



**Post-Harvest Grain Management
Practices and Food Security in Ethiopia:
Farmers' perception of risk, post-harvest management
choices, and their impact on household food security**

**Abebe H. Gabriel
and Bekele Hundie**

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Post-Harvest Grain Management Practices and Food Security in Ethiopia

Abstract

Foodgrains are the single most important source of calorie intake in Ethiopia. Because farmers consume so much of their own grain, most of what is produced does not reach the marketplace. As much as 75 percent of total production is retained for on-farm consumption. This means that farmers must store large amounts of grain from the time it is harvested until it is consumed or sold. Post-harvest losses from pests and moisture are huge, ranging from 5 to 19 percent for maize, 6 to 23 percent for wheat, and 5 to 20 percent for teff, depending on how it is stored and the techniques used to prevent loss. In a country where even the farmers who grow the grain frequently do not have enough to feed their families, losses of this magnitude are critical. Clearly, post-harvest grain management capacities and practices are pivotal in determining the immediate grain disposal behavior of farmers and their effects on food security at household and national levels.

Of the 25 percent of grain that is marketed, close to 80 percent is sold immediately after harvest, when the prices paid to farmers are the lowest in the year. It would make more sense for farmers to retain the grain for sale later in the year when prices usually rise. What role does fear of storage loss play in a farmer's decision to sell grain immediately after harvest?

Efficient and effective grain management practices minimize post-harvest losses at household, community, and national levels. They also generate employment opportunities, add significant value to products, maintain product quality and market stability, and enhance competitiveness of producers in the market place. Hence, they contribute directly to food security.

The purpose of this research project, therefore, is to explore the relationship between post-harvest grain management practices and aspects of food security. More specifically, the research seeks to identify the different post-harvest grain management processes and techniques that farmers use and the underlying reasons for their choice of one set of techniques over others. It also looks at the ways in which farmers' perceptions about post-harvest loss influence their marketing behavior and questions which aspect of risk (physical crop damage or price risk) is more important. It examines whether differences in post-harvest loss among crops are important in determining the relative shares marketed, and which options could enhance food security by improving post-harvest grain management practices and capacities at micro and macro levels.

The study is primarily based on a sample survey of three selected sub-regions in Ethiopia, each of which produces one of the dominant foodgrains (maize, wheat, or teff). A total of 300 farm households are included in the study. Data were collected using a structured questionnaire, interview guides, and group discussions with the participating farmers. Both qualitative and econometric techniques were employed to analyze the data. A Tobit regression technique was used to analyze the way in which various risk expectations and endowment patterns of farmers encourage immediate disposal of crops as marketing behavior.

Results indicate that farmers perceive post-harvest grain loss as an imminent risk, especially for maize, the most vulnerable crop. Application of insecticides, aeration, and

treatment with a solution made of chili peppers are the most widely used techniques for protecting stored crops. Other stock management techniques (such as lending grain to others for repayment later) exist, but they are not widely used.

Tobit regression results suggest that the sale of grains after harvest is triggered both by a temporary need for cash to purchase items for family members, where other sources of cash are limited, and by fear of impending post-harvest grain loss and the limited capacity to prevent it. Consumption expenditure (using grain or cash) during the season immediately following harvest is quite high, not only because taxes and loans must be paid, but also because the post-harvest season is a time when households are pressured to spend lavishly on social ceremonies such as weddings.

Hence, family size, female-headed households, taxes due, and loan repayment schedules are found to be significant variables positively associated with quick crop sales. Ownership of livestock and the capacity to apply chemicals (both indicators of wealth) are negatively associated with immediate crop sales; households prefer to sell livestock and their products to raise cash, rather than selling grain at a low price, and farmers who can afford to treat crops can expect to have lower losses. Cropping patterns suggest that those farmers who cultivate crops more susceptible to pest attacks (for example, maize) are more likely to dispose of their crops immediately after harvest at cheaper prices than those who cultivate less susceptible ones (such as teff).

The study suggests a number of policy options. Liquidity constraints could be relaxed by providing financial credit markets or by rescheduling payments to the government (for land taxes, input loans, and so forth), until later in the season when crop prices are higher. The significance of chemical treatment suggests that input markets should be linked to future product markets. Diversifying cash sources and integrating the production process with markets, so that farmers make more market-oriented decisions, would also help relax liquidity constraints. It is also important that disadvantaged sectors, such as female-headed households and the poor, receive special support, since they are more susceptible to shocks, and that interventions take into account and build on farmers' resources and knowledge.

Interventions to ease farmers' cash flow problems must be complemented by interventions to enhance the capacity of farmers to prevent post-harvest losses, which should be organized at household, community, and national levels. Otherwise, farmers will continue to dispose of grain in any way they can for fear of post-harvest loss.

Since markets often do not perform so efficiently as to achieve an optimal solution, appropriate institutions that enable markets to work better should be introduced. One viable option would be to introduce a grain warehouse receipt system, so that farmers could deposit their marketable surplus there to be sold when prices get higher. More than anything, the introduction of well-managed warehouses in rural villages would reduce post-harvest grain losses, ultimately supporting the effort to ensure national food security.

Drawing on lessons from other countries, policies should be adopted that ease access to finance at all levels in the marketing chain, moderate seasonal price variability, maintain quality standards, promote instruments to mitigate price risks, and reduce the need for government intervention in grain markets as well as the costs of such interventions.

Post-Harvest Grain Management Practices and Food Security in Ethiopia

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Post-Harvest Grain Management Practices and Food Security in Ethiopia

1. Background and Justification for the Study

1.1. The Significance of Foodgrains in Consumption and Production

Foodgrains (cereals, pulses, and oil crops) constitute the major source of food in Ethiopia; they account for 82 percent of total calorie intake¹ and 70 percent of food expenditure (CSA 1988; Abebe 2000:260). Cereals alone provide about 70 percent of the average Ethiopian's calorie intake (Howard et al. 1995). Studies conducted in some parts of the country (Shiferaw 1986; Tesfaye 1989) have reported even higher figures² indicating that foodgrains account for more than 95 percent of total food requirements.

This heavy dependence on foodgrains is well reflected in the cropping patterns. The country's agricultural production is dominated by grain. Out of 16.5 million hectares of land under cultivation, 14.6 million (88.5 percent) are under annual crops (Tefaye et al. 2001).

Grain production in Ethiopia is virtually a smallholder farmer's activity, and yield levels are among the lowest in the world. Studies indicate that only about a quarter of the total foodgrains produced by farmers is marketed (Gabre-Madhin 2001; Abebe 2000; Gebre-Meskel, Jayne, and Shaffer 1998); the bulk of production is retained for on-farm consumption³.

Table 1. Average Area, Output, and Yield Levels of Cereals (1974-99)

Crop	Area (000 ha)	Output (000 qts)	Yield (Quintals/ha)		
			Ethiopia	World Best	World Average
Wheat	665.57	7,787.27	11.71	57 (Holland)	28
Barley	838.97	9,164.25	11.06		
Teff	1,535.83	13,097.21	8.55		
Maize	1,033.11	16,063.96	15.48	74 (New Zealand)	30
Sorghum	837.86	10,134.58	11.92	48 (Spain)	13
Cereals (Total)	5,115.00	57,869.41	11.28		

Source: Ethiopian Economic Association 2002. (for Ethiopia)

Concern over marketed foodgrain surplus has always been at the center of policy formulation and implementation. In the past, the government tried different methods to control the marketing of foodgrains. For example, the state-owned Agricultural Marketing Corporation (AMC), which was established in 1976, fixed grain prices at

¹ The most important grains in terms of consumption are teff, wheat, and maize, which together constitute roughly two-thirds of caloric intake in Ethiopia (Alemayehu 1993).

² A high concentration of cereals (over 75 percent) in food intake is a symptom of an unbalanced diet. Diets high in cereals and tubers are low in micronutrients. (FAO 1998)

³ Of the total grain production, some 72 percent is retained for on-farm uses (Gebre-Meskel, Jayne, and Shaffer 1998).

below market levels and set a compulsory procurement quota. Another effort involved the use of state farms to capture production, since they found it difficult to control marketed surplus of food through markets only (see Abebe 2000: 80–83). That practice lasted for more than a decade, between the late 1970s and early 1990s. However, although state farms allowed the government to directly access and control grain output, their contribution was insignificant, accounting for only 2.8 percent of total cultivated area and 3.6 percent of grain production (Abebe 1990; PMGSE 1984). The AMC had an extensive network of about 2,200 warehouses throughout the country with a total capacity of more than 1 million tons of grains (Alemayehu 1993). With the change in government in the early 1990s, the AMC's importance dwindled. When it was downsized into the Ethiopian Grain Trade Enterprise, its primary role was to manage buffer stocks, acting as a market stabilizer. With pro-market reforms in place, the single most important source of marketed surplus of foodgrains is expected to be the smallholder farmers who also retain a significant proportion of their output for household consumption.

1.2. Post-Harvest Grain Management as a Missing Link

The crucial importance of ensuring sustained levels of marketed food surplus, both in terms of quantity and fair price, cannot be overemphasized if food security is to be attained in Ethiopia. However, government policies have focused more on aspects of production and marketing and less on what happens in between these two processes. For example, supporting increased grain production through improved agricultural technologies has been heavily emphasized. Indeed, efforts to improve grain production technologies have, for some foodgrain crops such as maize, yielded such remarkable results that prices declined dramatically. This, in turn, has generated arguments as to whether market stabilization mechanisms should be introduced to absorb price shocks, thus preventing depressed market prices from acting as production disincentives.

It is often assumed that the bulk of grain output is marketed soon after harvest, which fails to appreciate the fact that most farmers produce foodgrains mainly to provide their households with food, and they only consider selling grain if there are surpluses. Foodgrains are retained for longer periods, with sales staggered over several seasons. Nevertheless, most of the sales are concentrated in the few months immediately following harvest. Estimates show that about 79 percent of farm households' annual grain sales occur in the period between January and March⁴ (Gebre-Meskel, Jayne, and Shaffer 1998). Farming systems that integrate crop and livestock husbandry tend to have a higher capacity to earn cash by rearing and selling of small ruminants (sheep and goats). Taking into consideration the 75 percent retention rate by farmers and the 79 percent concentration rate of sales between January and March, the proportion of grains that are marketed immediately after harvest season amounts to about 20 percent of total production, which also implies that as much as 80 percent of total production is either retained for household consumption or marketed in a seasonally staggered fashion.

