire good is 1 whereas that of the staple crop within period $\boldsymbol{H}$ and $\boldsymbol{L}$ are $\boldsymbol{p_H}$ and $\boldsymbol{p_L}$ respectively.

The farmer maximizes Equation (2) subject to Equation (3).

$$\max_{M_H \in [0,X]} V_H(M_H) + V_L(M_L) \tag{2}$$

$$s.t.\, M_L = \eta(X - M_H) \tag{3}$$

Equation (3) represents the farmer's inter-seasonal budget constraint and $\boldsymbol{\eta}$ is the marginal rate of transformation (MRT) of harvested maize from harvest period to lean period. The MRT ($\boldsymbol{\eta}$) depends on the household's choice of storage technology used to transfer maize across the two periods and more so on the maize retention rate of the technology. $\boldsymbol{V_H}(\boldsymbol{M_H})$ and $\boldsymbol{V_L}(\boldsymbol{M_L})$ represent maximized indirect utility functions (Equation 4) subject to their respective budget constraint (Equation 5). So at any period t, $\boldsymbol{V_t(M_t)}$ is:

$$\max_{m_t \in [0, M_t]} u_{m,t}(m_t) + u_{c,t}(c_t) \tag{4}$$

$$s.t.\ c_t = p_t(M_t - m_t) \tag{5}$$

If the household chooses to store maize against lean season consumption, then the MRT ($\boldsymbol{\eta}$) of maize between both seasons will be equal to the retention rate ($\boldsymbol{\gamma}$) on the stored maize; and this may be affected by the effectiveness of the storage medium and level of aflatoxin contamination. Here, we conceive $\boldsymbol{M_t}$ as the net of maize adjusted for quality. However, if the household decides to save in cash against lean season consumption, then $\boldsymbol{\eta}$ will equal the ratio of harvest season to lean season prices $\left(\frac{\boldsymbol{p_H}}{\boldsymbol{p_L}}\right)$. Since the decision to store happens during the harvest period, the household will choose to store good quality grains using a technology with the highest marginal rate of transformation, such that $\boldsymbol{\eta = max\left\{\gamma, \frac{p_H}{p_L}\right\}}$. The first order conditions from the utility maximization problem is presented in Equation (6):

$$u'_{m,H}(m_H) = (\eta)u'_{m,L}(m_L) = (p_H)u'_{c,H}(c_H) = (p_H\eta)u'_{c,L}(c_L) \tag{6}$$

Thus, $\boldsymbol{\eta} = 1$ is the case without seasonality, whereas the existence of seasonality implies that $\boldsymbol{\eta} < 1$ as is the case in Nepal.

We extend the theoretical framework of Basu and Wong (2015) by introducing the concept of perceived food safety awareness into the model. Specifically, we argue that there is some level of uncertainty or ambiguity surrounding the retention rate of quantity of maize to be stored for inter-temporal allocation. Also, since the MRT depends on the retention rate, a higher uncertainty about the latter affects the former and subsequently the amount of endowment in the lean season (i.e. M_L). We conjecture that a higher uncertainty about the retention rate would lower the length of maize storage or the actual amount under storage in order to avoid mycotoxin contamination.

Since risk averse agents may give up some uncertainty payoffs, we hypothesize that if households are aware of food safety risks then the variation of the retention rate ($\boldsymbol{\gamma}$) would be narrower and they would choose to store higher amounts of maize in the production season, ceteris paribus. This implies that: $\partial M_L^* / \partial \sigma_\gamma < 0$.

where M_L^* is the optimal endowment of maize in the lean period and σ_γ is the standard deviation of the retention rate of maize in storage. The inequality expression above implies that higher perceived retention rates (would enhance the MRT) and lead to larger endowments of maize for use in the lean period: i.e. the lower the uncertainty about the retention rate the higher the amount stored for inter-temporal allocation in the lean season.

The household solves the following utility maximization problem (Equation 7):

$$\max_{M_L} U(M_H) + \beta V[\mu(M_L), \sigma(M_L)] \quad s.t\ M_H + M_L = X \tag{7}$$

where $U(M_H)$ is the utility function for quantity of maize consumed, V(.) is the indirect utility for maize stored expressed implicitly as a function of its mean ($\boldsymbol{\mu}$) and standard deviation ($\boldsymbol{\sigma}$). The standard deviation is an indication of the uncertainty regarding lean period endowment. The household maximizes the amount of maize endowment allocated to the lean season ($\boldsymbol{M_L}$) subject to the total maize endowment at harvest ($\boldsymbol{X}$). We substitute in the maize endowment constraint and derive the first order condition in Equations (8) and (9) respectively:

$$\max_{M_L}\ U(X - M_L) + \beta V[\mu(M_L), \sigma(M_L)] \tag{8}$$

$$F = -\,U'(X - M_L) + \beta \left\{ \frac{\partial V}{\partial \mu} . \underbrace{\frac{\partial \mu}{\partial M_L}}_{\mu_L} + \frac{\partial V}{\partial \sigma} . \underbrace{\frac{\partial \sigma}{\partial M_L}}_{\sigma_L} \right\} \to 0 \tag{9}$$

$$F = -\,U' + \beta\left\{\frac{\partial V}{\partial \mu}.\mu_{\gamma} + \frac{\partial V}{\partial \sigma}.\sigma_{\gamma}\right\} \quad (9)'$$

From the implicit function theorem (in Equation 10), we show that lower uncertainty regarding the retention rate of maize in storage will increase the amount of maize available for intertemporal allocation.

$$\partial M_L^* \big/ \partial \sigma_{\gamma} = -\,\frac{\partial F / \partial \sigma_{\gamma}}{\partial F / \partial M_L} \quad (10)$$

$$\partial F \big/ \partial M_L = \underbrace{U''}_{<\,0} + \beta\left\{\underbrace{\frac{\partial^2 V}{\partial \mu \partial M_L}}_{<\,0}.\mu_{\theta} + \underbrace{\frac{\partial^2 V}{\partial \sigma \partial M_L}}_{<\,0}.\sigma_{\theta}\right\} \rightarrow \partial F \big/ \partial M_L < 0 \quad (11)$$

In Equation (11), we show that the denominator of the right-hand-side expression in Equation (10) is unambiguously negative. To prove that Equation (10) is negative and meets our objective, we must show that the numerator in negative.

Considering the denominator: $\partial F \big/ \partial \sigma_{\gamma} = \beta\left\{\underbrace{\frac{\partial^2 V}{\partial \mu \partial \sigma_{\gamma}}}_{<\,0}.\mu_{\gamma} + \underbrace{\frac{\partial V}{\partial \sigma}}_{<\,0} + \underbrace{\frac{\partial^2 V}{\partial \sigma_{\gamma}^2}}_{<\,0}.\sigma_{\theta}\right\}$ (12)

By the concavity of $V[\mu(M_L), \sigma(M_L)]$, $\frac{\partial^2 V}{\partial \mu \partial \sigma_{\theta\gamma}} < 0$, $\frac{\partial V}{\partial \sigma} < 0$, and $\frac{\partial^2 V}{\partial \sigma_{\theta}^2} \leq 0$ for all μ and all $\sigma > 0$ (Meyer, 1987). By extension, Equation (12) is negative, making $\partial M_L^* \big/ \partial \sigma_{\gamma} < 0$.

In summary, we consider a usual case where farmers choose quantity of harvests to be allocated over harvest and lean periods. Drawing from the seasonal friction model of Basu and Wong (2015), we show that a reduction in the standard deviation associated with the retention rate is likely to increase the amount of grain endowment for the lean season. This implies that perceived awareness of food safety risks lowers the uncertainty of retention rates (i.e. increases retention rates) and prolongs maize storage.

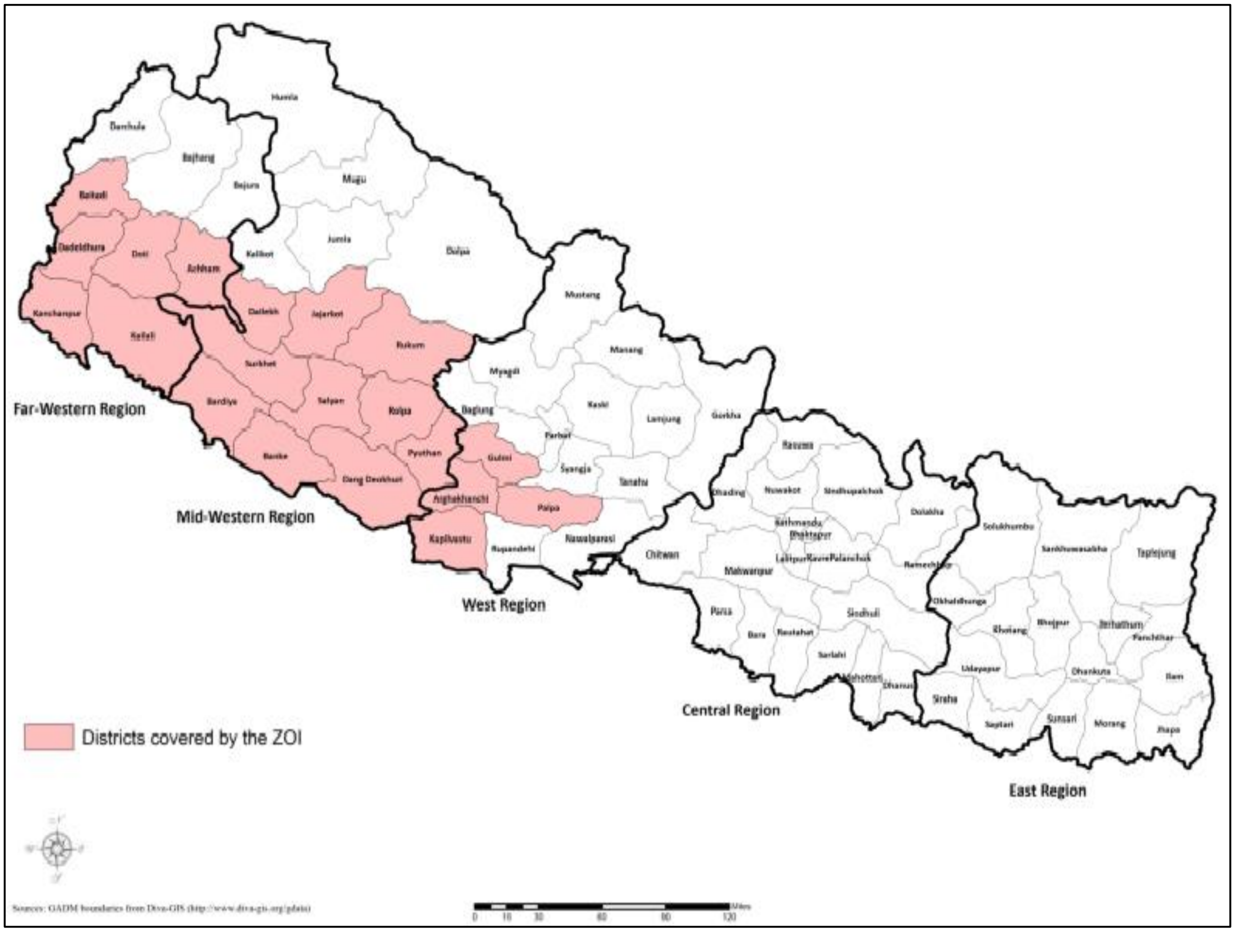
3.4 Study Design and Data

This study uses two rounds of panel data from the Postharvest Loss Innovation Lab (PHLIL) Mycotoxin Awareness Household Survey in Nepal. The survey was conducted in the Feed the Future Zones of Influence (FTF ZOI) and both rounds were conducted in 2018 (see Figure 3.1). The first-round survey was conducted within the minor production season (March-April), a period characterized by a dry spell with low rainfall, while the second survey round was conducted within the major production season (October-November).

The survey was conducted in four randomly selected districts: Dang, Salyan, Kailali and Dadeldhura. From each district, two local units were randomly selected and two wards were later per local unit. Every ward was divided into four quadrants and five households were randomly selected per quadrant. Thus, 20 households were surveyed per ward (i.e. 40 households per local unit or 80 households per district). Overall, a total of 320 households were randomly sampled in the first survey round. Six months after conducting the baseline survey, the second-round survey was conducted and both events are separated by the major maize producing season. From the 320 households in the baseline sample, about 317 were re-interviewed indicating a high resampling rate of about 99%. The structured questionnaire administered to each household during the survey collected information on household demographics, knowledge on aflatoxin and food safety awareness, assets, credit, postharvest practices, and sales practices.

The outcome variable of interest in this study is the duration of maize storage whereas the key independent variable is household's perceived awareness of food safety risks associated with aflatoxin contamination. Through the administered questionnaire, household provided storage information from which we computed the duration of maize storage by summing the number of days after harvest at which actual maize storage commenced and the length of storage from that date. We then standardized the outcome by converting to weeks. Our independent variable of interest is binary and indicates household's self-reported awareness of food safety risks.