⁴ This implies that farmers bear the full price risk in marketing their output, without informal mechanisms to lock in prices and without the financial means to withhold sales to mitigate the fall in prices at harvest (no forward contracts or credits) (see Gabre-Madhin 2001)

In Ethiopia, farm-level storage of grain includes grain pits, underground holes, and sacks. Traders store in small warehouses of varying capacities with poor ventilation and dirt floors (Dadi, Negassa, and Franzel 1992). Moreover, treatment to prevent damage (such as aeration or application of pesticides) is seldom practiced at the farm level, as is advisable, and treatment once damage becomes evident is mostly limited to aeration. This is because the designs of the storage facilities do not allow easy ventilation, or because farmers cannot afford pesticides, or even because treatment facilities are simply not available. Since storage conditions are poor both on the farm and in warehouses, damage to grain from pests and moisture is high. Estimates suggest that the magnitude of post-harvest loss in Ethiopia is tremendous. Depending on the post-harvest handling method, losses range from 5 to 19 percent for maize, 6 to 26 percent for millet, 6 to 23 percent for wheat, and 5 to 20 percent for teff (Dereje 2000). Although storage capacity at the macro level has increased since the enactment of market reforms in 1991, roughly two-thirds of traders indicate that their storage facilities are still inadequate in terms of availability, capacity, and location, with 19 percent of traders reporting in 1998 that they were unable to obtain rented storage space (Gebre-Meskel, Jayne, and Shaffer 1998). Inadequate storage, combined with damage risks, make traders unwilling to store stocks beyond the minimum turnover period.

In Ethiopia, little or no processing is done along the marketing chain. Marketing functions are limited to transportation and minimal storage. Hence, in view of the imminent vulnerability of foodgrains to damage, the risk of loss is high.

Absence of mechanisms for general post-harvest management, including handling and treatment, is probably one of the factors that induce farm households to dispose of most of their grains immediately after harvest, with plans to buy as needed. Unfortunately, cash can be quickly spent in many ways. This, among other things, affects intrahousehold distribution. Grain consumption is distributed among members of households more fairly than cash obtained from grain sales. In many rural areas, marketing (particularly for the purpose of household consumption) is primarily the domain of female household members (housewives). The women sell small amounts of grain, chicken, eggs, butter, and so forth and use the proceeds to purchase household consumption items (such as oil, detergents, salt, and spices). Usually such activities take place throughout the year, in some places as frequently as once or twice a week. When relatively larger sums of money are needed, households resort to selling small ruminants, heifers, or larger volumes of grain. Such transactions are left to the heads of households, who are predominantly men.

Because of a lack of saving institutions in rural Ethiopia, holding stocks of grain at the farm-level may be considered a close substitute for cash banking. And, the convenience of having a stock of grain to draw on all year round may be an important inducement for farmers to hold stocks of grain. It is also expected that farmers' stock management may include the practice of lending or selling grains, at different seasons of the year, to other farmers for later repayment either in kind or cash. Hence, in the absence of well-functioning formal financial institutions, grain stock management may be an important method of assuring household food security.

Therefore, if food loss is to be minimized, the case is strong for a sound post-harvest grain management system. This is especially so for Ethiopia where most of the people are food insecure. It must be recognized that post-harvest grain management practices and capacities (and not just production and marketing) are important for many reasons, including the achievement of food security. Clearly, a better post-harvest grain management system would minimize the size of the loss. This is in addition to the potential employment and income linkage effects and gains from the grain management activities. Nevertheless, very little effort has been made to study post-harvest management practices and capacities in Ethiopia. Those studies that remotely touch on post-harvest aspects only focus on marketing. Understandably, their policy recommendations do not go beyond the improvement of transportation, storage, and information infrastructure, and regulatory frameworks (see, for example, Alemayehu 1993; Wolday 1994, 1999; Bekele and Mulat 1995), with little mention of processing as an important post-harvest grain management activity. A few studies (for example, Jonsso 1972; Dereje 2000) focus on engineering and design aspects of storage infrastructure without any reference to wider perspectives such as food security.

2. Problem Statement

It is ironical that the immediate victims of food insecurity have traditionally been farmers, that is, the very producers of food. Each year, despite weather conditions, hundreds of thousands of rural households suffer food insecurity. They literally depend on food aid for their survival.

The fact that farm households have direct claims on their own production means that they depend less on markets in meeting their food consumption requirements. However, harvest is mostly once a year, or at most twice, with about 95 percent of production coming in at once. Long gestation periods coupled with low productivity levels have the effect of constraining both the flow and quantity of grain available from own production. Consequently, many rural households run the risk of food insecurity for several seasons of a year. Seasonality of food security corresponds closely with food production cycles. Farm households are relatively more food secure in the season immediately after harvest and insecure for longer periods, extending up to the next harvest season. The extent of food insecurity is most severe during land preparation and sowing periods, whereas the seasons following harvest are when the largest volume of grain is available at the household level and also at market levels—since these are the major marketing seasons as far as peasant households are concerned. One of the factors that contribute to a farmer's decision to dispose of foodgrains at once may be the need for cash to pay various dues (to government such as taxes, fees, loans) and to meet social obligations (loans, festivities). Fear of the risk of post-harvest grain loss is another factor.

Both seasonality in grain availability (at household and market levels) and household food security are probably related to farmers' post-harvest grain management systems and capacities. Smoothing food consumption from one season to the next, thus ensuring stability in food availability in markets and food prices, probably depends on an efficient

post-harvest grain management system not only at the household level, but also at the macro (national) level. Unfortunately, this crucial area has not received the attention it deserves. This is probably because of the often easily held assumption that what matters is production, and that success in increasing production and productivity will lead to increased availability of grains both at the household and market levels (see also Goletti and Wolff 1999). It is interesting to note that “the strategy of decreasing post-harvest losses is more economical because it requires smaller inputs per unit of the final product than a strategy of increasing production extensively, especially in the short –run” (Toma, Fansler, and Knipe.1990).

The country’s grain production and price trends clearly demonstrate the failure of post-harvest grain management systems to respond sufficiently to increases in production, so as to stabilize grain markets. Often, boom cropping years are followed by depressed prices. Recent evidence shows that cereal production increased by 19 percent between the 1999/2000 and 2000/2001 crop year. Prices, on the other hand, declined by up to 40 percent (MoA 2001). There were field reports that farmers found it difficult to sell their products since the prices offered were extremely low. This may be partly due to the fact that agricultural commodities are rarely processed before sale to the consumer; they are often marketed as harvested without undergoing any transformation process. This makes storage very difficult for the farmers since most of the commodities are perishable, and farmers generally lack the infrastructure necessary to preserve the commodities from damage. Therefore, it has been witnessed that, at the macro level, the poor post-harvest grain management capacities could not live up to the production expectations, leading to depressed market prices with pernicious disincentive effects on producers. Similarly, at a micro level, the farm households, realizing the poor capacity of their post-harvest grain management systems, tend to dispose of most of their grain immediately after harvest when prices are the lowest of any season in the year. The problems caused by poor post-harvest grain management are similar at both the macro and micro levels: physical crop damage, quality deterioration, and value depreciation. Obviously, the implications for food security at national as well as household levels are of paramount significance for a country such as Ethiopia, where food insecurity has become a structural problem. It is important to examine the post-harvest grain management practices and capacities of farmers and their effects on food security.

3. Purpose and Objectives

The purpose of this study is to explore the relationship between farmers’ post-harvest grain management practices and capacities and the availability of adequate household food supplies.

Specific objectives of the study are to

- i) Identify and document the different post-harvest grain management processes and techniques practiced by farmers and investigate the factors that determine the choice of a given (or a set of) post-harvest grain management technique over other techniques;

ii) Examine the extent to which farmers' perception of risk of post-harvest grain loss influences their marketing behavior. In particular, the study seeks to explain why farmers dispose of most of their output immediately after harvest when prices are low;

iii) Investigate the relative importance of the potential risk associated with physical post-harvest grain losses and price risk in explaining farmers' post-harvest grain management practices and their impact on food security;

iv) Explore the extent to which intercrop differentials in post-harvest risk of loss are important factors in determining the share of marketed surplus of foodgrains.

v) Highlight crucial policy issues that relate to attainment of food security objectives through improvement in the capacities and practices of post-harvest grain management, at both the macro and micro levels of organization.

4. A Conceptual Framework

Post-harvest grain loss is the decline of quality, quantity, or both in grains during the time between harvest and consumption. Reduction of food loss is sometimes considered a "third dimension" to the world food supply equation, along with increases in food production and population (Toma, Fansler, and Knipe 1990). That is, an adequate world food supply depends on food production minus crop losses keeping pace with population growth. Crop losses occur at all stages of post-harvest handling, including pre-processing, transportation, storage, processing, packaging, and marketing. Post-harvest grain losses can be classified as quantifiable (decreases in weight and economic value) and non-quantifiable (decreases in nutritional value, energy, and quality) (Toma, Fansler, and Knipe 1990). In a wider sense, the magnitude of post-harvest loss goes beyond the physical deterioration in quality to include "sunk" cost in terms of the wasted inputs used to produce the lost grain.

As noted earlier, the common forms of post-harvest grain management activities include storage, treatment, processing, and stock management (for example, loans, sales, purchases). In the absence of well-functioning rural savings or credit institutions, holding stocks of grain at the farm level may be considered a close substitute for cash banking. In addition, the convenience of having grain stock to draw upon throughout the year may also play an important role in the farmer's decision to hold stocks of grain. Farmers may also practice a kind of stock management when they lend or sell grains, at different seasons of the year, to other farmers for later repayment—either in kind or cash. Hence, where formal financial institutions do not exist, grain stock management may be an important method of ensuring household food security.

The extent of the post-harvest loss and the management choices differ with crop types. For perishable vegetables, post-harvest losses can go as high as 100 percent (Toma,

Fansler and Knipe 1990). Cereals and pulses are also vulnerable to insect attack at all stages and therefore require continuous protection. Inadequate storage immediately after harvest and before processing adds to the problem. Damage from infestation continues during transportation and the storage period before processing, causing an estimated overall loss of more than 30 percent.⁵ Experts in this kind of analysis cite minimum post-harvest losses of 10 percent for durable crops.

The relationship between post-harvest grain management practices and food security is conceptualized in Figure 1. At the household level, food security can be defined as availability of and sustained access to adequate food. It is determined by the amount of output produced (1, in Figure 1), which is itself a function of an adequate endowment of resources, the amount of post-harvest grain loss (3), and food prices (2).

Grain loss, either in terms of quantity damaged or quality deteriorated, is related to post-harvest grain management practices (5), including storage, handling, processing, and stock management, which in turn are a function of endowment and access to resources including credit (6). The output level may also influence the choice of grain management practices (7), which determines the magnitude of post-harvest grain losses (8) as well as farmer's stock management behavior.

The magnitude of post-harvest grain losses, whether actual or expected, influences farmers' behavior in the marketplace (8); that is, in the absence of working insurance markets, the fear of facing a high risk of grain loss may induce farmers to dispose of most of the grain they produce immediately after harvest, even if they have to repurchase at some future date. Obviously, they then are subject to interseasonal price discrepancies (9), which would affect the level of farmers' income and therefore their access to food (2).

Hence, the level of household food security may be affected directly by the size of the physical loss of grain or indirectly by income lost when grain prices decline as a result of deterioration in quality or inter-seasonal price variations.