Figure 3.1: Map of Nepal with Feed the Future Zone of Influence



Source: FTFZOI Baseline Report.[14]

Table 3.1 presents the descriptive statistics of our sample over both rounds of the survey. Panel A shows statistics on some postharvest practices. The average duration of maize storage for a household is about 9 weeks and 26 weeks for rounds one and two respectively. A potential source of the difference in the magnitude of storage duration is timing of each of the survey rounds:

[14]Feed the Future FEEDBACK (2013). Feed the Future Nepal Zone of Influence Baseline Report (Rockville, MD: Westat).

interval between maize harvest date and the household interview date. We computed a normalized version of the duration of maize storage variable to account for the huge difference in maize storage duration using the interval between maize harvest and interview dates. In both rounds, households provided production information from the immediate past production period. On average, the majority of the households dried their harvested maize after harvest, about 92% in round one compared to about 73% in round two, while 86% and 80% sort graded maize over the respective rounds. Further, nearly all households clean store rooms before storing maize over both rounds.

Panel B presents household sales practices and shows that maize sale is very low. On average, about 12% and 15% of the sample sell maize over the respective rounds. Furthermore, the start and finish dates for maize sale are higher in round one compared to round two although the sample size is lower for both rounds. On average, maize sales start three months after harvesting and ends within the fourth month after harvest. Marketing during this period is characterized by low prices due to influx of maize in village, local, or regional markets. In a study on postharvest loss reduction in eastern Tanzania, Chegere (2018) considers maize marketing within a few months after harvest to be too early. However, early sales might be used as a strategy to get rid of excess maize in the case of inadequate or poor storage infrastructure to avoid storage losses (Sheahan and Barrett, 2017). Farmers facing the prospect of losing much grains under storage such as may affect their consumption needs and income from sale of low quality or reduced quantity due to losses may sell during the harvest period as a coping mechanism against such losses.

Panel C presents some figures on food safety awareness. On average, about 33% of the sample in round one and 67% in round two are aware of fungal contamination while about 24% and 52% of the sample in the respective rounds are aware of negatives effects of aflatoxin contamination on human and animal health. Also, less than 20% of the sample evaluate their households as very healthy in both survey rounds.

From Panel D, less than half of the respondents are male, about 41 years of age, and at least half have formal education. Also, about 70% of the sample have agriculture as their main occupation, consume an average of 11 kg of maize per month, and spend nearly NPR 6000 per month on food. Overall, about 12% of the sample are food insecure: Gartuala et al. (2017) provides a similar characteristic of low food insecurity among farmers in the Kaski district in the mid-hills of Nepal. This notwithstanding, Nepal faces several complex challenges towards achieving food and nutrition security.

Table 3.1: Descriptive Statistics for Key Variables by Round

Variable	Round 1 N	Round 1 Mean	Round 1 Std. Dev.	Round 2 N	Round 2 Mean	Round 2 Std. Dev.
Panel A: Post-harvest Practices						
Maize storage date (weeks after harvest)	267	4.55	7.48	283	1.21	1.25
Length of maize storage (weeks)	267	9.13	14.08	282	26.28	15.84
Length of maize storage (normalized)	267	0.21	0.23	282	0.46	0.26
Dried maize after harvesting (1=yes, 0=no)	310	0.92	0.28	289	0.73	0.45
Maize drying date (days after harvest)	283	1.94	2.30	210	1.04	0.71
Duration of drying (days)	284	6.17	5.59	210	6.06	5.04
Sort grade maize (1=yes, 0=no)	310	0.86	0.35	289	0.80	0.40
Maize sorting date (days after harvest)	266	7.50	6.67	230	11.79	33.72
Duration of sorting (days)	266	8.59	22.75	230	1.97	1.19
Clean store before storing (1=yes, 0=otherwise)	320	0.91	0.28	320	1.00	0.06
Panel B: Sales practices						
Sell maize (1=yes, 0=no)	310	0.12	0.33	289	0.15	0.35
Maize sales start date (weeks after harvest)	37	12.62	13.53	42	10.17	6.94
Maize sales finish date (weeks after harvest)	37	14.16	19.51	42	13.90	8.25
Share of maize sales	37	0.64	0.81	42	3.00	5.11
Panel C: Food Safety Awareness						
Awareness of fungal contamination (1=yes, 0=no)	320	0.33	0.47	320	0.67	0.47
Awareness of negative effects (1=yes, 0=no)	320	0.24	0.43	320	0.52	0.50
Self-evaluation of food safety awareness						
Not aware	320	0.30	0.46	320	0.03	0.18
Indifferent	320	0.25	0.44	320	0.27	0.44
Aware	320	0.25	0.43	320	0.49	0.50
Very aware	320	0.16	0.37	320	0.19	0.39
Self-evaluation of Household health status						
Not aware	320	0.34	0.47	320	0.06	0.24
Indifferent	320	0.29	0.45	320	0.31	0.46
Aware	320	0.29	0.46	320	0.56	0.50
Very aware	320	0.03	0.17	320	0.06	0.24
Panel D: Socioeconomic characteristics						
Sex of respondent (1=male, 0=female)	320	0.40	0.49	320	0.33	0.47
Age of respondent (years)	320	41.32	15.46	320	41.76	14.90
Education (1=formal, 0=otherwise)	320	0.53	0.50	320	0.54	0.50
Occupation (1=agriculture, 0=otherwise)	320	0.75	0.43	320	0.69	0.46
Household maize consumption (kg/month)	182	13.16	13.76	258	8.04	9.46
Household food expenditure (NPR/month)	320	6045.94	3978.97	320	5407.85	3045.96
Household food insecurity (1=yes, 0=no)	320	0.15	0.35	320	0.09	0.29

Source: Author's computation from household survey

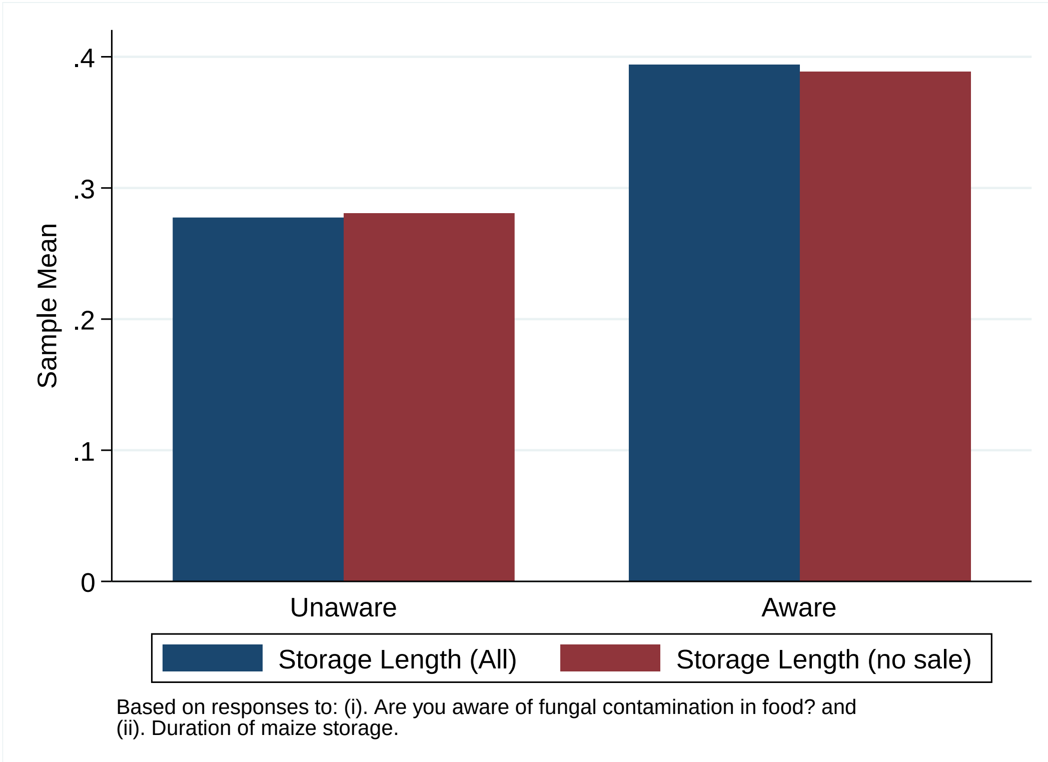
3.5 Results

3.5.1 Empirical Strategy

The storage literature outlines several options for reducing postharvest losses although their adoption remains low especially in developing countries. These options include the use of better postharvest practices as well as the adopting loss-mitigating technologies. The major barriers to rapid adoption of such technologies are numerous and include: household liquidity constraints, credit market constraints and incomplete insurance (Feder et al., 1985; Foster and Rosenzweig, 2010; Karlan et al., 2012); familiarity with technology and respondents' desirability of product attributes (De Groote et al., 2011); and heterogeneity in financial and nonfinancial returns to the technology (Foster and Rosenzweig, 2010; Suri, 2009). Furthermore, adoption of new technologies can be constrained by inadequate incentives associated with farm tenure arrangements, insufficient human capital, chaotic supply of complementary inputs (e.g. seed, water, and chemicals), inappropriate transportation infrastructure, and aversion to risk (Feder et al., 1985).

In the case where these barriers have been addressed, what role would household's perceived awareness of food safety risks play on the duration of maize storage? Our data shows that generally, households who are aware of food safety risks store maize for longer periods (see Figure 3.2). The figure further shows that the scenario remains the same with the exclusion of farmers who sold any marketable surplus within the season in retrospect. From this descriptive point, we observe that food safety awareness may have a positive association with duration of maize storage.

Figure 3.2: Food Safety Awareness and Length of Maize Storage



Source: Author's computation from household survey

We go further to test the suggested association between perceived food safety awareness and length of maize storage using empirical analyses. Determining the effect of perceived food safety awareness on length of maize storage may be complicated by several factors, including household's food insecurity statutes; household composition, consumption and food expenditure; education statuses of household members responsible for post-harvest decisions especially storage; and some unobserved variables like the actual degree or extent of food safety knowledge.

To analyze this relationship, we employ three different models with either survey-collected length of maize storage (in weeks) or the normalized version of this variable (computed by dividing weeks of maize storage by the interval between maize harvest and interview date) as outcome variables.

First, we specify an ordinary least square (OLS) model using the actual and normalized versions of length of maize storage as dependent variables and perceived awareness of food safety risks as the main independent variable (Equation 13).

$$Storelen_i = \alpha_0 + \alpha_1 AWARE_i + X'\delta + \varepsilon_i \qquad (13)$$

where $\boldsymbol{Storelen_i}$ is length of maize storage by respondent *i*, and $\boldsymbol{AWARE_i}$ indicates self-stated food safety awareness of respondent *i*. The notation $\boldsymbol{X}$ represents a vector of control variables: i.e. respondent characteristics (sex, age, education, and occupation) and household characteristics (average quantity of maize consumed by household, household food expenditure, household food insecurity, and whether household sold any maize). α_1 is our coefficient of interest while ε_i is the idiosyncratic error term.

Some key issues may complicate the OLS model above. The model deals with pooled respondents across the baseline and follow-up surveys but ignores household and survey-round heterogeneity. Thus, we specify a second model, the fixed effects model, to estimate the relationship between the versions of the outcome variable and key independent variable focusing on household and survey-round fixed effects (Equation 14). The identifying variation here is based on changes in awareness across rounds.

$$Storelen_{ir} = \alpha_0 + \alpha_1 AWARE_{ir} + X'\delta + \xi_i + \lambda_r + \varepsilon_{ir} \qquad (14)$$

where $\boldsymbol{\xi_i}$ and $\boldsymbol{\lambda_r}$ denote individual households and survey-round fixed effect respectively.

Finally, we analyze the relationship between the normalized version of length of maize storage and perceived awareness using a Correlated Random Effect (CRE) Tobit model. This approach is used for two reasons. First, normalizing the dependent variable introduces right censoring. For a linear regression model, $y = X'\beta + \varepsilon$, censoring leads to observed dependent variable (y) that has distribution with conditional mean other than $X'\beta$, conditional variance different from σ^2 despite ε being homoscedastic, and a non-normal distribution even if ε is normally distributed (Cameron and Trivedi, 2005). Secondly, fixed effects specifications are incompatible with the Tobit model, so we used the CRE Tobit model which addresses the censoring issue in the dependent variable. The CRE approach is complementary to fixed effects/bias adjustment approaches, and applies in situations with short panels, arbitrary time heterogeneity, and arbitrary time dependence (Wooldridge, 2018). The author shows that for the linear model with additive heterogeneity (i.e. $y_{it} = \phi + X_{it}\beta + u_{it}$), the fixed effects estimator can be computed as a pooled OLS estimator using the original data and time averages of the covariates as additional regressors (this approach can be used in both balanced and unbalanced panels). The resulting equation to be estimated would be $y_{it} = \varphi + X_{it}\beta + \bar{X}_i\psi + v_{it}$ and the general result implies that the coefficient vector $\widehat{\boldsymbol{\beta}}$ is identical to the fixed effects (within) estimator on the unbalanced panel.

In our case, we include averages of the main independent variable ($AWARE_i$) and all other control variables in the model in Equation (15) as follows:

$$Storelen_{ir} = \alpha_0 + \alpha_1 AWARE_{ir} + X'\delta + \overline{W}'\zeta + \varepsilon_{ir} \tag{15}$$

where $\overline{W}$ denotes a vector of the averages of all covariates including from Equation (3) including the main independent variable ($AWARE_{ir}$).

3.5.2 Relationship Between Perceived Awareness and Intertemporal Allocation

All the three estimated models indicate positive and significant relationship between perceived food safety awareness and length of maize storage (Table 2). Compared with the OLS estimator, the fixed effects (FE) model shows a higher magnitude for the relationship; as does the CRE Tobit model.