5. Hypotheses

Given resource endowments and output levels, it could be hypothesized that poor post-harvest grain management practices would result in a low level of food security through (1) the output effect, that is, a reduction in grain *availability* due to physical losses and involuntary sales, and

(2) the income effect, that is, a reduction in *access* to food because prices received when grains are sold immediately after harvest are lower or prices are higher when grains are repurchased, or the quality of grains deteriorates so that they fetch lower prices.

The following specific hypotheses were suggested to guide the research work.

⁵ See <http://www.unu.edu/unupress/food/8f012e/8f012E0b.htm>

(a) Farmers' perception of risk about post-harvest grain loss influences their marketing behavior, that is, it explains why farmers dispose of most of their output immediately after harvest and at cheaper prices, eventually producing suboptimal outcomes, which result in a low level of household food security.

(b) Farmers' choices of post-harvest grain management practices are conditioned by resource endowment patterns (for example, liquidity constraints), which determine the magnitude of losses. Hence, better-off farmers are likely to choose better post-harvest grain management practices than the poorer ones.

(c) The potential risk associated with physical post-harvest grain losses is more important than the potential risk associated with the market in explaining farmers' post-harvest grain management practices and their impacts on food security.

(d) Intercrop differences in post-harvest risk of loss are important factors determining the share of marketed surplus of food grains; that is, the crops that are mainly marketed immediately are those for which the risk of post-harvest loss is highest.

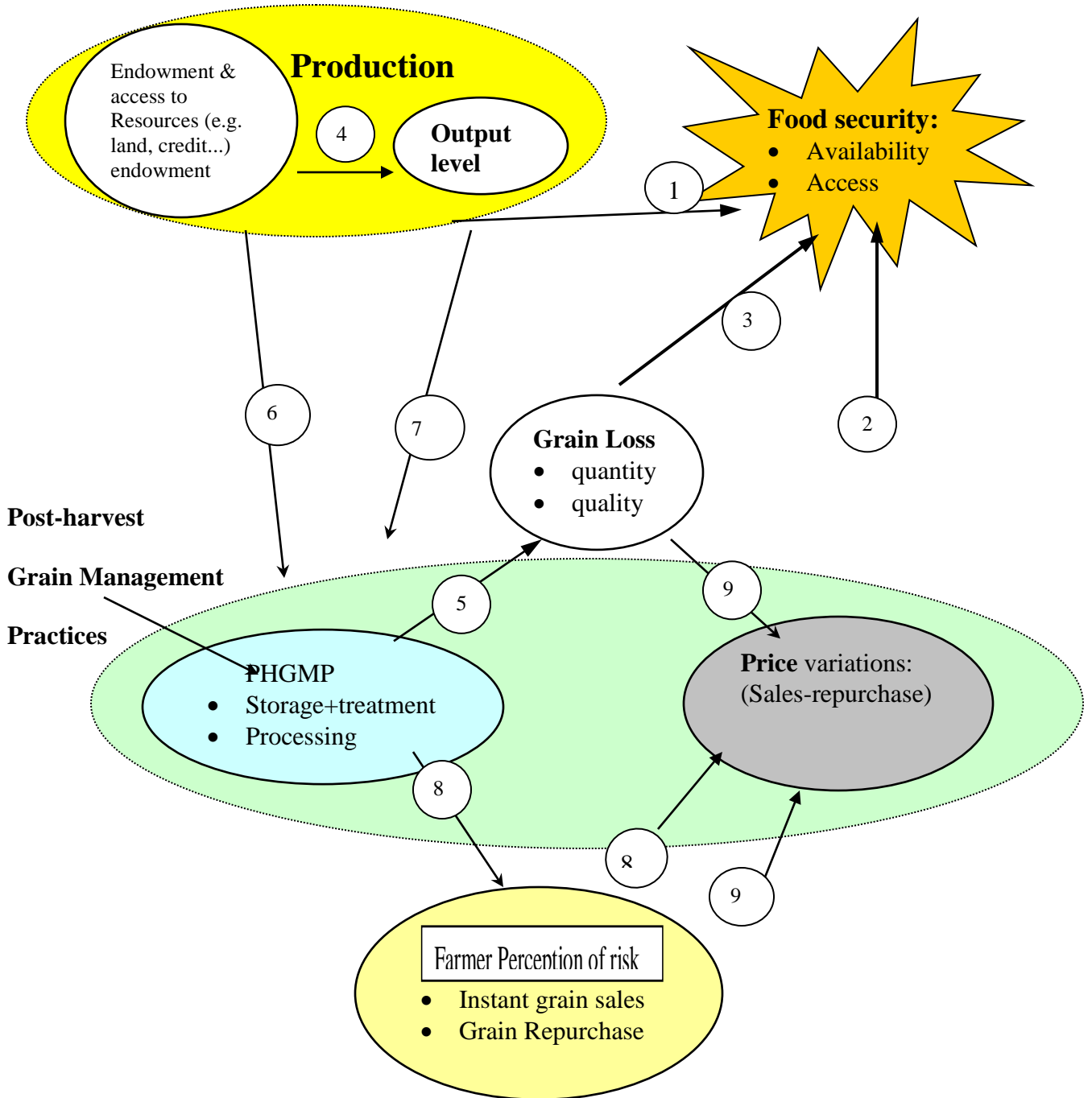


Figure 1. A Conceptual Framework: Post-Harvest Grain Management as a Determinant of Household Food Security Levels

6. Methodology

6.1. Data Requirements and Collection

The study is basically a household-level analysis. Relevant secondary information was collected from the archives of various organizations (for example, the Central Statistical Authority). Field surveys were conducted to collect primary data. The set of information collected included resource endowment patterns, socioeconomic characteristics, production, post-harvest infrastructure, inventory of storage, processing, stock-management practices, losses, food availability, sales, purchases, prices, functions, and importance of rural institutions (formal and nonformal) such as credit, saving, and cooperatives.

Three areas that mostly produce maize (Bako, west of Addis), wheat (Chilalo, south of Addis), and teff (Ada, east of Addis) were included in the study for the obvious reason that these crops are the major food items in the country (together they would constitute two-thirds of total calorie intake). East Shewa and Arssi and, to some extent, Bako (in western Shewa) occupy an important place in the history of Ethiopia's agricultural development for several reasons. First, the regions are better endowed than most with good agricultural potential. Rainfall has been adequate and its distribution normal with reasonable stability, compared with many other areas in the country. Second, they are the most accessible areas within the country. Third, these are among the few surplus-producing regions. Fourth, partly due to the above factors and their proximity to major urban centers, these regions have served as testing sites for a series of "rural development" ventures. Fifth, they tend to exhibit a distinct cropping pattern marked by a relatively high degree of intensification, concentration, and market orientation. The tendency to specialize in the production of distinct cereals is apparent. Their ratio of marketed surplus is one of the highest in the country.

Although the target sites were selected because of their specialization in the three crops (maize, wheat, and teff), data were collected for all other crops grown in the area and the analysis was done accordingly. Two peasant associations (PAs) from each region were purposively considered, making a total of six PAs. These are Oda-Jila and Gode-Finchama in Chilalo; Keteba and Ude in Ada; and Sadan-Kite and Dembi-Gobu in Bako. Each PA provided a list of peasant households, which served as a sample frame for stratification purposes and ultimate selection of sample households. Peasant households were randomly selected after the food-deficit (or poorer) ones were excluded. This is because post-harvest grain management assumes the existence of surplus production over and above immediate consumption, which the poorer households do not have. Fifty peasant households from each PA were selected; hence, a total of 300 households were included in the survey.

Primary data were collected using a questionnaire, interview guides, participatory discussions with focus groups, and informants. Six enumerators (two for each area) were

employed and trained to administer the questionnaire. The researchers undertook a series of discussions with the focus groups and informants and supervised the enumerators.

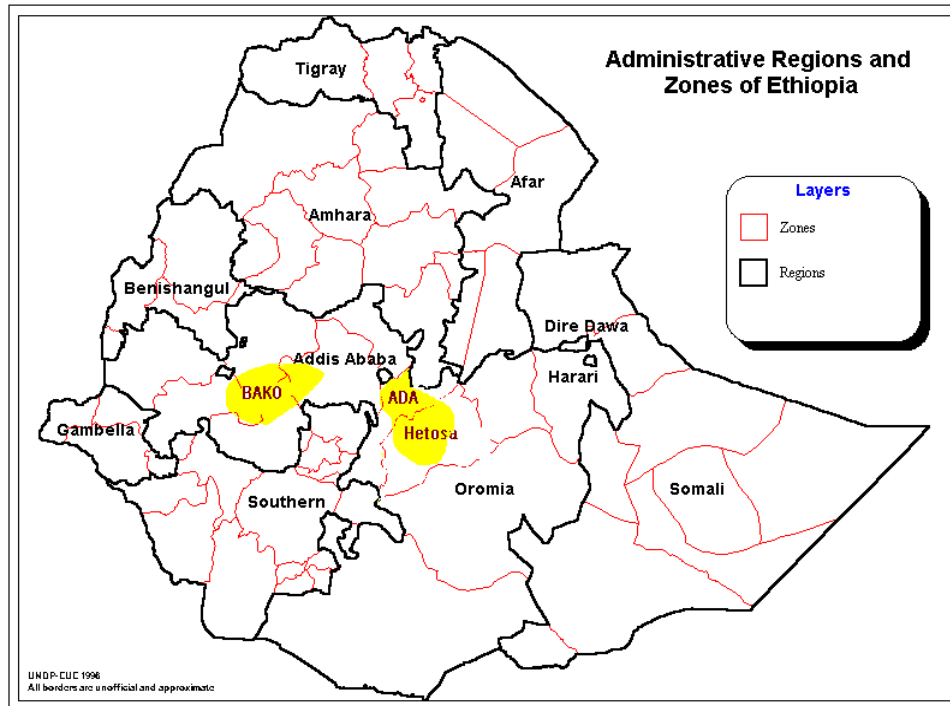


Figure 2: The Study Areas (shaded areas are Bako, Ada, and Hetosa)

6.2. Methods of Data Analysis

Both descriptive (qualitative and quantitative) and econometric methods of data analysis were employed. Farmers were asked to describe in detail their post-harvest grain management systems, as well as production levels, past post-harvest grain losses and their causes, and traditional loss-minimizing strategies, among others..

We wanted to know what factors influenced farmers' grain marketing behavior, in particular, their decision to dispose of most of their grain produce immediately after harvest, and if the risk of post-harvest loss is significant in explaining such behavior. Also we wanted to know if, and in what ways, these decisions are related to household food security issues. Hence, the dependent variable is *farmer's instant disposal behavior* (D_i); while the explanatory variables would be risk of post-harvest grain loss (z) characteristics of the post-harvest grain management practices (m), grain prices (P), household characteristics (W), and farmers' resource endowments (x).