In Columns (1) and (2), we show that respondents' perceived awareness of food safety risks, on average, increases the length of maize storage by about seven weeks and ten weeks respectively compared to other respondents. The similarity of the results in both the OLS an FE models suggests an absence of reverse causality in which case farmers' experience with prolonged storage also determines perceived awareness of food safety risks. Food safety concerns have received heightened attention worldwide due to the increasing recognition of the important links between food and health (Unnevehr, 2003). Our finding implies that providing farmers with food safety information may enhance storage behavior which will have further implications for optimal intertemporal grain allocation.

While respondents' age and education status does not influence length of maize storage, respondents whose main occupation is farming have store for longer periods on average. From the data, we notice that respondents contribute to households' decisions on post-harvest practices or have the sole responsibility for such decisions (including storage). The results show that male respondents responsible for storage store maize for shorter durations compared; however, this relationship is significant only under the FE estimation in column (2). Furthermore, that additional quantities of maize consumed by households has negative and significant relationship with length of maize storage. Typically, depleting available maize stock through consumption reduces duration of storage for intertemporal grain allocation and may also affect quantities of maize stored.

Household food expenditure significantly correlates with prolonged maize storage. This may be the case because the majority of our sample are female farmers who more likely are responsible for many such household decision concerning food. A recent study shows that the current agrarian transition in Nepal has transformed women's roles from mere agricultural coworkers to de facto household decision-makers (Gartaula et al., 2017). In many developing countries, food purchases represent an overwhelming share of household expenditures and preferences are widely believed to differ systematically between men and women (Bellemare et al., 2013; Hoffmann et al., 2009). Using evidence from Cote d'Ivoire, Hoddinott and Haddad (1995) show that a larger share of income in the hands of women is correlated with higher household expenditures on food.

Additionally, food insecurity is significantly correlated with shorter length of maize storage. On average, food insecure households lower the duration of maize storage by about seven weeks and ten weeks per the results from the respective OLS and FE models in Columns (1) and (2). According to Gartuala et al. (2017), farmers' limited food supply from own production for year-round consumption is compensated for by food purchases. However, Nepal faces serious challenges in achieving food and nutrition security, despite spatial differences. We also notice that there is no significant correlation between maize sale and duration of maize storage although the direction is negative in but column (2).

The coefficient significance and signs are similar for Columns (3) to (5) and follow from the discussion of Columns (1) and (2).

Table 3.2: Relationship Between Food Safety Awareness and Length of Maize Storage

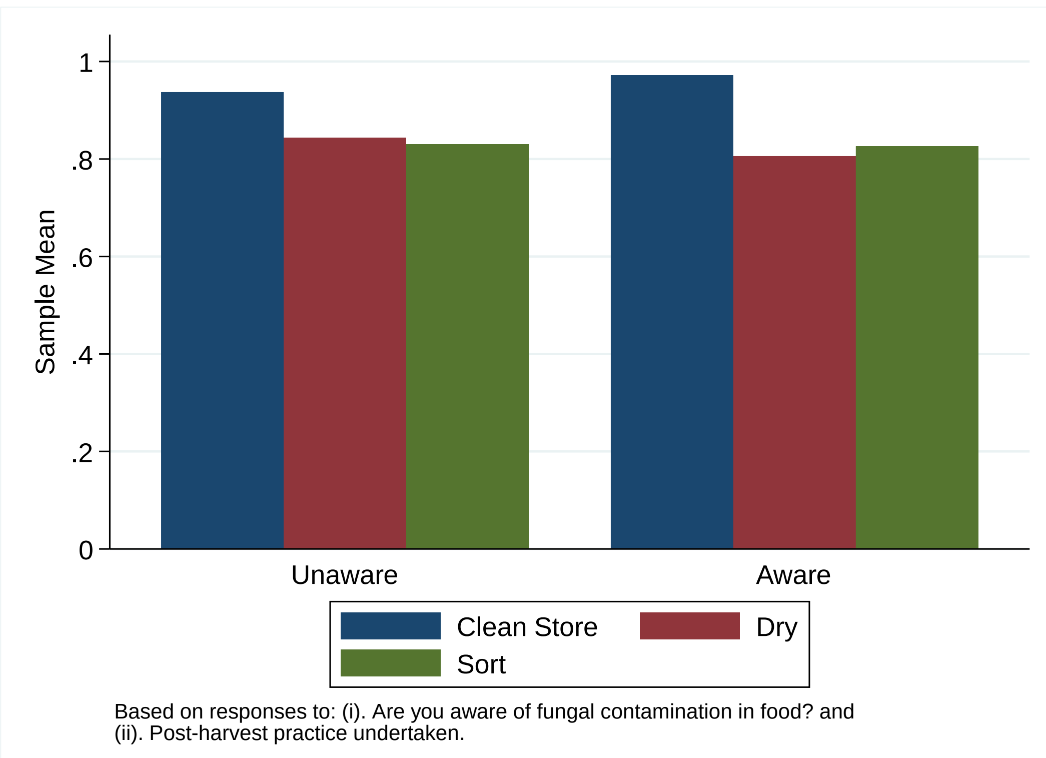
	Storage length (weeks)		Storage length (normalized)		Storage length (normalized)
	OLS.	FE	OLS.	FE	Tobit (CRE)
	(1)	(2)	(3)	(4)	(5)
AWARE	7.1773	9.6625	0.0809	0.1492	0.1911
	(1.5800)***	(2.3185)***	(0.0272)***	(0.0386)***	(0.0353)***
Sex of respondent	-2.9962	-6.7611	-0.0148	-0.0228	0.0055
	(1.8880)	(3.2421)**	(0.0324)	(0.0553)	(0.0476)
Age of respondent	0.0964	0.0943	0.0002	-0.0028	-0.0017
	(0.0682)	(0.1153)	(0.0012)	(0.0020)	(0.0018)
Education	2.4743	1.7689	0.0104	-0.0758	-0.0596
	(2.0030)	(3.2521)	(0.0344)	(0.0602)	(0.0509)
Occupation	6.3695	6.9530	0.1142	0.1372	0.1017
	(1.8273)***	(3.8088)*	(0.0314)***	(0.0617)**	(0.0478)**
Maize consumed	-0.3420	-0.6493	-0.0055	-0.0104	-0.0109
	(0.0658)***	(0.0941)***	(0.0011)***	(0.0021)***	(0.0018)***
Food expenditure	0.0005	0.0009	0.0000	0.0000	0.0000
	(0.0002)**	(0.0004)**	(0.0000)**	(0.0000)**	(0.0000)***
Food insecurity	-7.1082	-10.0193	-0.1229	-0.1775	-0.1473
	(2.6257)***	(4.0175)**	(0.0449)***	(0.0627)***	(0.0595)**
Sell maize	-2.2511	1.8855	-0.0434	-0.0234	0.0143
	(2.2364)	(4.1761)	(0.0382)	(0.0812)	(0.0568)
Constant	5.3326	6.7012	0.2458	0.3971	
	(4.0558)	(6.4148)	(0.0694)***	(0.1143)***	
R^2	0.16	0.31	0.13	0.29	
Observations	407	407	401	401	401

Notes: AWARE is perceived food safety awareness variable (1=respondent is aware of fungal contamination in food; 0=otherwise). Standard errors are in parenthesis. * p<0.1; ** p<0.05; *** p<0.01

3.5.3 Relationship Between Perceived Food Safety Awareness and Post-Harvest Practices

From the previous section, we observe a difference significant difference in length of maize storage between households whose respondents (mainly responsible for storage decisions) are aware of food safety risks and those otherwise. We further the analysis to examine the potential drivers of the difference and whether perceived awareness of food safety risks affects post-harvest practices. We notice that post-harvest practices (i.e. drying maize, sorting maize, and cleaning store before storage) are similar for respondents who are aware of food safety risks and those who are unaware (Figure 3.3). These are standard practices carried out after harvest to avoid mold growth or insect infestation and to subsequently reduce associated losses.

Figure 3.3: Food Safety Awareness and Postharvest Practices



Source: Author's computation from household survey

For the regression analysis, we use a Linear Probability Model (LPM) and a Fixed Effects (FE) estimation to estimate the relationship between perceived food safety awareness and the aforementioned post-harvest practices (i.e. maize drying and sorting, and storeroom cleaning before storage). For this estimation, all three regressands are individual indicator variables in the model:

$$PHpract_i = \theta_0 + \theta_1 AWARE_i + X'\gamma + \nu_i \tag{16}$$

where $PHpract_i$ indicates post-harvest practice (drying; sorting; clean store) for household i; *AWARE* is the indicator variable for perceived food safety awareness; and *X* is a vector of control variables including respondent's sex, age, education, and occupation, and household's maize consumption, food expenditure, food insecurity, and maize sale.

In Table 3.3, we present the results from the LPM and FE estimations of equation (16) to explain the potential effect of perceived food safety awareness and post-harvest practices in the study area. The results, Columns (1) to (6), show no significant relationship between the dependent and independent variables. For smallholder farmers with limited options to invest in improved post-harvest practices and technologies, the simplest option—with only minor financial implications—is improvement in basic storage hygiene and good storage management (The World Bank, 2011). The report further states that although this principle is well documented by many studies, they are often not applied by farmers. This implies that without better information about food safety risks, the problem of food contamination and its effect on intertemporal allocation of staple crops may remain or perhaps worsen. Therefore, there is the need for strengthening the research-extension link to provide extension officers and farmers with access to updated information on post-harvest management and the provision of feedback to research (The World Bank, 2011). Such a partnership will provide opportunities for improved post-harvest management, an understanding of the barriers to these improvements, as well as possible options overcoming these barriers.

Table 3.3: Relationship Between Food Safety Awareness and Post-Harvest Practices

	CLEAN STORE		DRY MAIZE		SORT MAIZE	
	LPM	FE	LPM	FE	LPM	FE
	(1)	(2)	(3)	(4)	(5)	(6)
AWARE	0.0170	-0.0468	-0.0266	-0.0356	-0.0137	-0.0469
	(0.0187)	(0.0384)	(0.0370)	(0.0568)	(0.0364)	(0.0566)
N	424	424	424	424	424	424

Notes: AWARE is food safety awareness variable (1=respondent is aware of fungal contamination in food; 0=otherwise). All regressions are controlled by respondent characteristics (sex, age, education, and occupation) and household characteristics (average quantity of maize consumed by household, household food expenditure, household food insecurity, and whether household sold any maize). Standard errors are in parenthesis. * $p<0.1$; ** $p<0.05$; *** $p<0.01$

3.5.4 Relationship Between Post-Harvest Practices and Length of Maize Storage

In this sub-section, we examine the relationship between length of maize storage and three main post-harvest practices (i.e. drying and sorting maize as well as cleaning store before storage). In Table 4, we present results from the estimation of fixed effects and CRE Tobit specifications of the following equation:

$$Storelen_i = \tau_0 + \tau_1 CLEANSTO_i + \tau_2 DRY_i + \tau_3 SORT_i + X'\delta + \epsilon_i \qquad (17)$$

where *CLEANSTO* is an indicator variable denoting whether respondent cleans store before storing maize; *DRY* refers to whether respondent dries maize; *SORT* indicates respondents sorting of maize before storage; and *X* is a vector of control variables as in the previous regression equations stated in this section.

The results show that cleaning before storage has a mixed but insignificant effect on length of maize storage. Our *a priori* expectation was to observe a positive and significant correlation due to the fact that nearly all respondents engage in this post-harvest practice which has the tendency of minimizing the effect of biological and environmental factors on maize contamination and deterioration. Good storage hygiene is an important element in ensuring grain quality and reducing post-harvest losses during storage (The World Bank, 2011). Thus, non-adherence to store hygiene principles may require increased expenditure on storage chemicals to treat grains in storage in order to prevent insect infestation which is likely to induce aflatoxin contamination.

Additionally, drying significantly correlates with shorter length of maize storage length especially due to unsuitable weather conditions. In Nepal (as in other developing countries), drying maize after harvest is hugely reliant on sunshine and atmospheric air and so a limitation in either poses challenges for reaching required moisture contents for maize. As noted in section two, summer maize harvesting in Nepal overlaps with the rainy season at a point when moisture content ranges from 23% to 28%; about 7 to 12 percentage points higher than the national maximum allowable moisture content for maize. Additionally, since maize shelling is mainly a manual activity, farmers may prefer harvesting at lower moisture contents to ease the process; as a result, maize may be left in the field for an extended period of time than necessary. These phenomena interfere with appropriate drying and have implications for maize contamination through mold growth, especially when less dried maize is kept in storage, and insect attack even before storage. Thapaliya et al. (2010) report that short pre-storage drying duration coupled with lack of knowledge about the determinants of grain contamination and lack of better storage techniques or infrastructure worsen the post-harvest situation in Nepal. Exposing grains to heat treatment could have very beneficial effects, although to date the application of this process has been limited to pulses (The World Bank, 2011). The report further states that proper drying in humid regions is a critical constraint to postharvest improvements; drying cannot be managed with proper handling or management practices alone, but in combination with cost-effective drying systems and business models that create incentives to farmers for investments in proper drying technologies.