Taking an extreme example, a farmer may decide either to dispose of all of his or her produce during the first quarter immediately after harvest (when prices are at their lowest levels) or to wait until later, in which case sales during the first quarter would be zero.

Hence, the utility associated with each alternative is a function of the independent variables. Denoting U_{il} and U_{io} as the i^{th} farmer's indirect utilities associated with instant disposal and late disposal, respectively, and assuming a linear function (for ease of presentation, taking only two sets of explanatory variables Z and W), we have

$$(1) \quad U_{io} = \alpha_0 + \beta_0 Z_{io} + \gamma_0 W_{io} + \epsilon_{io},$$

and

$$(2) \quad U_{il} = \alpha_1 + \beta_1 Z_{il} + \gamma_1 W_{il} + \epsilon_{il}.$$

The i^{th} farmer tends to dispose of all of his or her grain immediately after harvest if $U_{il} > U_{io}$ and to delay sales to a later season (in this case, beyond the first quarter after harvest) if $U_{il} < U_{io}$ ⁶. Hence, the probability that the i^{th} farmer disposes of all of his or her produce during the first quarter immediately after harvest can be given by:

$$P(D_i=1) = P(U_{il} > U_{io})$$

$$= P[(\epsilon_{io} - \epsilon_{il} < \alpha_1 - \alpha_0 + \beta(Z_{il} - Z_{io}) + \gamma(W_{il} - W_{io}))];$$

$$(3) \quad P(D_i=1) = F(\alpha_1 - \alpha_0 + \beta(Z_{il} - Z_{io}) + \gamma(W_{il} - W_{io})),$$

where F is the distribution function of $\epsilon_{io} - \epsilon_{il}$. If a normal distribution is assumed for $\epsilon_{io} - \epsilon_{il}$, then the model turns out to be a probit or logit one (Amemiya 1985; Maddala 1988).

Expressing D_{it} in terms of the proportion of the volume of sales during the first quarter after harvest (S_{it}) to total sales during the year (Q_{it}), that is, $D_{it} = S_{it}/Q_{it}$,

one could note that the distribution of D_{it} is continuous but tends to behave like a probability; its value tends to lie between zero and one (that is, $0 \leq D_{it} \leq 1$). However, it is also conceivable for D_{it} to assume negative values, in cases where some farmers might purchase grains (instead of selling) during the first quarter after harvest. In fact, this implies that the latent variable can take negative values, in which case the Tobit model is more appropriate to use.

The Tobit model is given by:

$$(4) \quad D_{it} = \begin{cases} \alpha + \beta Z_{it} + \gamma W_{it} + u_{it}, & \text{if } D_{it} > 0; \quad i = 1, 2, 3, \dots, n, \\ 0 & \text{if } D_{it} \leq 0 \end{cases}$$

The problem with the estimation of this model is that Z_i cannot be observed since it is the expected risk of post-harvest grain loss. Hence, specification of a model that explains how farmers form expectations on the bases of actual and past post-harvest grain losses and other observable variables is essential. Theoretically, this learning process in which farmers adjust their expectations as a function of the magnitude of the mistakes they

⁶ There could be indecision if $U_{il} = U_{io}$, but the probability of this is zero if ϵ_{il} and ϵ_{io} are continuous random variables (see Amemiya 1985).

made in the previous period can be expressed as a weighted sum of all past post-harvest grain losses with a geometrically declining weight.

$$(5) \quad Z_{it}^e = \sum_{i=1}^{\infty} \beta_i Z_{it-1}.$$

These models are called distributed lag models of expectations since they consider the entire past history of the decisionmaker with respect to the target variable. If β_i is geometrically decreasing, we can write

$$(6) \quad \beta_i = \beta_0 \lambda^i, \quad 0 < \lambda < 1.$$

The sum of the infinite series is $\frac{\beta_0}{(1-\lambda)}$, and if this sum is equal to 1, then we should have $\beta_0 = 1 - \lambda$. Thus we get

$$(7) \quad Z_{it}^e = \sum_{i=1}^{\infty} (1-\lambda) \lambda^i Z_{it-1}.$$

A further manipulation of equation (7) implies that

$$(8) \quad Z_{it}^e - \lambda Z_{it}^e = (1-\lambda) Z_{it-1}.$$

We can use equation (8) to eliminate the unobserved Z_{it}^e and estimate the resulting equation. That is, lagging equation (5) by one time period and multiplying throughout by λ , we get

$$(9) \quad \lambda D_{it-1} = \alpha \lambda \beta \lambda Z_{it-1}^e + \lambda \gamma W_{it-1} + v_{it-1}.$$

Subtracting equation (9) from equation (5) and using the definition of adaptive expectations model as given in equation (8), we get

$$(10) \quad D_{it}^* = \alpha' + \lambda D_{it-1} + \beta' Z_{it-1} + \lambda W_{it-1} - \lambda' W_{it-1} + u_{it},$$

where $\alpha' = \alpha(1-\lambda)$, $\beta' = \beta(1-\lambda)$, $\gamma' = \gamma\lambda$, and $u_{it} = v_{it} - \lambda v_{it-1}$.

Hence, the Tobit equation that will be estimated becomes

$$(11) \quad D_{it} = \begin{cases} D_{it}^*, & \text{if } D_{it}^* > 0; \\ 0 & \text{if } D_{it}^* \leq 0 \end{cases} \quad i = 1, 2, 3, \dots, n,$$

In fact, Z_i could also be disaggregated into a risk of loss in quantity and prices, and the relative importance of either of these elements of risk in explaining instant disposal of grains by farmers could be detected. It is important to note that a higher level of D_{it}

reduces the household level of food security, especially if this is the result of some involuntary process this is because it does not make any economic sense to dispose of a larger proportion of one's produce immediately after harvest at the lowest price level.

6.3 Definition of Variables

Nine explanatory variables are included in the Tobit regression estimation. Each explanatory variable is described below. Appendix Table 1 presents the mean values of continuous explanatory variables and the proportion of 1s for the dummy explanatory variables.

Table 2: Description of Variables

Variable	Code	Definition/expectation	Expected sign
Household size	FSIZE	High demand for cash to meet nongrain or nonagricultural consumption needs of the household members triggers larger sales during the first quarter.	Positive
Gender	SEX	A dummy variable, which takes a 1 if the household head is male and 0 otherwise. It is expected that male-headed households tend to market their crops earlier than female-headed households.	Positive
Education level	EDUC	The highest level of formal education achieved by a member of the household. Education is expected to influence the decision to sell grain in such a way that those households with higher education levels are hypothesized to demonstrate better- informed sales decisions and vice versa. Proportion of grain sales during the first quarter is expected to be lower for those households with better education.	Negative
Chemical application.	CHEM	A dummy variable that takes on a value of 1 if a household used chemicals to reduce post-harvest grain loss and 0 otherwise. Application of pesticides is expected to reduce the risk of post-harvest grain loss, thus reducing instant grain sales.	Negative
Storage capacity	STCAP	Estimated total nonbag storage capacity owned by households. With larger capacities of granaries, the proportion of grains to be sold during the first quarter is	Negative

		expected to be less.	
Livestock ownership	TLU	Total livestock owned by households expressed in terms of Tropical Livestock Units. Standard conversion factors have been used for different categories of livestock (see Appendix Table 2). Livestock ownership is expected to reduce instant crop sales since households may resort to livestock (and/or livestock products) sales to meet cash needs.	Negative
Expectation of losses	EXPLOSS	The proportion of output that farmers expect to lose due to storage pests (or other factors) if grain crops were to be stored until prices rise substantially (in this case until the third quarter). It is hypothesized that fear of risk of loss might cause farmers to sell their crops sooner rather than later.	Positive
Intercrop differences	PRICDIF	The difference in average prices of grains that prevailed between the third quarter (July to September, when highest) and the first quarter (January to March, when lowest) measured in birr per kilogram ⁷ . On the one hand, this variable captures the market risk element; i.e., as the difference increases farmers postpone their sales until later, when prices actually get higher; and conversely, as the price difference narrows, farmers prefer to sell their crops sooner, since waiting is associated with a higher risk premium, especially since post-harvest grain loss could be larger. However, since the price differences are the same for each location (not household-specific), each household's risk perception is not captured; therefore, this interpretation might be misleading. On the other hand, since price differences are largest for teff and smallest for maize, this variable might capture the intercrop differences (could be considered crop dummies). In this case, the variable takes on a negative	Positive

⁷ Since we could not generate grain price data at the household level, we used the average of grain wholesale prices for each location. Prices of the major crop in each location are considered since farmers use these crops as “cash” crops (teff for Ada, wheat for Hetosa, and maize for Bako).

		coefficient, suggesting a tendency toward instant sales for Bako and delayed sales for Ada (capturing the intercrop differences in susceptibility to post-harvest grain losses).	
Liquidity constraints	TAXLOAN	The total monetary value of grains sold to cover dues such as repayment of input loans and/or land taxes. It is expected that farmers' instant crop sales are largely involuntary but triggered primarily by the need to pay the government for input loans, land taxes, or the like.	Positive

7. Empirical Results

7.1. Description of Survey Findings

7.1.1. Farm Resources and Grain Production

Grain production in Ethiopia is almost entirely based on rain-fed agriculture and is characterized by a dominant harvest (*meher*)—generally around November and December—and a secondary harvest (*belg*)—around May and June. Of course, production cycles vary among different agro-ecological zones. The study areas depend on *meher* production of cereal crops.

Land is the major farm resource in the study areas, and it can be accessed in two ways: via land allocations by PAs and through informal land markets. About 98 percent of the sample households were allocated some land by their PAs.] In addition, 51 percent of the households also acquired some of their farm plots through sharecropping or rental arrangements. Few of the sample households (5 percent) shared or rented out their farm plots during the year surveyed. The small proportion of farmers who shared out their land reflects the bias in the sampling procedure toward relatively better-off farmers, who usually seek additional land. As discussed in the methodology section, the selection of better-off farmers was deliberate because the basic research problem, post-harvest grain loss, assumes that there is surplus production, and therefore, surplus-producing farmers.

On average, cultivated area per household is about 2.7 hectares. This is on the high side for the area, which perhaps reflects the importance of informal land markets. That is, since the farmers included in this study are relatively better off, they tend to have leased in land from resource-poor farmers. Significant variations exist among the three sites vis-à-vis the average area allocated to production of different crops. Table 3 shows the cultivated area under major crops included in the study during the 2002/03 main harvest period. Grains, largely wheat, teff, and maize, take the lion's share of total cultivated land: 65 percent in Hetosa, 47 percent in Ada, and 75 percent in Bako.

Livestock is the other important asset owned by the sample households. The study areas are characterized by mixed farming and almost all sample households own some livestock. Various types of animals are reared including large and small ruminants, pack animals (equines), and poultry. An average livestock holding, excluding poultry, is 11 animals per household, which is equivalent to 8.5 tropical livestock units (TLU).⁸ Almost every household owns at least two milking cows and three oxen, which again reflects the relatively better resource endowments of the sample households.

Livestock is an important source of income for the sample households. More than one-half of the households sell either livestock or livestock products to generate cash revenue. On average, a household generated about 460 birr from the livestock subsector in the year under consideration⁹. Households enumerated various reasons for selling livestock and their products; the main ones included repayment of input loans (28.1 percent of households) to replace old animals (19 percent of households), to purchase household equipment and furniture (14.3 percent of households), and to cover expenses related to education and health (9 percent of households).

Table 3. Average cultivated land area (hectares) of major crops per household

Crops	Hetosa		Ada		Bako	
	Area	Percent of total	Area (ha)	Percent of total	Area (ha)	Percent of total
Teff	0.052	1.79	1.17	46.54	0.20	7.69
Wheat	1.88	64.56	0.80	31.82	0.00	0.00
Maize	0.27	9.27	0.024	0.95	1.95	75.00
Sorghum	0.14	4.81	0.0	0.00	0.23	8.85
Other crops	0.57	19.57	0.52	20.68	0.22	8.46
Total	2.91	100.00	2.51	100.00	2.60	100.00

7.1.2. Post-harvest Grain Management Practices and Losses

(i) Farmers' Grain Management Practices

Unlike mechanized farms where mowing and threshing can be undertaken simultaneously, grain harvesting on these farms involves mowing of crops using sickles and threshing by letting a group of animals trample upon them on level ground until the grains and the shaft are separated. Harvesting of maize is different in that the ears are removed by hand. Several days may elapse before crops are threshed; that is, crops stay piled for some time either around the homestead or *in situ* before threshing. In many cases, losses during the harvesting process are significant (as a result of attacks by

⁸ TLU is a standardized measure of livestock numbers. (see Abebe 2000).

⁹ This amount doesn't include the revenue generated indirectly from livestock use, for instance, by renting out draft animals to others.

rodents and pests, moisture, livestock, and the like.).The length of time that crops are kept piled up varies among crops. Usually, crops that are susceptible to loss (such as pulses) do not stay long, while other crops (such as teff) may be piled up for a long time. The amount of time that crops are piled up also varies depending on the household’s food and financial requirements: those with immediate needs would thresh their crops at once.

Farmers use various methods and types of facilities to store their crops after they are threshed or shelled. Maize may be stored either shelled or unshelled. In the latter case, maize is shelled manually a little at a time as required for consumption or sale. Hired machines are used to shell maize, especially when production is large. The traditional grain stores identified in the study areas include *gotera* (grain pits), bags (made of polyethylene, sisal, or goat skin),¹⁰ and earthen pots. More than 70 percent of the respondents use polyethylene bags and sacks made of sisal, while about two-thirds use *gotera* (Table 4). For storing large quantities for longer periods, farmers prefer *gotera*. Some farmers also use pots and small granaries entirely made of mud. Slight variations have been observed among the three sites vis-à-vis the proportion of farmers using each type of storage: *gotera* are widely used in Bako, whereas bags (or sacks) are commonly used to store grain in the other two sites, perhaps suggesting that farmers store grains only temporarily in Ada and Hetosa.

Table 4. Type of stores used (by number and percent of respondents)

Type of Storage	Hetosa		Ada		Bako		Total	
	No.	%	No.	%	No.	%	No.	%
Bags/ sacks	93	94.9	84	84.0	33	33.0	210	70.5
Gotera	73	74.5	49	49.0	80	80.0	202	67.8
Pots	14	14.3	9	9.0	5	5.0	28	9.4
Underground pits	1	1.0	-	-	-	-	1	0.3
Others	4	4.1	32	32.0	18	18.0	54	18.1

Farmers acquire their grain stores in different ways. The majority of *gotera* users construct them, reflecting a weak dependence on markets. In most cases, *goteras* are constructed from flexible materials (such as bamboo trees) and are mud-walled and thatch-roofed. Although not common, farmers could purchase these traditional granaries from local markets. The average owner estimated the monetary value of the *gotera* at about 62 birr, with figures ranging from 10 to 500 birr. The value of a store depends upon its capacity and the materials used for its construction. Polyethylene bags and sacks (made of sisal) are commonly purchased from local markets. In fact, farmers use fertilizer bags to store grains after the bags have been used. The average estimated monetary value of these containers is 3.25 birr. We have also observed some higher figures (up to 35 birr) probably indicating the value of *silicha*, which are relatively durable. Other small

¹⁰ This traditional container is commonly known as a *silicha*, and it is estimated to hold 50 to 60 kilograms of grain. Making *silicha* is a special skill, and care is required when the goat is skinned.

traditional granaries are mostly self-made. These are usually used to store seeds or grains produced in small quantities and their estimated values range from 4 to 30 birr.

Table 5 shows the number of grain stores owned by peasant households and their storage capacities. The average storage capacity of the sample households is 3.27 metric tons, enough foodgrain storage for one, or possibly two, production seasons. If all kinds of storage mechanisms (temporary and fixed) are considered,¹¹ few households can store more than 5 metric tons of foodgrain. If, on the other hand, bags and sacks are excluded from the analysis, the average storage capacity per household could be reduced to 2.52 metric tons. This is quite low compared with the average volume of total grain produced (4.39 metric tons), indicating that storage is constrained in the survey areas. To put it in a different way, about 79 percent of the farm households did not have adequate fixed stores for their produce. A disaggregated analysis by site shows a more detailed picture (Table 6). While fixed stores could absorb more than three-quarters of total output in Hetosa and Bako, these are not widely used in Ada, possibly because teff, the major crop in Ada, is relatively less susceptible to storage pests (particularly weevils). Hence, it can be readily stored in bags, or even sold at once. This is clearly not the case in Hetosa and Bako, where the bulk of grain production is wheat and maize, respectively, which are more susceptible to storage pests.

Table 5. Number and capacity of grain stores owned by households

Storage type	Number		Capacity (MT)	
	Mean	Maximum	Mean	Maximum
Gotera	1.6	8	2.105	26.0
Bags/sacks	12.9	200	0.739	11.0
Pots	0.5	7	0.025	2.5
Others	2.7	96	0.385	20.0
Total			3.27	37.0

Table 6. Storage capacity compared with total grain production

Study Sites	Total Capacity (MT)				Total output (MT)
	All Stores	Percentage ^a	Fixed Stores	Percentage ^a	
Hetosa	4.74	102.6	3.52	76.2	4.62
Ada	1.69	39.4	0.78	18.2	4.29
Bako	3.41	80.2	3.35	78.8	4.25
All Sites	3.27	74.5	2.54	57.9	4.39

^aStorage capacity as a percentage of total grain produced.

¹¹ Strictly speaking, bags and sacks are not permanent grain stores. Rather they are used to store grains, that will be sold in the market quickly.

Grain losses could arise from poor post-harvest handling or from production beyond the capacity of available stores or both. When production exceeds total storage capacity, two options are available to solve the problem: instant disposal of the excess produce (through sales or loans.), or increase of storage capacity. If grain markets are demand-constrained, or supply is price-elastic, as it is in the case of grains, immediate sale after harvest will have a price-reducing effect. Hence, this option seems to be less preferable for producers. At the study sites, however, about two-thirds of the sample farmers resort to selling their grains whenever production is in excess of their storage capacity.

Grains may be stored outside as well as inside residential houses. The majority of the respondents (71.6 percent) reported that they locate their stores inside their homes to protect grains from theft and moisture. Others store grains outside because they believe the outdoor environment provides better aeration, keeping crops for longer periods without damage from insect pests. Locating grain stores outside the home also has another advantage: it frees up space in the living room that would otherwise be crowded with grain, especially after harvest.¹² Since *gotera* occupy a larger space, they are commonly located outside.

(ii) Post-harvest Grain Losses

The majority of the farmers (93.3 percent) perceive an imminent risk of grain loss from attack by storage pests or other factors if they store their crops for longer periods. The minimum expected average amount of loss per household for all grain crops is about 150 kilograms for Ada (where teff, the least susceptible crop, is dominant), whereas the maximum expected average amount of loss per household is more than 800 kilograms for Bako (where maize, the most susceptible crop, is dominant). Also as can be observed in Figure 3, there is large variation about the median in post-harvest grain loss in Hetosa and Bako, as compared with Ada, again indicating the intercrop differences in post-harvest grain losses. In some cases, the magnitude of loss even goes as high as 2,000 kilograms.

The respondent farmers reported to have actually lost large quantities of their produce to various factors (Table 7a). The average actual loss per household (as opposed to expected loss) was about 500 kilograms of total grain output during the previous year, which is equivalent to 12 percent¹³ of the average total grain production of the sample households. Farmers in Bako reportedly lost about 700 kilograms of crops and those in Hetosa, 620 kilograms, due to post-harvest damage, while the figure for Ada was much less. Of course, these variations reflect differences in cropping patterns among the three sites and, therefore, the higher degree of susceptibility for maize and wheat than for teff. The reported amount of loss is quite substantial, underscoring the importance of not only raising yield levels, but also ensuring that all of the grain produced reaches consumers'

¹² In most cases peasants live in traditional huts having a single room in which the whole family dines and sleeps; the same room may also be used to prepare food.

¹³ Other studies (Coursey and Proctor (n.d)) have reported wheat loss (by weight) ranging from 8 to 52 percent for India, 6 to 19 percent for the Sudan, and 15 to 20 percent for Brazil.

tables without loss. Hence, yield-enhancing interventions cannot be considered in isolation from those that minimize post-harvest grain losses.

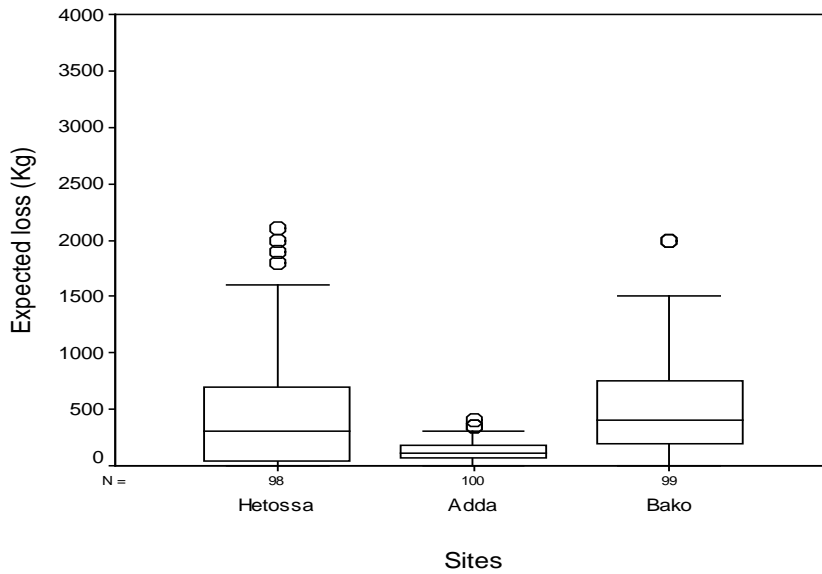


Figure 3. Distribution of expected loss if grains are stored until the fourth quarter

Table 7a. Estimated grain loss during 12 months preceding the survey (kgs. by site)

Study Areas	Mean	SD	CoV
Hetosa	618	438.6	0.71
Ada	237	308.9	1.30
Bako	707	1118.6	1.58
All Sites	520	744.0	

Table 7b. Estimated grain loss during 12 months preceding the survey (kgs. by crop)

Major Crops	Mean	SD	CoV
Wheat	243	360.0	1.48
Teff	106	179.7	1.70
Maize	501	930.0	1.86
All Crops	520	744.0	

As can be seen in Table 7b, maize is the most affected crop, that is to say, on average a maize-producing household lost 501 kilograms of maize during the 12 months preceding the survey period. The average loss by wheat producers was 243 kilograms. Teff, as expected, was less susceptible to post-harvest loss than wheat and maize. On average, the sample households lost about 106 kilograms of teff.