The results also show that sorting marginally reduces length of maize storage (columns 2 and 3). Grain sorting, carried out right before storage, is typically a manual process which may take about five days to complete ahead of actual storage of maize commences. Careful sort grading is essential as it helps to separate low quality grains resulting from physical damage or aflatoxin contamination. Contaminated maize is significantly less likely to be consumed as food by household as such maize is more likely to be used as an input for alcoholic beverage production, used as livestock feed, or sold (Hoffmann et al., 2013).

Table 3.4: Relationship Between Post-Harvest Practices and Length of Storage

	Fixed Effect		Tobit (CRE)
	Storage length (weeks)	Storage length (normalized)	Storage length (normalized)
	(1)	(2)	(3)
CLEANSTO	1.5111	0.0727	-0.0274
	(4.0673)	(0.1158)	(0.0868)
DRY	-16.8379	-0.2385	-0.2496
	(3.5579)***	(0.0588)***	(0.0508)***
SORT	-4.7104	-0.1146	-0.1112
	(3.9157)	(0.0634)*	(0.0511)**
N	407	401	401

Notes: CLEANSTO (1=clean store before storage; 0=otherwise); DRY (1=dried maize after harvesting; 0=otherwise); SORT (1=sort graded maize after harvest). All regressions are controlled by respondent characteristics (sex, age, education, and occupation) and household characteristics (average quantity of maize consumed by household, household food expenditure, household food insecurity, and whether household sold any maize). Standard errors are in parenthesis. * $p<0.1$; ** $p<0.05$; *** $p<0.01$

3.6 Study Limitations

We are aware that timing of the study is important and may have had some implications on the measurement of length of maize storage. For example, interview months for both rounds of data collection almost coincided with harvest periods around which time maize storage may not have started in earnest. The mean maize storage duration reported exceeds the short spell between harvest and interview dates and indicates that farmers referred to previous year's harvest instead of harvest from the current cropping season. This implies that we likely measured the outcome variable with recall error, which may have consequences for gauging the actual length of maize storage.

Also, we do not have much information about the components of respondents' perceived awareness of food safety risks. Therefore, we are unable to track the mechanism of change in perceived awareness over the two rounds. For example, participating in the baseline survey may expose respondents to some food safety information which may alter their initial state of unawareness to being aware of food safety risks upon resampling in the second round. This may introduce some noise in the awareness measure if the change does not represent a true increase in perceived food safety awareness.

From the conceptual model, we state that maize retention rate may have a subjective component and so any uncertainty about the standard deviation of retention rate may affect duration of maize storage. Specifically, our model shows that lower uncertainty regarding the retention rate increases the optimal length of maize storage *ceteris paribus*. However, lacking a better measure, we use a respondents' perceived awareness of food safety risks as a proxy for the standard deviation for maize retention rate.

We are mindful that the effectiveness of the proxy may be compromised by errors in its measurement. Further, if awareness of food safety risks not a good proxy for storage retention uncertainty, the empirical analysis may not capture the mechanism elucidated by our model.

We also acknowledge that this study lacks statistical power due to the small sample size and may not reflect the situation across Nepal. Despite the shortcomings, our results provide an important step in the quest to study the link between farmers' perceived food safety awareness and length of maize storage; and the subsequent implications for intertemporal allocation of maize in a developing country context. In the future, it would be useful to expand the sample, extend the rounds, and collect data on the mechanism of perceived food safety awareness. This would enhance the accuracy of the results and provide a means of detecting effects of rounds.

3.7 Summary of Findings

Using a two-round household level panel data from Nepal, we examine the relationship between farmers' self-reported awareness of food safety risks and the duration of maize storage.

The baseline survey results show that about one-third of the sample perceived themselves to be aware of food safety risks and to some extent its negative effects and this proportion of awareness more than double upon resampling. We find that, on average, respondents' perceived awareness of food safety risks is associated with prolonged maize storage duration which is capable of enhancing intertemporal allocation decisions of the household. However, we note that regardless of this aforementioned relationship, perceived awareness of food safety risks does not reflect on post-harvest practices; such as cleaning storerooms before storage, drying, and sorting maize. While cleaning storeroom before storage is not associated with length of maize storage, drying and sorting maize ahead of storage are both negatively correlated with a reduction in storage duration.

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Chapter 4 - Overall Conclusion

4.1 Study 1: Loss Aversion and Improved Storage Technology Adoption: Evidence from a Field Experiment in Ghana

Despite the persistent challenges that limit development, there is growing evidence on the economic transformation occurring in many parts of SSA.[15] Agricultural growth, by expanding job opportunities in the non-farm sectors through multiplier effects, is likely to remain an important driver of continued transformation, though it will increasingly need to rely on productivity growth rather than area expansion (Jayne et al., 2018). Crop production accounts for about 70% of typical incomes, of which grain crops account for about 37% on average, and is mostly consumed by small farming households (The World Bank, 2011). However, crop production which forms a vital part of the livelihoods of smallholder farmers in Ghana (and across SSA in general) remains predominantly rain-fed and postharvest losses is a major challenge to such farmers.

We investigate the demand for an improved postharvest technology—ZeroFly hermetic storage bag—among farmers in Ghana. The data shows that farmers consider hermetic storage bags to yield higher expected returns compared to all other storage technologies in use (baskets; metal/plastic drums; and jute/plastic sacks), and knowledge about their potential benefits is not a major constraint. Further, demand for hermetic storage bags is high, with more than half the sample willing to pay market price or above. However, access to these bags low, suggesting supply side inefficiencies.

We focus on whether farmers' loss aversion impacts their willingness to pay for the improved storage bags. We used a risky lottery game to obtain the farmers loss aversion

[15]There is rising per capita incomes, rapid reduction in poverty rates, major self-investments by households in youth education and skills training, and rise in workforce engaged in non-farm sectors (Jayne et al., 2018).

parameters and obtained willingness to pay (WTP) estimates using the Becker, Degroot, and Marschak (1964) experimental auction approach. We describe basic conditions under which loss averse farmers would be more willing to purchase hermetic storage bags due to their potential to protect stored maize against postharvest losses. Our results showed the opposite: loss aversion is inversely related to farmers' WTP for hermetic storage bags despite the fact that investing in the bags may be profitable.

Our field observations revealed that selling crops soon after harvest is one way farmers cope with potential postharvest losses. Accordingly, if selling immediately defines a reference point for storage losses of zero, then farmers' loss aversion will likely reduce their WTP for hermetic storage bags despite their potential benefits. In that case, loss aversion may even serve as a behavioral impediment to purchasing storage related PHL technologies. The evidence we provide is that loss aversion is negatively correlated with farmers' WTP for hermetic storage bags and the negative relationship likely stems from the reference point generated by selling immediately. We show this by examining farmers' decision on time of sale and amount sold during each period and and demonstrate that the negative relationship between loss aversion and their WTP for hermetic storage bags is driven by farmers who sell immediately. For those who store to take advantage of higher prices during the lean season, there is no signficant relationship between loss aversion and demand.

Over the years, there has been major investments by development agencies toward the development, introduction, and adoption of improved varieties and chemical fertilizers to boost crop yields especially among smallhoder farmers. While adoption of crop and soil related technologies have steadily—albeit slowly—increased, the adoption of improved storage technologies remains low. We show that behavioral biases such as loss aversion may be part of the reason why agricultural storage technologies are not exploited despite their mitigation capacity against storage losses and the potential of enhancing farm household wellbeing through increased incomes. However, we also demonstrate that demand is likely not the limiting factor for adoption of hermetic storage technology, as WTP for bags is quite high. Consequently, private sector supply chain issues, including transmission of demand signals, may be constraining adoption.

4.2 Study 2: Perceptions of Food Safety Risk, Post-Harvest Practices and Intertemporal Staple Crop Allocation: Evidence from Maize in Nepal

Next to paddy, maize is the most grown staple crop in Nepal: accounting for 15% of total cereal consumption (Pokhrel, 2016). Thus, even relatively low levels of aflatoxin exposure may have significant health consequences (Shephard, 2008) as well as implications for postharvest losses. While improving food safety is important for improving access to sufficient and healthy food (Unnevehr, 2003), the assurance of food safety awareness by farmers and other actors along the stages of the food supply chain is not a given. The interconnectedness of post-harvest practices and the varying degrees of efficiency in their performance are likely to lead to contamination of food by mycotoxins (e.g. aflatoxin). In many developing countries, compliance to minimum food safety standards is generally low; and mycotoxin testing is mainly by visual inspection which only detects severe cases and quite imperfectly (Sheahan and Barrett, 2017).

Using data from the Postharvest Loss Innovation Lab (PHLIL) Mycotoxin Awareness Household Survey conducted in Nepal we show that farmers' perceived awareness of food safety risks significantly associated with prolonged maize storage for optimal intertemporal allocation. The data show that despite the aforementioned relationship, there is no difference in post-harvest practices carried out by farmers who are aware of food safety risks compared to those who are not. We find that farmers' perceived awareness of such risks has no effect on their post-harvest practices (i.e. drying and sorting of maize; and cleaning store before storing maize). Further, our analysis show that while cleaning storeroom before storage is not effect on length of storage, drying and sorting maize before storing is correlated with shorter length of maize storage: this may have some implications for intertemporal allocation of maize.

Appendix A - Study 1

Table A.1: Similarities Among Farmers Given the Time of Sale (Within or After 2 Months of Harvest)

	Sold none after 2 months (N=93)		Sold some after 2 months (N=188)		Sold all after 2 months (N=105)	
Variable	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Farmer/Household characteristics						
Male (%)	0.62	0.49	0.75	0.43	0.68	0.47
Age (years)	42.13	14.69	42.71	13.60	40.84	14.44
Education (years)	3.92	4.51	4.93	4.48	4.43	4.44
Farming experience (years)	19.48	13.78	18.36	12.60	18.37	13.38
Married (%)	0.82	0.39	0.80	0.40	0.75	0.43
Occupation (% farmers)	1.00	0.00	0.97	0.16	1.00	0.00
Total HH size (persons)	7.74	3.85	9.38	5.27	7.17	4.97
Production characteristics						
Total farm size (acres)	7.03	6.13	8.58	7.24	8.58	7.96
Maize farm (acres)	3.54	4.06	5.05	4.90	4.74	5.53
Maize harvested (kg)	1674.19	2200.09	3195.75	4556.96	2900.00	5089.03
Maize consumed (kg)	214.85	185.22	318.23	338.66	198.94	205.23
Maize sold (month 1 (kg))	698.38	1229.48	792.54	1184.93	0.00	0.00
Maize sold (month 2 (kg))	760.97	1602.46	1208.19	3794.00	0.00	0.00
Maize sold after 2 months (kg)	0.00	0.00	876.78	1757.14	2891.54	5585.40
Maize revenue (GHS)	1938.12	2554.17	4190.86	12139.17	3812.33	8429.94
Off-farm income	253.25	932.55	372.45	2399.37	173.14	840.42
Maize storage						
Basket/pot/jar (%)	0.01	0.10	0.00	0.00	0.00	0.00
Metal/plastic drums (%)	0.02	0.15	0.03	0.18	0.00	0.00
Jute/plastic sacks (%)	0.97	0.18	0.96	0.20	1.00	0.00
Hermetic storage bag (%)	0.00	0.00	0.01	0.10	0.00	0.00
Stored with chemicals (yes=1)	0.13	0.34	0.21	0.41	0.16	0.37
Hermetic bag ever used (yes=1)	0.04	0.20	0.04	0.20	0.01	0.10
Hermetic bag still in use (yes=1)	0.01	0.10	0.04	0.19	0.00	0.00
Hermetic bag availability (yes=1)	0.04	0.20	0.03	0.16	0.03	0.17
Storage perception						
Baskets/pots/jars						
Best case						
- 3 month survival (%)	67.07	19.35	69.96	24.62	59.58	28.37
- 6 month survival (%)	51.18	25.86	57.84	31.11	40.71	31.52
Worst case						
- 3 month survival (%)	40.75	29.90	52.13	34.10	18.04	24.87
- 6 month survival (%)	30.87	29.75	43.85	36.42	9.04	20.60

Table A.1 Continued

Variable	Sold none after 2 months (N=93)		Sold some after 2 months (N=188)		Sold all after 2 months (N=105)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Metal/plastic drums						
Best case						
- 3 month survival (%)	57.88	20.26	72.17	23.82	56.28	29.29
- 6 month survival (%)	41.14	28.01	61.63	28.87	36.94	31.24
Worst case						
- 3 month survival (%)	37.26	27.95	50.39	34.10	16.00	25.18
- 6 month survival (%)	26.13	28.14	43.29	36.19	9.32	22.11
Jute/plastic sacks						
Best case						
- 3 month survival (%)	84.69	15.27	84.27	17.18	85.38	20.66
- 6 month survival (%)	71.53	24.23	76.93	22.92	69.84	27.03
Worst case						
- 3 month survival (%)	57.85	33.49	62.31	34.38	34.40	34.69
- 6 month survival (%)	47.18	36.34	54.46	37.82	21.20	32.03
Hermetic storage bag						
Best case						
- 3 month survival (%)	94.19	15.23	95.08	17.84	99.22	2.76
- 6 month survival (%)	90.67	19.08	93.69	18.49	96.14	7.25
Worst case						
- 3 month survival (%)	75.92	33.34	77.43	32.76	50.33	38.81
- 6 month survival (%)	67.28	39.47	71.18	37.41	36.43	40.97
Location (Municipality)						
(1=Ejura-Sekyedumasi, 0=Techiman)	0.5054	0.5027	0.5426	0.4995	0.5143	0.5022

Note**:** Exchange rate at the time of interview was GHS 1 = US$ 0.22.