Taking the nominal average producer price¹⁴ that prevailed during the year 2002 for the three crops, the amount of loss in birr would be 244, 185, and 360 for wheat, teff, and maize producers, respectively. As can be seen, the variations narrowed down to price differentials; teff and wheat fetched higher prices than maize. It can also be seen that estimated grain losses for the three crops are less than the estimated losses for all crops in the region ; perhaps such variations suggest that post-harvest losses of other crops such as pulses might have been large.

Defining the shelf life of grain crops as the number of months in which they can be stored without loss in quantity or quality, shelf life varies depending on a number of factors: the type of storage infrastructure, type of crop, weather conditions, treatments made to reduce loss, among others. In the study sites, grain crops can reportedly be stored on average for about 7 months without loss. Of course, the shelf life may increase to about 10 months if the grains are treated with chemicals. The sample farmers reported that grains, particularly maize, could turn into powder in a few months due to weevils if the grain was not treated with insecticides. The longest average shelf life was reported for teff (with or without chemical treatment) and the smallest was reported for maize (without chemical treatment) (Table 8). It is also apparent from the figures that maize can only be stored for a relatively short period of time (half a year) even if it is treated with chemicals.

Table 8: Estimated shelf life of selected crops with and without chemical treatment

Crop	Estimated Shelf Life (Months)	
	With chemical treatment	Without chemical treatment
Teff	Not applicable	19.0
Wheat	11.5	6.4
Maize	6.9	2.8

Among the reported causes of the post-harvest losses experienced by the peasant households are attacks from weevils and rodents and moisture or growth of molds, with weevils the most commonly reported cause (Table 9). Rodents, moisture, and molds are also important in areas such as Hetosa and Bako.

¹⁴ Producer prices were computed from various CSA reports; average producer prices for 2002 for wheat, teff, and maize were 100.2, 174.6, and 71.9 birr per 100 kilograms.

Table 9. Causes of grain loss identified by respondents (percent)

Causes	Hetosa (N=98)	Ada (N= 100)	Bako (N=100)	All Sites (N=298)
Rodents	28.2	18.9	59.1	30.8
Weevils	90.4	82.2	95.3	87.7
Moisture/molds	22.6	11.4	45.7	22.5
Others	1.1	1.9	9.4	3.3

Note: Figures indicate percent of respondents who reported each cause of grain losses.

The most important preventive techniques used by the surveyed farmers were chemicals and aeration (Table 10). The majority of the sample farmers (83.2 percent) used chemicals to reduce grain losses from pest attacks, especially on maize and wheat, which are susceptible to weevils. In addition, a quarter of the farmers reported using aeration. Grain management practices such as lending to others and selling and repurchasing later were not widely used. Some farmers also reported that they used various indigenous methods to reduce post-harvest grain losses due to pest attack. For instance, in Bako and Hetosa, grains (especially maize and wheat) are mixed with chili peppers to repel storage pests. Blaum and Abate (2002) also report on this practice. However, the effectiveness of such practices has yet to be confirmed by scientific research.

Table 10. Techniques used by farmers to reduce grain losses

Techniques Used	Percentage of households (N = 298)
Aeration	25.1
Use of Chemicals	83.2
Sell and repurchase latter	0.8
Lend to others	1.1
Others (including indigenous techniques)	8.5

Farmers were asked if they knew techniques other than those they have been practicing so far. The objective was to explore whether farmers have other options by which they could reduce grain losses. While the majority (71.4 percent) replied that they did not know any other techniques, nearly 30 percent reported that they were aware of the existence of various post-harvest grain management techniques, but they did not apply them for various reasons. For example, more than 50 percent of the interviewed farmers did not utilize those “other” techniques because they perceived the methods they were already using to be more effective in reducing grain losses.

7.1.3. Grain Marketing Practices and Patterns

Ninety-nine percent of all farmers reported that they sell some crops under normal conditions. Some farmers also purchased grain crops; about 40 percent of the respondents purchased crops using their previous savings. Crops are usually sold in a staggered pattern across the quarters of a year. Table 11 shows the share of total grain output

produced that is marketed. The share of marketed surplus to total output for Hetosa was 40 percent; for Ada, 63 percent; and for Bako, 48 percent. With the exception of Ada, more than one-half of total production does not reach the market; it is consumed within the farm household. That farmers do produce a large assortment of crops and sell some proportion (not most) of it reflects the extent to which production is oriented toward household consumption rather than sale. However, the proportion of total production that is marketed—the extent to which a given crop resembles a “cash crop”—varies among crops as well as sites. A considerably higher proportion of total production of the major crops, wheat, teff, and maize, was marketed, compared with other crops in Hetosa, Ada, and Bako. Obviously, these three crops are dominant in terms of area cultivated as well as output. For example, 65 percent of the total cultivated area in Hetosa was allocated to wheat production, and about 42 percent of the output was marketed. Similarly, of the total cultivated land in Ada, 47 percent was allocated to teff, while 32 percent was allocated to wheat production; the proportion of teff that was marketed was 67 percent and the share of wheat marketed was 57 percent. In Bako, 75 percent of the land cultivated was allocated to maize, and 44 percent of the output was marketed.

Table 11 Percentage of crops marketed of total output produced

Crops	Hetosa	Ada	Bako
Teff	0.0	67.0	3.9
Barley	0.0	14.1	---
Wheat	41.9	57.4	---
Maize	5.2	0.0	44.0
Sorghum	1.5	---	12.6
Horse bean	1.8	14.6	0.0
Field pea	1.8	11.2	---
Chickpea	0.0	47.4	---
Others	0.0	31.9	29.1
All crops	39.7	63.2	48.3

On aggregate levels, the proportion of actually marketed output during the first quarter of 2002 was about 51 percent of total marketable surplus for the entire year. The average percentage of crops sold declines as one moves from the first quarter to the fourth quarter (Figure 4a). To the contrary, the producers’ prices tend to rise as one moves from the first quarter through to the third and, in some cases, even during the fourth quarter (Figures 4b–4d).

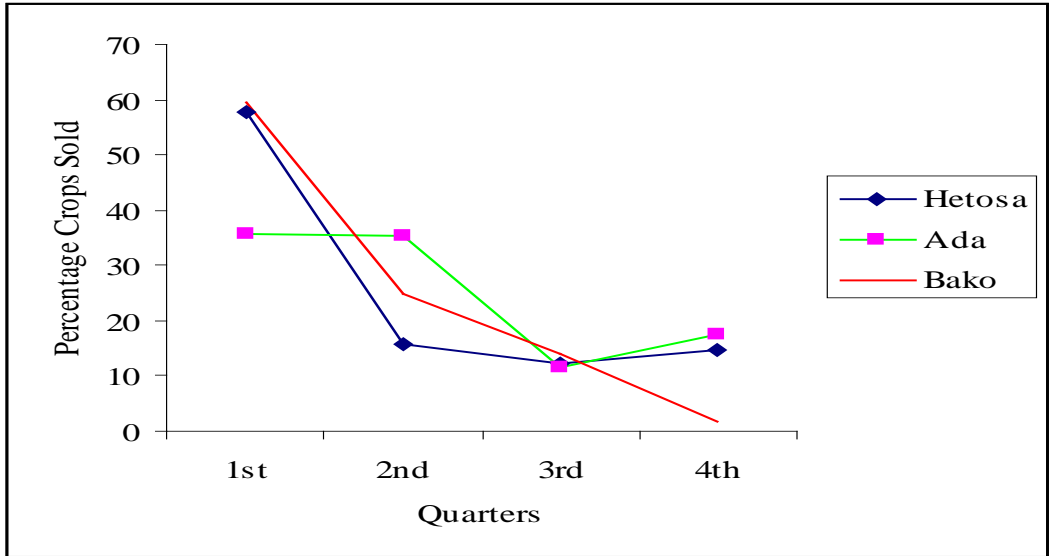


Figure 4a. Movement of crop sales by quarter (percentage of total sales)

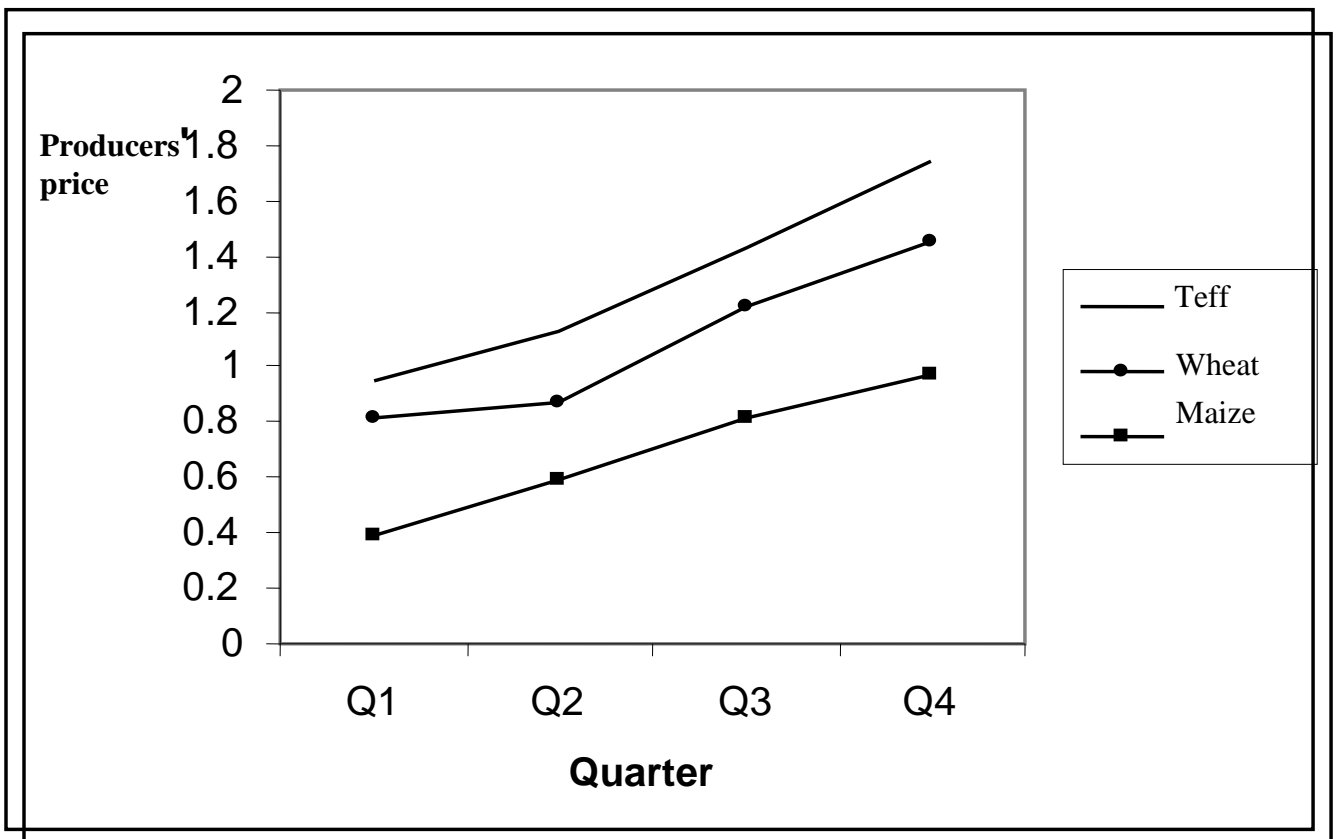


Figure 4b. Movement of producers' prices of selected crops (2002 Bako area, 2002)

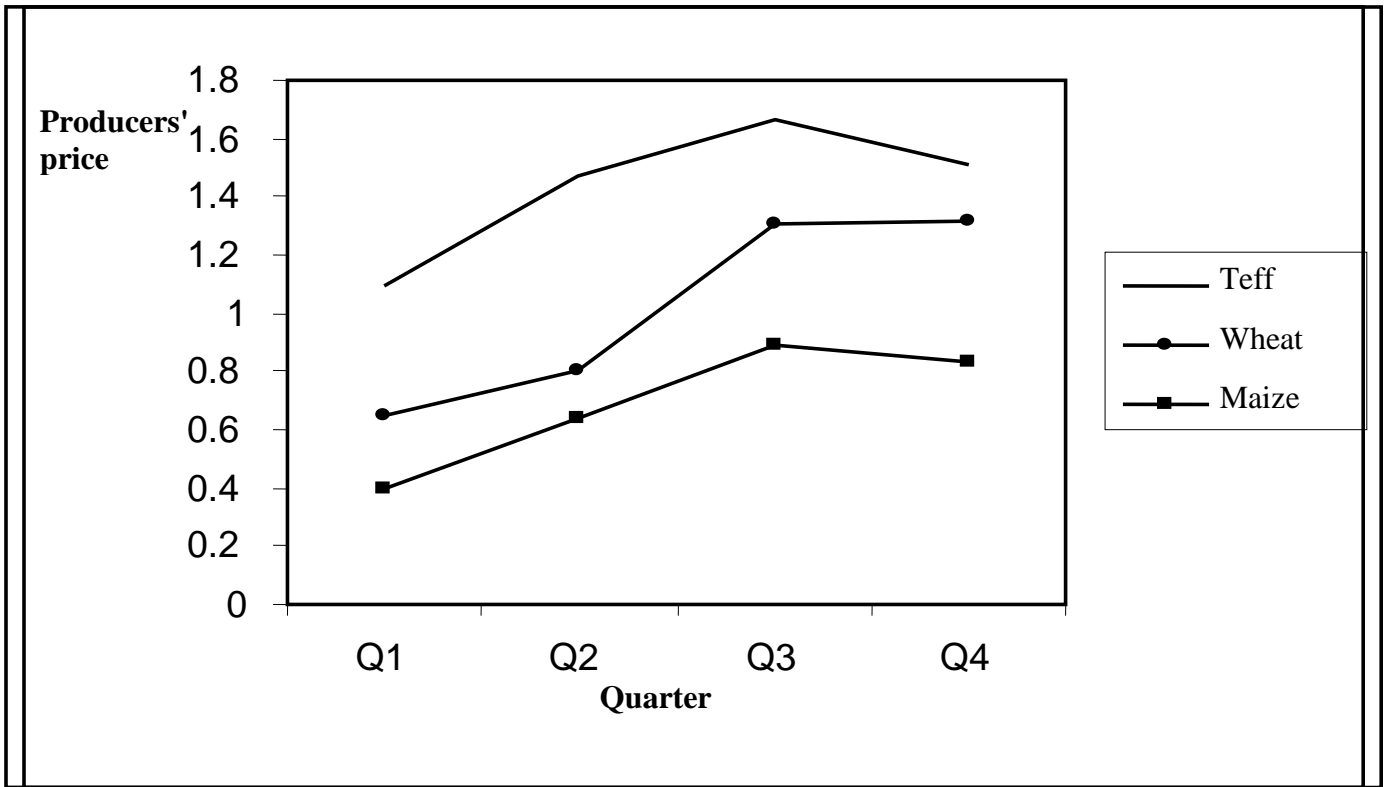


Figure 4c. Movement of producers' prices of selected crops (Hetosa area, 2002)

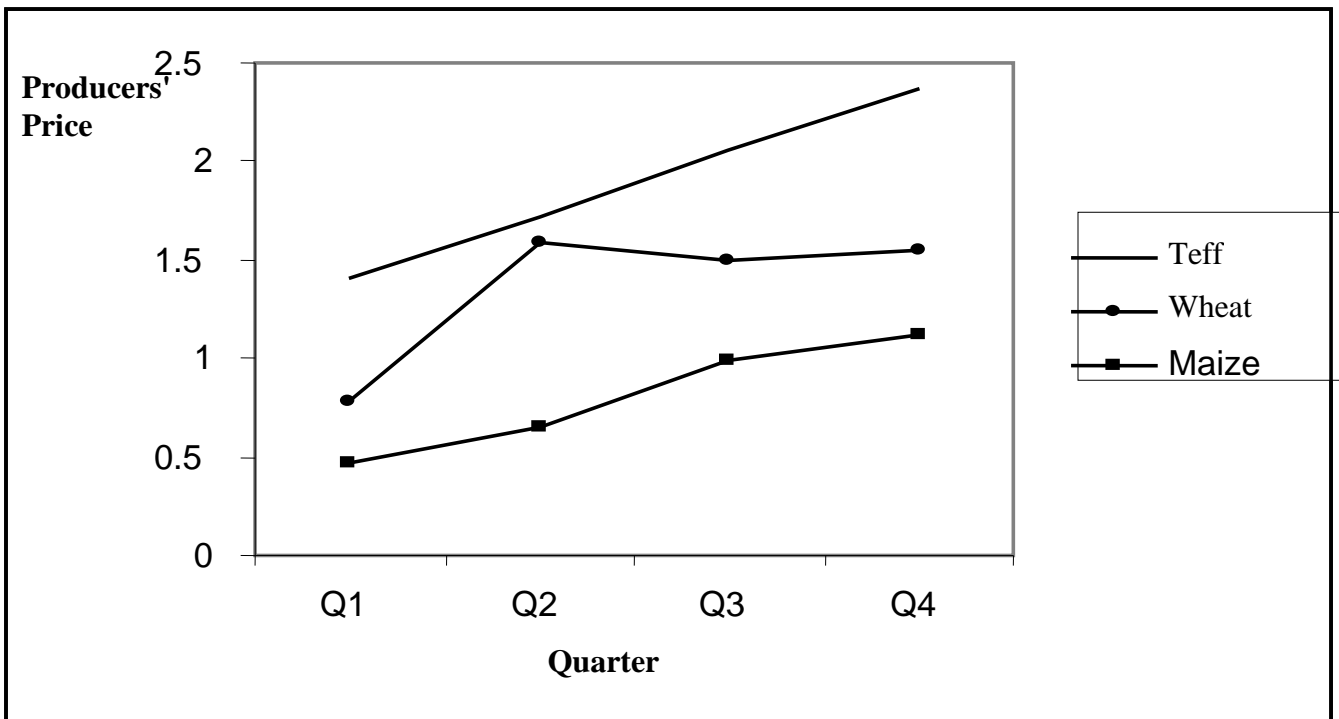


Figure 4d. Movement of producers' prices of selected crops (Ada area, 2002)

Also, the proportion of crops sold during the first quarter varies considerably among the three sites. . The average figures are higher for Hetosa and Bako than for Ada, indicating that farmers in the former two sites sold the bulk of their crops immediately after harvest (Table 12). It is worthwhile to note that farmers are unorganized in their sales decisions; hence they lack bargaining power to deal with traders who have better resources, information, and coordination to influence market outcomes.

Table 12. Crops sold as a percentage of total crop sales in a year (by quarter)

Quarter	Percentage of Crops Sold			
	Hetosa	Ada	Bako	All Sites
1 st Quarter (January-March)	57.6	35.8	59.5	50.9
2 nd Quarter (April-June)	15.9	35.4	24.9	25.5
3 rd Quarter (July-September)	12.3	11.4	13.9	12.5
4 th Quarter (October-December)	14.6	17.6	1.8	11.1

Farmers knew about the general pattern of seasonal price fluctuations. The farmers reported that they were aware that prices would increase after the first quarter, especially during the lean season. Why then would they want to sell a large proportion of their marketable surplus immediately after harvest when prices are the lowest in the year?

One important reason could be the high demand for cash during the first quarter. As indicated earlier, that particular season is the time when farmers need money to settle financial obligations including repayment of loans and taxes and to meet social obligations (such as marriage, religious festivals, and other ceremonies). For instance, the interviewed farmers reported that about 33 percent of the gains from grains marketed during the first quarter went to finance repayment of input loans or to pay land taxes or both.

The other important reason might be fear of the risk associated with post-harvest grain losses. The majority of the interviewed farmers viewed post-harvest problems as matters of grave concern.

The commonly held view, which happens to be true most of the time, is that crop prices will be lowest during the first few months following harvest; then they will rise monotonically until they reach the maximum during the months of July and August, after which they start to decline in expectation of a new harvest in a few months' time. But, what happens to the pattern of prices following a bumper harvest? Prices monotonically decline during the months in which they normally peak. They may be depressed even further if another good harvest is expected. This is what actually happened in 2001(see Figure 5 a, b, and c).

The year 1999 was followed by expectation of a good harvest in 2000. Prices increased consistently from January until September for all crops; then they started to fall. Maize prices dropped earlier than wheat and teff prices because the harvest season is earlier for maize. But the decline of prices after October in all crops is associated with expectation of the next harvest in 2000.