Figure A.1: Expected Maize Survival vs Probability of Worst Case/Condition (3 Months after Harvest)

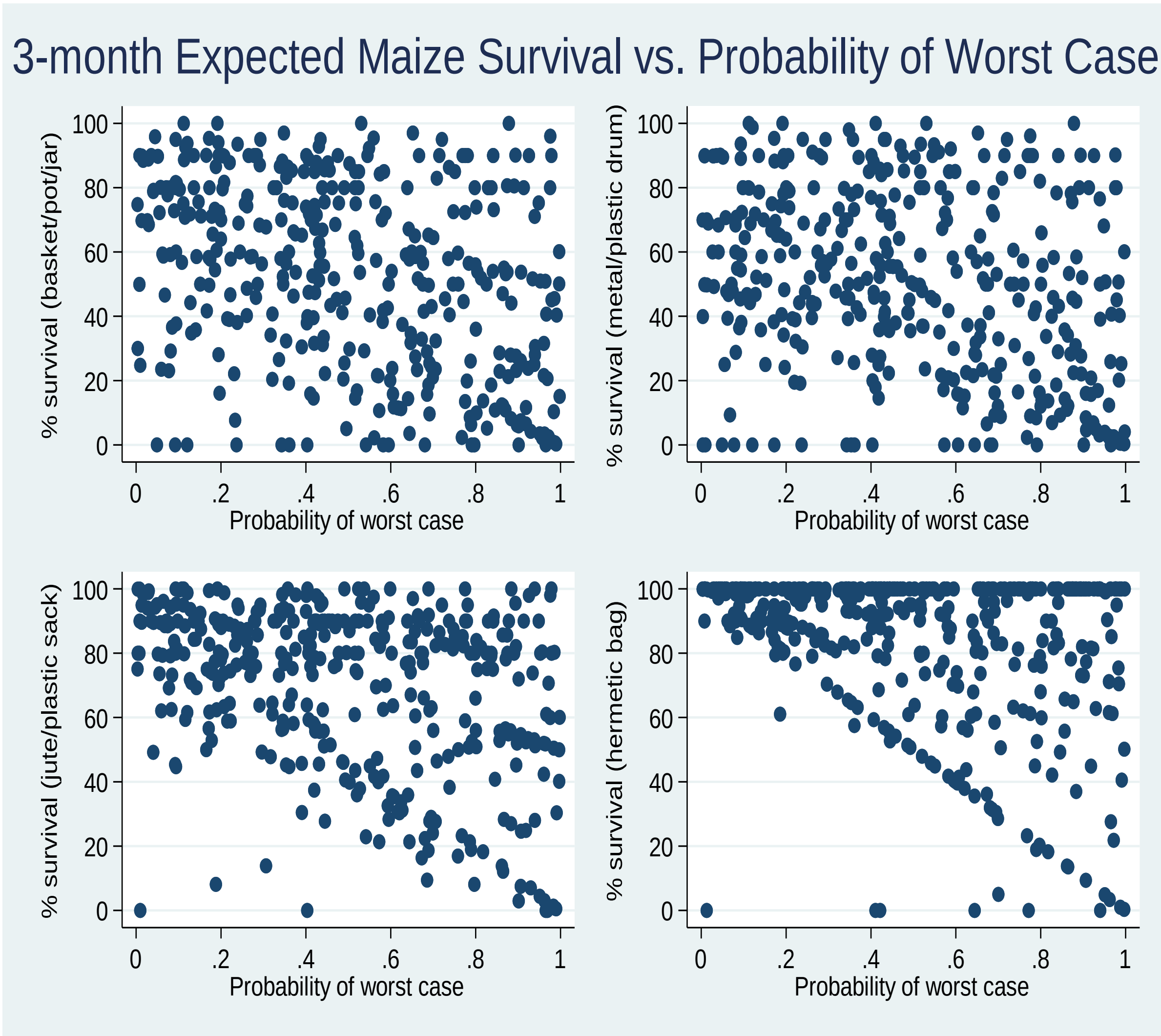

Figure A.2: Expected Maize Survival vs Probability of Worst Case/Condition (6 Months after Harvest)

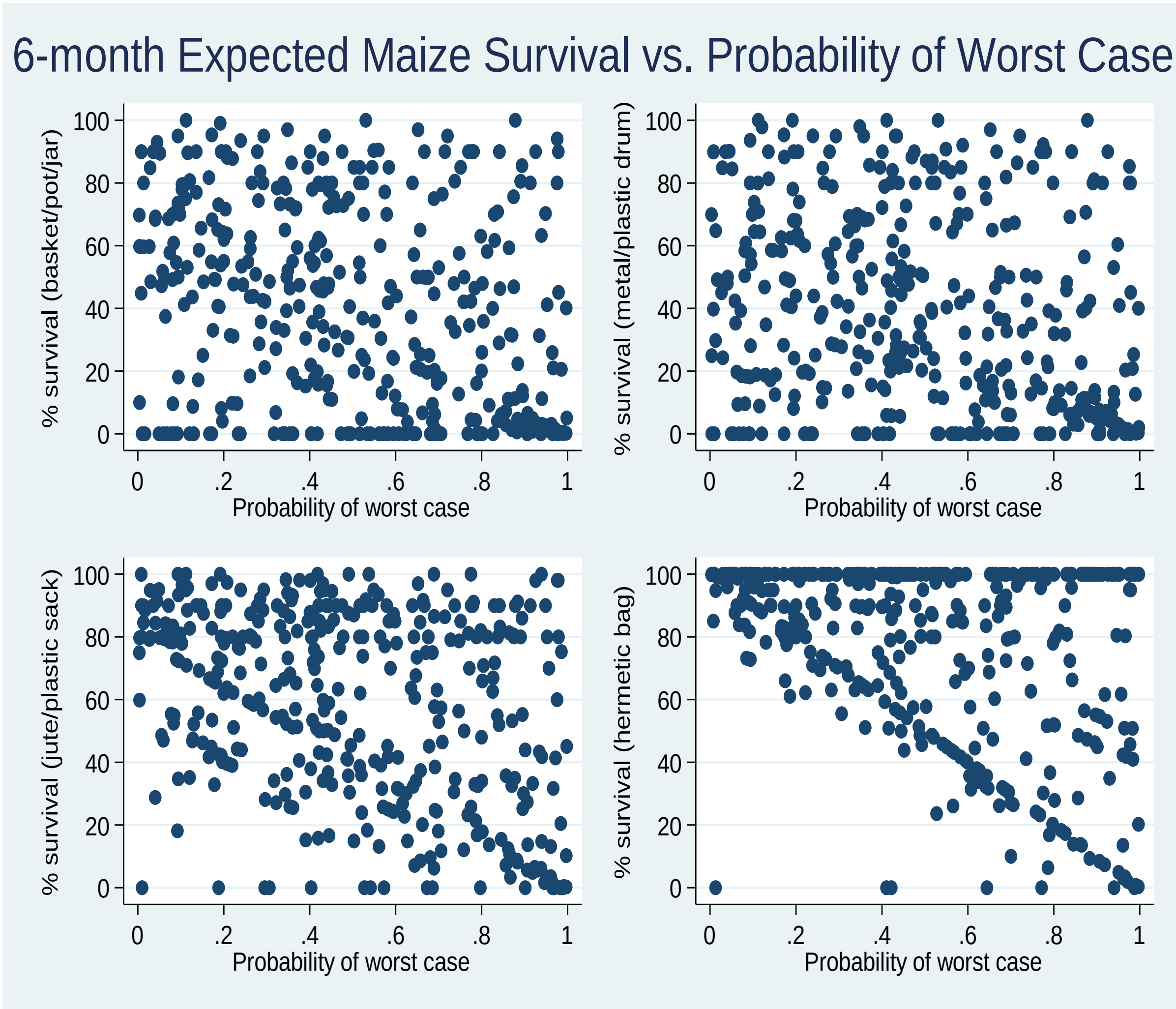

Figure A.3: Relationship Between WTP and Loss Aversion by Farmers' Educational Level and Marital Status

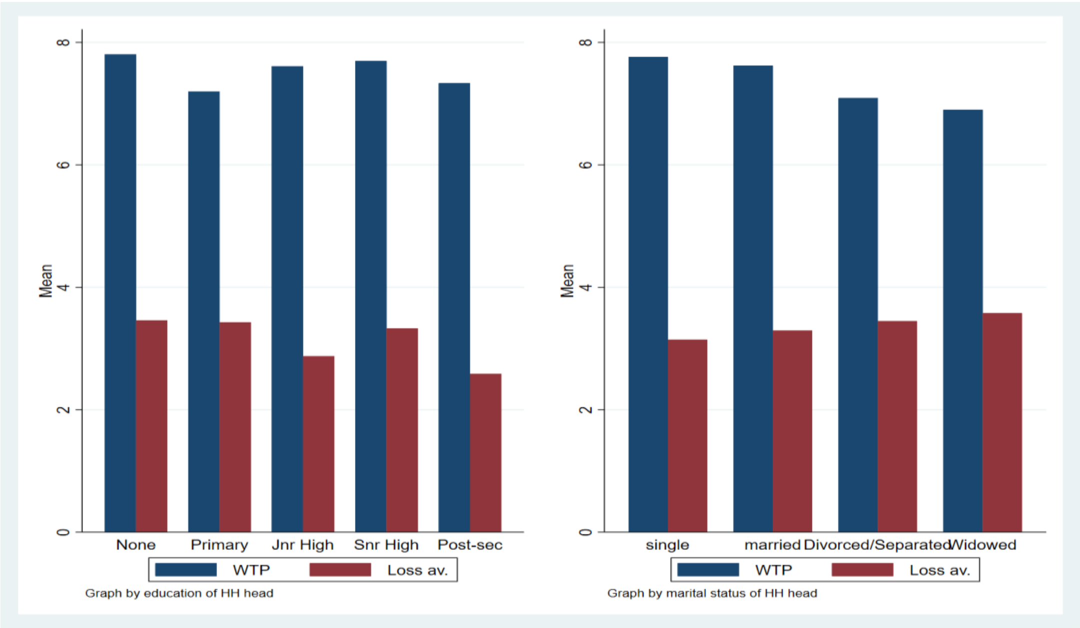

Figure A.4: Perceived Efficiency in Reducing PHL: Comparison Among Storage Technologies

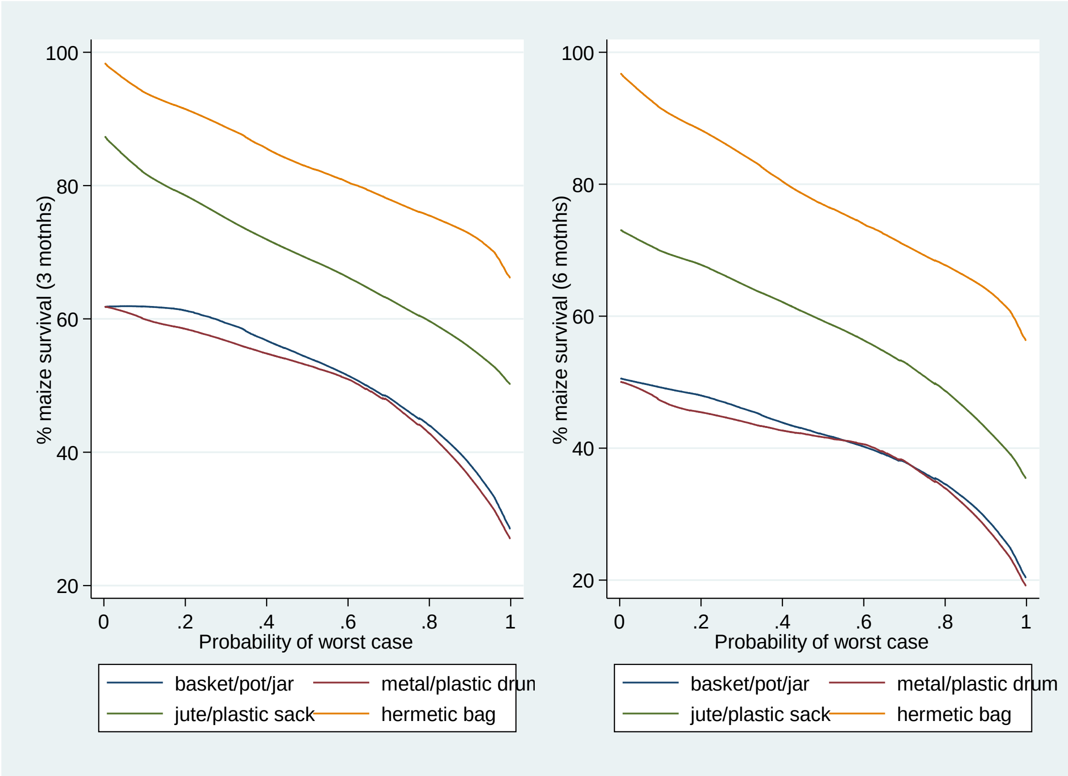

Table A.2: Lottery Choice Task

Lottery (following a coin toss)	Accept	Reject
1. if heads, you lose GHS 2; if tails, you win GHS 6		
2. if heads, you lose GHS 3; if tails, you win GHS 6		
3. if heads, you lose GHS 4; if tails, you win GHS 6		
4. if heads, you lose GHS 5; if tails, you win GHS 6		
5. if heads, you lose GHS 6; if tails, you win GHS 6		
6. if heads, you lose GHS 7; if tails, you win GHS 6		

Note: Ratio of gains to loss for the final choice task accepted indicates respondent's loss aversion parameter. Exchange rate at the time of interview was GHS1 = US$ 0.22.

Table A.3: Becker-DeGroot-Marschak (BDM) Auction

Price of hermetic storage bag (GHS)	I am willing to purchase	I am **NOT** willing to purchase
If the price is GHS 1		
If the price is GHS 2		
If the price is GHS 3		
If the price is GHS 4		
If the price is GHS 5		
If the price is GHS 6		
If the price is GHS 7		
If the price is GHS 8		
If the price is GHS 9		
If the price is GHS 10		

Note: The final price chosen by a respondent indicates their willing to pay for the hermetic storage bag. Exchange rate at the time of interview was GHS 1 = US$ 0.22.

Table A.4: Factors Affecting WTP Using the Double Censored Tobit Approach

Variables	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	0.3436		2.5153	0.3543	0.4342	0.4542
	(0.8942)		(1.5123)*	(0.8697)	(0.8392)	(0.8428)
Loss aversion		-0.6322	-0.2748	-0.7080	12.8256	-0.7846
		(0.1826)***	(0.2992)	(0.1786)***	(1.6202)***	(0.3615)**
Loss treatment X Loss aversion			-0.5837			
			(0.3755)			
Some maize sold after 2 months				-0.7781	-0.7071	-1.2998
				(1.0022)	(1.0187)	(1.8847)
All maize sold after 2 months				3.9763	4.2597	3.3761
				(1.2881)***	(1.2699)***	(2.3367)
Loss aversion X some maize sold						0.1563
						(0.4293)
Loss aversion X all maize sold						0.2267
						(0.5192)
Control variables	NO	NO	NO	NO	YES	YES
N	386	386	386	386	386	386

Note: Control variables include sex, education, and years of farming experience of household head, household size, farm size, household income, and perceived loss reduction with hermetic storage bag (for worst case after 6 months of harvest). * p<0.1; ** p<0.05; *** p<0.01. standard error in parenthesis.

Table A.5: Factors Affecting WTP Using the Double Censored Tobit Approach (Plastic Sack and Hermetic Bag Users Only)

Variables	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	0.0877		2.1136	0.1252	0.1252	0.2271
	(0.9119)		(1.5472)	(0.8879)	(0.8879)	(0.8567)
Loss aversion		-0.6287	-0.2988	-0.6918	-0.6918	-0.7085
		(0.1850)***	(0.3070)	(0.1808)***	(0.1808)***	(0.3677)*
Loss treatment X Loss aversion			-0.5312			
			(0.3829)			
Some maize sold after 2 months				-0.6765	-0.6765	-0.9326
				(1.0210)	(1.0210)	(1.9069)
All maize sold after 2 months				4.0471	4.0471	3.7294
				(1.2993)***	(1.2993)***	(2.3474)
Loss aversion X some maize sold						0.0739
						(0.4353)
Loss aversion X all maize sold						0.1478
						(0.5231)
Control variables	NO	NO	NO	NO	YES	YES
N	386	386	386	386	386	386

Note: Control variables include sex, education, and years of farming experience of household head, household size, farm size, household income, and perceived loss reduction with hermetic storage bag (for worst case after 6 months of harvest). * $p<0.1$; ** $p<0.05$; *** $p<0.01$. standard error in parenthesis.

Table A.6: Factors Affecting WTP (Without Treatment Variable); Using the Double Censored Tobit Approach

Variables	(1)	(2)	(3)	(4)
Loss aversion	-0.6322 (0.1826)***	-0.7036 (0.1788)***	-0.6487 (0.1784)***	-0.7737 (0.3635)**
Some maize sold after 2 months		-0.8050 (0.9964)	-0.7362 (1.0136)	-1.3151 (1.8929)
All maize sold after 2 months		3.9742 (1.2888)***	4.2567 (1.2694)***	3.4426 (2.3440)
Loss aversion X some maize sold				0.1529 (0.4308)
Loss aversion X all maize sold				0.2089 (0.5184)
Control	NO	NO	YES	YES
N	386	386	386	386

Note: Control variables include sex, education, and years of farming experience of household head, household size, farm size, household income, and perceived loss reduction with hermetic storage bag (for worst case after 6 months of harvest). * p<0.1; ** p<0.05; *** p<0.01. standard error in parenthesis.

Table A.7: Relationship Between WTP and Loss Aversion (Only Farmers Who Store Maize)

Variables	(1)	(2)	(3)	(4)
Loss aversion	-0.2209 (0.0825)***		-0.1681 (0.0885)*	-0.1625 (0.0870)*
Perceived gains from hermetic bag (6 months)		-0.0051 (0.0068)	0.0052 (0.0088)	0.0047 (0.0087)
Loss aversion X perceived gains from bag			-0.0039 (0.0029)	-0.0039 (0.0028)
Constant	8.3688 (0.2823)***	7.7449 (0.2052)***	8.2930 (0.3138)***	8.5773 (0.5698)***
Control	NO	NO	NO	YES
N	293	293	293	293

Note: Control variables include sex, education, and years of farming experience of household head, household size, farm size, and household income. * p<0.1; ** p<0.05; *** p<0.01. standard error in parenthesis.

A.8: QUESTIONNAIRE FOR HOUSEHOLD SURVEY

Questionnaire ID:		Date:
Name of enumerator:		
Region:		Region code:
District:		District code:
Community:		Community code:
Altitude (meters):	Latitude, X:	Longitude, Y:

A. General Information

1. Respondent ID: [ ]
2. Sex of respondent: [ ] 1=Female 0=Male
3. Age of respondent (years): [ ]
4. Education (in years): [ ]
5. Highest level of formal education of respondent: [ ]
   0=None 1=Basic(Primary/JHS/Middle) 2=Secondary (Secondary/Vocational) 3=Tertiary (Training college/Polytechnic/University)
6. Marital status of respondent: [ ]
   0=Single 1=Married 2=Divorced/Separated 3=Widowed
7. Respondent's years of farming experience: [ ]
8. Is the respondent the head of the household (HH)? (If man is away >6 months/year, then woman is head)? [ ] 1=Yes 0=No, If yes, skip to 15.
9. Sex of the HH head: [ ] 1=Female 0=Male
10. Age of HH head (years): []
11. Education of HH head (in years): [ ]
12. Highest level of formal education of HH head: [ ]
    0=None 1=Basic (Primary/JHS/Middle) 2=Secondary (Technical/Vocational) 3=Tertiary (Training college/Polytechnic/University)
13. Marital status of HH head: [ ] 0=Single 1=Married 2=Divorced/Separated 3=Widowed
14. HH head's years of experience of farming: [ ]
15. Place of origin of HH head: [ ] 1=Native 2=Settler 3=Migrant 4=Other (specify)………………
16. If non-native, how long have you being staying in this community? [ ]

B. Assets

17. What is the main material used to roof your house? [ ]

1=Mud 2=Thatch 3=Wood 4=Iron Sheets 5=Cement/Concrete 6=Roofing Tiles 7=Other (specify): ....

18. What is the main material used in building the walls of your house?

1=Mud/Mud bricks 2=Burnt bricks 3=Wood/Bamboo 4=Iron Sheets
5=Cement/Concrete 6=Other (specify): ....

19. How many of these assets do your household own?

Item	Radio	TV	Mobile Phone	Bicycle	Motor bike	Car
Number						

20. How many of the following animals (livestock/poultry) does the household own?

Livestock	Current number	No. sold in last 12months	Total value at sale (GHS)
Sheep and Goats			
Cattle			
Pigs			
Draught animals (e.g. oxen, donkey etc.)			
Poultry (e.g. chickens, guinea fowls, ducks etc.)			

C. Household Composition

Questions	Males	Females	Total
21. How many persons are in this household?			
22. How many are orphaned (<18 & have lost 1 or both parents)?			
23. Number of persons between 0-5 years			
24. Number of persons between 6-17 years			
25. Number of persons with between 18-64 years			
26. Number of persons attending school			

D. Household Income Sources

27. What is the main occupation of the head of the household? [ ]

1=Agriculture 2=Petty trading 3=Craftsmanship 4=Salaried work (formal sector)
5= casual wage work 6=other (specify): ………...

28. Are members of your household engaged in any off-farm income generating activities? [ ] 1=Yes 0=No, If no, skip to 32. *(including migrant workers who contribute to financially to HH)*

29. If yes, please provide the details below

Activity	Number of females	Avg. Income 2017 (GHS)	Number of males	Avg income 2017 (GHS)
Petty trading				
Handicrafts making				
Gathering something from the wild or water body for sale				
Salaried or wage workers				
Other:.................				

30. Did anyone work for wage between June and September, 2017? [ ] 1=Yes 0=No if No, skip to 32

31. If yes: Number of persons [ ]; Hours of work [ ]; Total wage income [ ]

E. Farm Characteristics

32. What is your total farm size (acres)? [ ] {*note: 1 hectare = 2.471acres*}

33. Maize area cultivated 2017 (acres)	34. Amount harvested (100kg).	35. % consumed	36. % sold	37.% sold 1 month after harvest	38. % sold 2 months after harvest	39. Total sales revenue of maize (GHS)

40. How much of last year's maize harvest do you currently have in storage (kg)? [ ]

41. What type of storage system do you mainly use for maize?

1=Basket/pot/jar 2=Metal/plastic drums 3=Jute/plastic sack 4=ZeroFly/PICS storage bags

42. Do you spray stored grain with chemicals? [ ] 1=Yes 0=No (if No, skip to 44)

43. If yes, what is the average total amount you spend on chemical (GHS) on storage last year? []

44. Other crops produced (2017)	45. Acreage (acres)	46. Qty harvested in 2017 (kg).	47. % consumed	48. % sold	49. Total sales revenue (GHS)
Rice					
Millet					
Cowpea					
Other 1:					
Other 2:					

50. Have you heard about the hermetic storage bag? [ ] 1=Yes 0=No (if No, skip to 55)

51. Have you ever used the hermetic storage bag? [ ] 1=Yes 0=No (if No, skip to 54)
52. If yes, what was the source? [ ]
    1=given by NGO 2=coupon or subsidy 3=purchased from market
53. Do you still use the hermetic storage bag? [ ] 1=Yes 0=No
54. Is the hermetic storage bag available for you to purchase? [ ] 1=Yes 0=No
55. Expected depreciation: **suppose you have 100kg maize to store at harvest time**. Using materials listed in Q41, what quantity of maize do you expect will survive after 3 and 6 months in best and worst cases?

Period		Baskets/pots/jars		Metal/plastic drums		Jute/plastic sack		Hermetic storage bag	
		best case	**worst case**	**best case**	**worst case**	**best case**	**worst case**	**best case**	**worst case**
3 months	Quality								
	Quantity								
6 months	Quality								
	Quantity								

56. Does this household save seeds to cultivate in the next planting season/year? [ ] 1=Yes 0=No
57. Did your household have adequate food throughout 2017 from own production and purchases?
    1=Yes 0=No, If yes, skip to 59
58. If no, in which of the following months did this household experience food shortage and to what extent?

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rank *(1 to 5)**												

** 1 (Very bad); 2(Bad); 3(Fair); 4(Good); 5(Very good)*

G. Access to Credit

59. Money borrowed from relatives/friends/formal credit source in the past 12 months (GHS)

Amount borrowed	Amount repaid	Duration of payment	Use for the money

60. In the past 12 months, did you seek to obtain a loan but were unsuccessful? 1=Yes 0=No
61. Money you lend to other in the past 12 months (GHS)

Amount lent	Amount repaid	Duration of payment

62. Which of the following assistances have you received from others in the past 12 months? *(please tick)*
    Remittances [ ]; Care during sickness or medicines [ ]; Sale of crops or livestock [ ]

J. Access to Extension Services and exposure to shocks

63. Have you received any agricultural extension services in the past 12 months? [ ]1=Yes 0=No

64. Has your household been affected by a serious shock* in the last 12 months?

Specific shocks within a year/season	Rank the five most serious shocks *1(very serious); 2(serious); 3(fair); 4(less serious); 5(not serious)*
Drought	
Flood	
Pests/insects and diseases	
Death of breadwinner/ close relative	
Bush burning	
Other 1: ………	
Other 2: ………	

* An event that led to a serious reduction in the household's asset holding, and/or substantial income fall resulting in a significant reduction in consumption

End of interview: Thank you for your cooperation

Appendix B - Study 2

B2: QUESTIONNAIRE FOR PHLIL CROP MYCOTOXIN HOUSEHOLD SURVEY

FEB 20, 2018, PHLIL

SN	Questions	Remarks
A	Name of Enumerator	
B	Date:	
C	District	Select one
D	Please select the local unit:	Select one
E	Ward no:	Select one
F	Please select, if these commodities are available at HH: 1. Maize 2. Ground nut 3. Chili 4. Animal Feed	Please include questions of only available commodities in following sections
MODULE 1: HOUSEHOLD CHARACTERISTICS		
1.1	Household ID: |______|	Goes from 1 to 320
1.2	Number of Male Household Members: |________|	
1.3	Number of Female Household Members: |________|	

1.4	Housing Condition <Observation basis>:	
1.4 A	Roof Condition: 1. Poor 2. Medium 3. Good (1= Thatched roof/Clay/tiles, 2=GI/Asbestos sheet/GI plate 3=RCC)	
1.4 B	Wall Condition: 1. Poor 2. Medium 3. Good (1=wood/planks/straw/Bamboo 2= Mud bonded bricks or stones 3= Cement bonded bricks or stones)	
1.5	Do you have electricity/solar in your house? 1. Yes 2. No	
1.6	Which major fuel do you use for cooking in your family? 1. Firewood 2. LPG Gas 3. Biogas 4. Briquette/rice husk 5. Kerosene/Coal 6. Cow dung cake 7. Electricity (regular/Irregular supply) 8. Other (Specify………)	Single choice
1.7	What is the main source of water for your household? 1.Pipeline available in house 2. Public tap 3. Tube well 4. Well (covered) 4. Well (uncovered) 5. River/stream 6. Water tanker 7. Jar water (mineral water) 8. Rain water 9. Other (Specify)	Single choice

MODULE 2: INTERVIEWEE INFORMATION

2.1	Age: |______|	
2.2	Gender: 1. Male 2. Female 3. Other |_____|	Single choice
2.3	Marital Status: 1. Married | 2. Unmarried | 3. Divorced 4. Widow | 5. Single/Separated | 6. Other (Specify……)	Single choice
2.4	What is your level of education? 1.Illiterate | 2.Non-formal education | 3. Elderly education | 4.Primary (Class 1-5) 5.Secondary class (6-10/SLC) | 6.+2 (Higher secondary) | 7.Bachelor | 8.Above	Single choice
2.5	Caste/Ethnicity? 1. Brahmin/Chhetri | 2. Janajati | 3. Newar 4. Dalits | 5. Other (Specify)__________ |	Single choice
2.6	What is your primary occupation? 1. Agriculture 2. Industry/Business 3. Service 4. Labor 5. Student 6. Housewife 7. Retired 8. Unemployed 9. Other (Specify)____________	Single choice

2.7	Relationship of respondent to HH head? 1. HH head 2. Wife/ Husband 3. Son/ Daughter(in-law) 4. Brother/ Sister (in-law) 5. Parent 6. Other (Specify)	Single choice

MODULE 3: DIVISION OF LABOR AND DECISION MAKING

3.1 Who is responsible for the following activities? (Multiple choice possible)

Activities	1. HH head 2. Wife/ Husband 3. Son/ Daughter(in-law) 4. Brother/ Sister (in-law) 5. Parent 6. Other (Specify)	Activities	1. HH head 2. Wife/ Husband 3. Son/ Daughter(in-law) 4. Brother/ Sister (in-law) 5. Parent 6. Other (Specify)
a. Seed bringing/buying	|____|	f. Drying	|____|
b. Land preparation	|____|	g. Sorting	|____|
c. Planting/Sowing	|____|	h. Shelling	|____|
d. Weeding/Hoeing	|____|	i. Storing	|____|
e. Harvesting	|____|		

3.2 Who takes decision on the followings? (Single choice)

Decision on	1. HH head 2. Wife/ Husband 3. Son/ Daughter(in-law) 4. Brother/ Sister (in-law) 5. Parent 6. Other (Specify)	Decision on	1. HH head 2. Wife/ Husband 3. Son/ Daughter(in-law) 4. Brother/ Sister (in-law) 5. Parent 6. Other (Specify)
a.Food choice	|____|	e.Hiring of labor	|____|
b.Area to be cultivated	|____|	f.Fertilizer to be used	|____|
c.Crops to be grwn	|____|	g.Marketing of crop products	|____|

	d.Varieties to be used	|____|	h.Use of revenue received	|____|	

MODULE 4: INFRASTRUCTURE ACCESSIBILITY

Travel time and transportation means from your house for the following

All field mandatory

	Infrastructures	Distance (km, if not known, leave as DK)	Time (Min)	Means of transportation: 1. Foot 2. Vehicle 3. Rickshaw 4. Horse cart 5. Other (Specify)	
4.1	Closest shop				
4.2	Closest market				
4.3	Closest school				
4.4	Closest seed/Fertilizer/Pesticide market				
4.5	Closest bank				
4.6	Nearest bus station				
4.7	Nearest paved road				

MODULE 5: HOUSEHOLD FOOD CONSUMPTION LAST MONTH

5.1 Did the household/ your family consume the following food in the last month?

Skip 5.1A for 2

S.N.	**Food Type**	**1. Yes 2. No**
a	Maize	|_____|
b	Ground nut	|_____|
c	Chili (dry)	|_____|
d	Chili (Fresh)	|_____|
e	Milk	|_____|

5.1 A Quantity consumed and food source

	Food Type	1.What is the average quantity of food (kg/month) for whole family?	2. What are the primary source of the food for your household?	3.What are the secondary source of the food for your household?	
			1.Own product; 2.Open market; 3.Street store (shop); 4.Neighbor; 5.Government sale centre (Sajha); 6.Free Distribution; 7.Other (Specify)	1.Own product; 2.Open market; 3.Street store (shop); 4.Neighbor; 5.Government sale centre (Sajha); 6.Free Distribution; 7.Other (Specify)	
	a.Maize				
	b.Ground nut				
	c.Chili (dry)				
	d.Chili (Fresh)				
	e.Milk				
5.2	What is your average monthly household food expenditure? (NRS) |_______________|				
5.3	Do you have food insecurity in your family? 1. Yes 2 No				Skip 5.4 for 2
5.4	What are the measures you follow in case of food insecurity in your family? 1. Wage labor; 2. Borrowing; 3. Barter; 4. Credit; 5. Other (Specify…)				Multiple choice

MODULE 6: KNOWLEDGE ON AFLATOXIN AND FOOD SAFETY/SOURCE OF INFORMATION

6.1 What is the most concerning factor regarding the food safety?

1.Rotten/Odorous food	2.Spoilt Food	3.Contained/molded food	4.Pesticide used in food
5.Stale food	6.Purity of grain (Inert mixed)	7.Moths/weevils/insects	8.Other (specify)____

6.2	Are you aware of fungal contamination in food? 1. Yes 2. No |_______|	Skip 6.3 for 2.
6.3	If yes, do you know its negative effects to human/animal health? 1. Yes 2. No |_______|	
6.4	How do you evaluate yourself in terms of food safety awareness (1 – 5 scale, 1 is not very aware, and 5 is very aware)? |_______|	Single choice
6.5	How do you evaluate health status of your household (1 – 5 scale, 1 is not very healthy, and 5 is very healthy)? |_______|	Single choice
6.6	How do you feel about the safety level of food that your household consumes (1 – 5 scale, 1 is not very safe, and 5 is very safe)? |_______|	Single choice
6.7	Where do you get food safety related information? 1. Local Extension offices; 2. Media; 3. Universities 4. NGOs/INGOs; 5. Community/CBOs; 6. Others (Specify)________	Multiple choice
6.8	Can you identify spoilt commodities? 1. Yes 2. No |_____|	Skip 6.9 and 6.10 for 2
6.9	If yes, how do you identify? (Choose all applicable) 1. Softness; 2. Odor; 3. Bitter/Bad taste 4. Visual inspection (Specify); 5. Other (Specify)	Multiple choice
6.10	What did you do with spoilt grains? (Choose up to 2) 1. Throw/Dispose; 2. Feeding livestock/poultry; 3. Making local brew 4. Re-dry/clean and consume; 5. Sell to market; 6. Other (specify)	Multiple choice

6.11	What are the causes of spoilage in commodities? 1. Poor drying; 2. Heaping on the floor; 3. Fungal growth; 4. Poor storage condition; 5. High moisture on surface; 6. Premature harvest; 7. Other (Specify)	Multiple choice
6.12	Do you clean the store before storage? 1. Yes 2. No |______|	Single choice
6.13	Do you know the measures for controlling fungal growth/spoilage in the store? 1. Yes 2. No |_________|	Skip 6.14 for 2
6.14	If yes, what measures do you apply? 1. Drying commodities properly before storage; 2. Pesticide spray in room; 3. Drying and cleaning room/storage; 4. Put on wooden planks/sacks; 5. Other (Specify)	Multiple choice
6.15	Are you willing to pay for testing of safety of your crops? 1. Yes 2. No	
MODULE 7: AGRICULTURE LAND AND ASSET		
7.1	How many plots (if fragmented) of agricultural land do you have? |________| plots	Link the plot number to 7.3 and 7.5
7.2	What unit do you use to measure the land area? 1. Ropani 2Aana 3. Bigaha 4. Kaththa 5. Dhur	Single Choice
7.3	Total area of your agricultural land (Size of each plot)	

Plots	1.Area of each plot	2.Unit of Plot	3.Land ownership

		1.Ropani 2Aana 3. Bigaha 4. Kaththa 5. Dhur	1.Own 2. Leased 3. Adhiya 4.Other (Specify)
a. Plot 1			
b. Plot 2			
c. Plot 3			
d. Plot 4			
e. Plot 5			

7.4 Did you plant any of the following three commodities? If yes, please state the acres planted and quantity harvested (During the last session defined as till 8 months prior to survey)?
1. Yes 2. No

Maize|______|
Groundnut |_______|
Chili |________|

Skip 7.5 for 2. Also, skip quest on comm. in mod 8 and 9 if the comm. is not planted

7.5 Please give names in order of area:

	a.Maize			b.Ground nut			c.Dry Chilli		
	1.Area planted	1a Unit of Land 1.Ropani 2Aana 3. Bigaha 4. Kaththa 5. Dhur	2.Quantity harvested (kg)	1.Area planted	1a Unit of Land 1.Ropani 2Aana 3. Bigaha 4. Kaththa 5. Dhur	2.Quantity harvested (kg)	1.Area planted	1a Unit of Land 1.Ropani 2Aana 3. Bigaha 4. Kaththa 5. Dhur	2.Quantity harvested (kg)
1.Plot 1									
2.Plot 2									
3.Plot 3									
4.Plot 4									

	5.Plot 5									
7.6	Do you have following farm equipment in your house?	
7.7	**Access to credit:** Have you taken loan for agricultural use? 1. Yes 2. No	Skip 7.8 for 2
7.8	for what purpose and how much?	

Farm Equipment	1=Yes 2=No	Farm Equipment	1=Yes 2=No
a. Sickle/spade	|____|	f. Maize sheller	|____|
b. Tractor	|____|	g. Rice trans planter	|____|
c. Thresher	|____|	h. Harvester	|____|
d. Local Plough	|____|	i. Sprayer	|____|
e. Power tiller		j. Other (Specify): ………	

S.N.	1.Purpose	2.Amount (NPR)	3.Source of credit 1.Commercial bank, 2.Agricultural bank, 3.Cooperatives, 4.Microfinance, 5.Relatives, 6.Other (specify)	4. Interest rate (% per annum)
a.	|____|	|____|	|____|	|____|
b.	|____|	|____|	|____|	|____|

MODULE 8: LAST SEASON CROP PRODUCTION PRACTICE (BY CROP)

8.1	Do you obtain any farming related information or recommendation from outside of your household members? 1. Yes 2. No |___|	Skip 8.2 and 8.3 for 2

8.2	what is your main source of information? 1. Local Extension Offices | 2. Seed dealer | 3. Media | 4. Neighbor 5. DADO | 6. Sajha cooperatives | 7. NGO/INGO | 8. Other (Specify)	Single Choice
8.3	What information did you get? 1. Seed | 2. Machinery | 3. Fertilizer | 4. Insecticide 5. Fungicide | 6. Drying | 7. Storage | 8. Marketing 9. Other (Specify)	Multiple choice
SEED FOR SOWING		
8.4	How did you obtain seeds for planting? a.Maize |_______| b.Groundnut |______| c.Chilli (Dry) |______| 1. Own | 2. Seed dealer | 3. Street/open market | 4. Neighbor 5. DADO | 6. Sajha cooperative | 7. NGO/INGO | 8. Other (specify)	Multiple choice
8.5	Do you store seeds separate from food? 1. Yes 2. No |_____| a.Maize |_______| b.Groundnut |______| c.Chilli (Dry) |______|	Skip 8.6 and 8.7 for 2
8.6	How did you store seeds before planting? a.Maize |_______| b.Groundnut |______| c.Chilli (Dry) |______|	

1. Special structure cemented all round	2. Metal bin	3. Bamboo mat	4. Clay bin
5. Open room	6. Hanging on the poles	7. Sacks	8. Other (specify)

8.7 How long did you store seeds before planting (months)?
a.Maize |_______|
b.Groundnut |______|
c.Chilli (Dry) |______|

PRE-HARVESTING

8.8 Can you give following information on cultivation of maize?

Crop type	1.Planting				2.Interculture (management from after planting to harvest)		3.Harvest		
	Labor (Person-day)		3.Tractor (NPR)	4.Pair Bull/ ox (per day)	Labor(Person-day)		Labor(Person-day)		3.Tractor (NPR)
	1.Male	2.Female			1.Male	2.Female	1.Male	2.Female	
a.Maize									
b.Ground nut									
c.Chili									

<table>
<tr><td>8.9</td><td>Did you do any seeds treatment before using them for plantation?
1. Yes 2. No
a.Maize |_______|
b.Groundnut |______|
c.Chili (Dry) |______|</td><td>Skip 8.10
for 2</td></tr>
<tr><td>8.1
0</td><td>Please give the following information for your seed treatment?
<table><tr><td>Crop type</td><td>1.Cost (NPR)</td><td>2.Type</td><td>3.Source</td><td>4.Amount</td><td>5.When Applied</td></tr><tr><td>a.Maize</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>b.Groundnut</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>c.Chili</td><td></td><td></td><td></td><td></td><td></td></tr></table></td><td></td></tr>
<tr><td>8.1
1</td><td>Did you use fertilizer for your crop?
1. Yes 2. No
a.Maize |_______|
b.Groundnut |______|
c.Chili (Dry) |______|</td><td>Skip 8.12
for 2</td></tr>
<tr><td>8.1
2</td><td><table><tr><td>Crop type</td><td>1.Cost (NPR)</td><td>2.Type</td><td>3.Source</td><td>4.Amount</td><td>5.When Applied</td></tr><tr><td>a.Maize</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>b.Groundnut</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>c.Chili</td><td></td><td></td><td></td><td></td><td></td></tr></table></td><td></td></tr>
<tr><td>8.1
3</td><td>Did you use fungicide for your crop?
1. Yes 2. No
a.Maize |_______|
b.Groundnut |______|
c.Chili (Dry) |______|</td><td>Skip 8.14
for 2</td></tr>
</table>

8.14

Crop type	1.Cost (NPR)	2.Type	3.Source	4.Amount	5.When Applied
a.Maize					
b.Groundnut					
c.Chili					

8.15 Did you use insecticide for your crop?

1. Yes 2. No

a.Maize |________|
b.Groundnut |_______|
c.Chilli (Dry) |_______|

Skip 8.16 for 2

8.16

Crop type	1.Cost (NPR)	2.Type	3.Source	4.Amount	5.When Applied
a.Maize					
b.Groundnut					
c.Chili					

8.17 Did you irrigate your land at any time during the season?

1. Yes 2. No

a.Maize |________|

b.Groundnut |_______|

c.Chili (Dry) |_______|

8.18

Crop type	1.Cost (NPR)	2.Source of water 1.Rain water 2. River/Stream 3. Canal water 4. Boring/Deep-boring 5.Other (specify)	3.Number of times irrigated	4.Dates of irrigation (month-week) if available
a.Maize				
b.Groundnut				
c.Chili				

Source of water single choice;

8.1 9	Production cycle (last season)	

Crop type	1.Planting date (Month-week)	2.Was planting done right after first rain (Yes/No)	3.Harvesting date (Month-week)	4.Harvesting Timing (1. Early, 2. On time, 3. Late)
a.Maize				
b.Groundnut				
c.Chili				

MODULE 9: POST HARVEST PRACTICE (BY CROP)

DRYING

9.1 When did you dry your crops after harvest? How long did you dry your crops and what was the method?

Crop type	1.When after harvest (days)	2.Duration (days)	3.Drying Method: 1. Sunlight 2. Solar dryer 3. Others (Specify)	4.Where 1. Tarp 2. Uncovered ground 3. Roof 4. Other (specify)
a. Maize	|___|	|____|	|____|	|____|
b. Ground nut	|___|	|____|	|____|	|____|
c. Chili	|___|	|____|	|____|	|____|

9.2	How do you check if your maize is dry? 1. Biting kernels to check hardness 2. Shaking kernels in hand for sound 3. Use moisture meter 4. Visual observation 5. Number of days dried	Multiple choice

	6. Other (specify)	
9.3	Do you dry maize on cobs or shelled grain to dry? 1. Cobs 2. Grain	
9.4	Are you willing to pay rupees 150 for drying a quintal of maize, if a drying machine (service) is available to you? 1. Yes 2. No |_____|	Skip 9.5 for 2
9.5	At what price (NPR) would you use the service? Specify |_______|	
SORTING /GRADING		
9.6	Do you sort/grade your commodities? 1. Yes 2. No a.Maize |_______| b.Groundnut |______| c.Chili (Dry) |______|	Skip 9.7 and 9.8 for 2

<table>
<tr><td>9.7</td><td>When did you sort the commodities after harvesting? How long did you spend for the sorting? What was the method? Who practices sorting?
<table>
<tr><th>Commo dities</th><th>0/1.How often (Every__weeks/ months)</th><th>2.When after harvest (days)</th><th>3.Duration (Days)</th><th>4.Sorting method: 1.Manually 2. Others (Specify)</th><th>5.What did you do with lower quality portion- primary solution 1.Feed (specify livestock species 2.Family consumption 3.Discard (Specify how) 4.Other (specify)</th><th>6.What did you do with lower quality portion – Secondary solution? 1.Feed (specify livestock species 2.Family consumption 3.Discard (Specify how) 4.Other (specify) 5. NA</th><th>7.What did you do with lower quality portion – tertiary solution? 1.Feed (specify livestock species 2.Family consumption 3.Discard (Specify how) 4.Other (specify) 5. NA</th><th>8.For lower quality consumed by family, consumed by whom? 1. Father 2. Mother 3. Children 4. All 5. NA</th></tr>
<tr><td>a.Maize</td><td></td><td>|____|</td><td>|____|</td><td>|____|</td><td>|____|</td><td>|____|</td><td>|____|</td><td>|____|</td></tr>
<tr><td>b.Ground nut</td><td></td><td>|____|</td><td>|____|</td><td>|____|</td><td>|____|</td><td>|____|</td><td>|____|</td><td>|____|</td></tr>
<tr><td>c.Chili (dry)</td><td></td><td>|____|</td><td>|____|</td><td>|____|</td><td>|____|</td><td>|____|</td><td>|____|</td><td>|____|</td></tr>
</table></td><td></td></tr>
<tr><td>9.8</td><td>Why do you sort/grade the commodities?
<table>
<tr><td>1.</td><td>For good sale due to grading</td></tr>
<tr><td>2.</td><td>For getting good seeds for next year</td></tr>
<tr><td>3.</td><td>For separating for home consumption and selling</td></tr>
<tr><td>4.</td><td>Others (specify) _______________</td></tr>
</table>
|______|</td><td>Single choice</td></tr>
<tr><td colspan="3">STORAGE</td></tr>
<tr><td>9.9 A</td><td>Do you store following commodities?
1. Yes 2. No
a.Maize |_______|</td><td>Skip following</td></tr>
</table>

<table>
<tr><td></td><td>b.Groundnut |______|
c.Chili (Dry) |______|</td><td>question
9.9B for 2</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>9.9
B</td><td>When did you start to store the crops? How long did you store the crops? Who practices storage?
<table>
<tr><th>Crop type</th><th>1.When after harvest (days)</th><th>2.Frequency of checking crops (once in X days).</th><th>3.Duration of storage (Days)</th><th>4.Grain status:
1. Shelled
2. Unshelled</th><th>5.Storage type
1. enclosed cement structure
2. metal bin
3. bamboo mat
4. clay bin
5. open room
6. hanging
7. sacks
8.other (specify)</th></tr>
<tr><td>a.Maize</td><td>|____|</td><td></td><td>|____|</td><td>|____|</td><td>|____|</td></tr>
<tr><td>b.Grounnut</td><td>|____|</td><td></td><td>|____|</td><td>|____|</td><td>|____|</td></tr>
<tr><td>c.Chili (dry)</td><td>|____|</td><td></td><td>|____|</td><td>|____|</td><td>|____|</td></tr>
</table></td><td></td></tr>
<tr><td>9.1
0</td><td>(Description of a hermetic bag with picture). Are you willing to buy this bag at the price of Nrs 250 rupees (capacity 70 kg) for storage of your commodities?
1. Yes
2. No |______|</td><td>Skip 9.11
for 1</td></tr>
<tr><td>9.1
1</td><td>At what price would you use this service? (Specify)
|_____|</td><td></td></tr>
<tr><td colspan="3">MODULE 10: FEED AND DAIRY</td></tr>
</table>

10.1	Do you keep any livestock for milk production? 1. Yes 2. No |______|	Go to module 11 for 2
10.2	Milk production (liters/day): |_____|	
10.3	Type of feed Given to animal 1. Maize 2. Groundnut 3. Soymeal 4. Other (specify) |_____|	
10.4	Was the feed purchased? 1. Yes 2. No |______|	Skip 10.5 for 2
10.5	How many weeks ago you purchase it? |_____|	
10.6	How do you store your feed? (Please specify) |_____|	
10.7	Who is responsible for storage? 1. Myself 2. Wife/ Husband 3. Son/ Daughter(in-law) 4. Brother/ Sister 5. Parent 6. Other (Specify)	Multiple choice
MODULE 11: CROP SALE PRACTICE (BY CROP)		

<table>
<tr><td>11.
1A</td><td>Did you sell any of the following crops?
1. Yes
2. No
W.Maize |________|
X.Groundnut |_______|
Y.Chilli (Dry) |_______|
ZGreen chili |______|</td><td>Skip 11.1B
and 11.2
for 2</td></tr>
<tr><td>11.
1B</td><td>When did you sell your crops last year? How much quantity of the crop was sold? How much revenue did you get?
<table>
<tr><th>Crop type</th><th>1.When started selling – weeks after harvest</th><th>2.When finished selling -weeks after harvest</th><th>3.Quantity (Kg)</th><th>4.Revenue received (Rs.)</th></tr>
<tr><td>W.Maize</td><td>|______|</td><td>|______|</td><td>|______|</td><td>|______|</td></tr>
<tr><td>X.Ground nut</td><td>|______|</td><td>|______|</td><td>|______|</td><td>|______|</td></tr>
<tr><td>Y.Chili</td><td>|______|</td><td>|______|</td><td>|______|</td><td>|______|</td></tr>
<tr><td>Z.Green chili</td><td>|_______|</td><td>|_______|</td><td>|_______|</td><td>|_______|</td></tr>
</table></td><td></td></tr>
<tr><td>11.
2</td><td>Where did you sell the crops? Did your commodities get rejected because of the quality? Did you have to discount the price due to quality of commodities?
<table>
<tr><th>Crop type</th><th>1.Where
(1. Local Market 2. Distance Market 3. Whole seller 4. Individual 5. Others………………..)</th><th>2.Rejected due to low quality (1=Y,2=N)</th><th>3.Discounted due to low quality (1=Y,2=N)</th></tr>
<tr><td>a.Maize</td><td>|_____|</td><td>|_____|</td><td>|_____|</td></tr>
<tr><td>b.Ground nut</td><td>|_____|</td><td>|_____|</td><td>|_____|</td></tr>
<tr><td>c.Chili</td><td>|_____|</td><td>|_____|</td><td>|_____|</td></tr>
</table></td><td></td></tr>
</table>

<table>
<tr><td colspan="3">MODULE 12: CROP SAMPLES-SAMPLE/COMMODITY SPECIFIC CHARACTERISTICS</td></tr>
<tr><td>12.1</td><td>a1.Sample ID: |____| a2.Crop name:
b1.Sample ID: |____| b2.Crop name:
c1.Sample ID: |____| c2.Crop name:
d1.Sample ID: |____| d2.Crop name:</td><td></td></tr>
<tr><td>12.2</td><td>Are any of the sample (crops/ animal feed) purchased?
1. Yes
2. No
a.Maize |_______|
b.Groundnut |______|
c.Chili (Dry) |______|
d.Animal Feed |______|</td><td>Skip 12.3 for 2</td></tr>
<tr><td>12.3</td><td>Crop variety, brand, quantity and price:
<table><tr><th>Crops</th><th>1.Crop Variety</th><th>2.Brand (If any)</th><th>3.Quantity (kg)</th><th>4.Price (per kg)</th></tr><tr><td>a.Maize</td><td></td><td></td><td></td><td></td></tr><tr><td>b.Ground nut</td><td></td><td></td><td></td><td></td></tr><tr><td>c.Chili</td><td></td><td></td><td></td><td></td></tr><tr><td>d.Animal Feed</td><td></td><td></td><td></td><td></td></tr></table></td><td></td></tr>
<tr><td>12.4</td><td>Origin of crops:
1. Own product 2. Domestic 3. India
4. Distant market 5. China 6. Other (Specify)___________

a.Maize |_______|
b.Groundnut |______|
c.Chili (Dry) |______|
d.Animal Feed |______|</td><td>Go to 12.5 for 2; and 12.6 for 1.</td></tr>
</table>

12.5	If domestic, which district(s) is the product from?	

Crops	**Districts**
Maize	
Ground Nut	
Chili	
Animal Feed	

12.6	**HOW DAMAGED/DISCORLORED DO YOU THINK THE CROP SAMPLES ARE (1 -5 SCALE, 5 BEING MOST OF CROPS ARE DAMAGED/DISCOLORED AND 1 BEING NO DAMAGED CROPS OR NO DISCOLORED CROPS)?**	

CROPS	**DEGREE OF DAMAGE**	**DEGREE OF DISCOLOREDNESS**
Maize	|____|	
Ground Nut	|____|	
Chili	|____|	
Animal Feed	|____|	

12.7	What is the length of time of crops/food commodities were stored after harvesting?	

Crops	**Length of time since harvesting (1= 1month, 2= 1-3 months, 3=3-6months, 4= 6 mnths-1 year, 5= More than 1 year, 6= Don't Know**
Maize	|____|
Ground Nut	|____|
Chili	|____|
Animal Feed	|____|

Thank you!!