Now compare this with what actually happened to prices in 2001. It is the reverse of the previous story. Instead of rising, prices declined steadily, only picking up after October when it became known that a bad harvest seemed likely the following season. In fact, the harvest was so bad that much of the country faced famine in 2002/03. This illustrates the extent of market failures. Crises occur both when the harvest is good and when it is bad. On the one hand, when the harvest is good, especially when it is matched with high expectations for the next season, grain prices tend to be depressed. Storing grains might not be advisable. Since prices may not get better even during lean seasons. On the other hand, during normal years, storing of grains until the third quarter might pay, if the risk of grain loss is minimized below market risks.

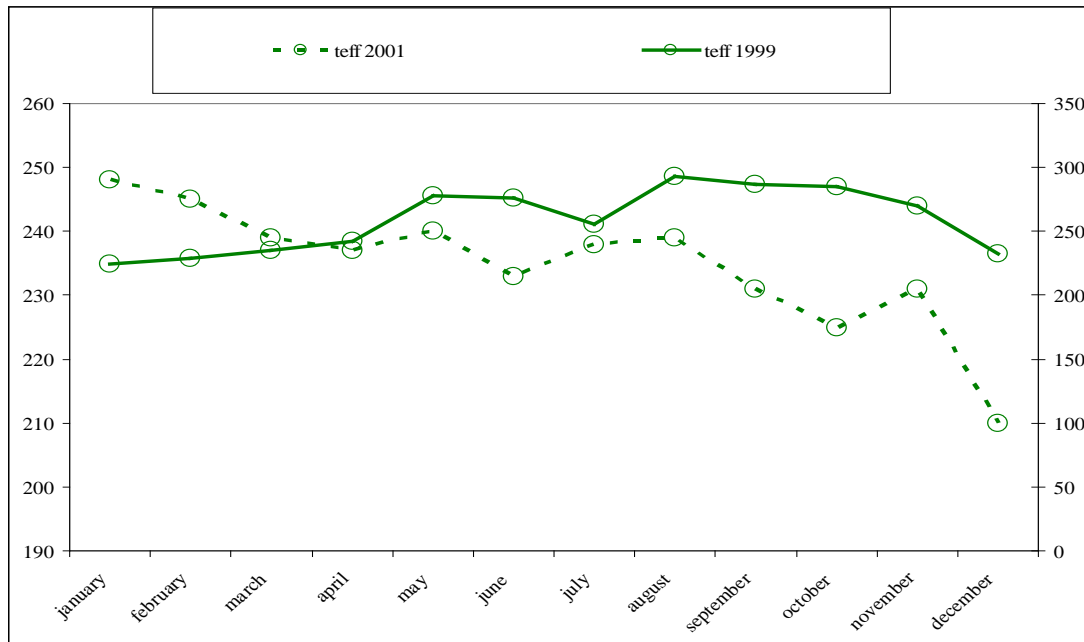


Figure 5a. Monthly average wholesale prices for teff (birr/100 kgs.), 1999 and 2001)

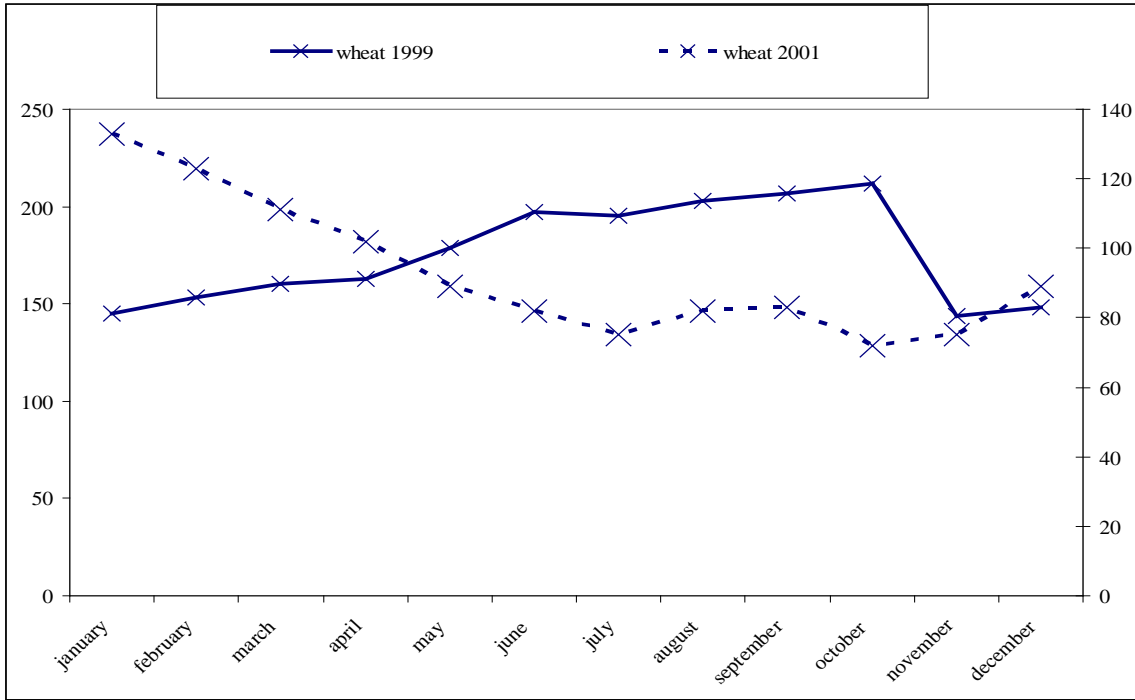


Figure 5b. Monthly average wholesale prices for wheat (birr/100 kgs., 1999 and 2001)

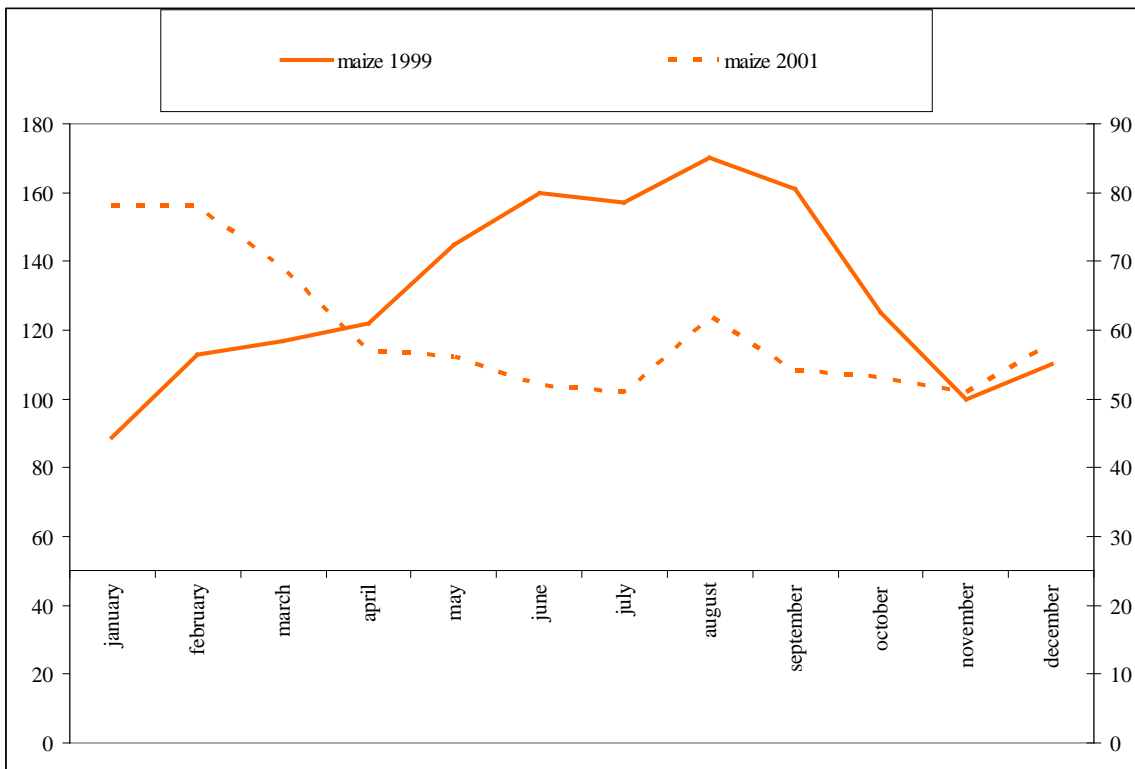


Figure 5c. Monthly average wholesale prices for maize (birr/100kgs., 1999 and 2001)

Source: Central Statistical Authority, various issues.

When grain prices are substantially reduced, it discourages farmers from applying chemicals to prevent pest attacks, leading to even larger crop losses than usual. This is because the marginal benefit as a result of chemical treatment could be less than the marginal cost of the treatment. For example, during the 2001/02 crop season, maize prices were reduced by as much as 80 percent, as a result of a 40 percent increase in output. Under such circumstances, crop prices might be so unattractive that farmers would not even pay the transport charges to take their grain to the nearest market place for sale.

7.2. Regression Results

Table 13 presents the Tobit regression results. Note that nonbag storage capacities were not significant. Education also was not significant in explaining variations in the dependent variable. Similarly, farmers' expectations of grain loss were found to be not statistically significant.

Table 13: Regression results (Tobit estimates: the dependent variable is the proportion of sales during the first quarter to total sales during the year)

Variables	Coefficient	t-ratio
Constant	0.7694*	6.296
FSIZE	0.0135**	2.119
SEX	-0.1407***	-1.926
EDUC	0.0014	0.303
CHEM	-0.0762**	-2.440
STCAP	-0.0011	-0.183
TLU	-0.0084**	-2.547
PRICDIF	-0.3026**	-2.429
EXPLOSS	0.0984	1.081
TAXLOAN	0.0001*	3.150
Sigma	0.2598	
Number of samples	292	
Log likelihood function	-30.9562	

*, **, *** Significant at 1 percent, 5 percent and 10 percent levels, respectively.

A total of six variables turned out to be significant in explaining the variations in the proportion of crop sales during the first quarter to total sales by households. Moreover, with the exception of the SEX variable, the signs of all of these variables are also according to a priori expectations, leading to the following conclusions:

- (i) The pressure on households, triggered by large family sizes, to meet nongrain purchased consumption needs tends to force farmers into immediate crop sales;
- (ii) Female household heads are more likely to sell crops immediately during the first quarter than male household heads. This may be ascribed to fewer options available to female-headed households in terms of resorting to other sources of cash income (for example, livestock sales);

- (iii) Application of chemicals (insecticides) reduces the risk of pest attack and the tendency to instant sales;
- (iv) Livestock ownership reduces the pressure to meet cash needs by selling crops, because households tend to resort to sale of livestock and its products rather than crop sales;
- (v) Intercrop differences are important explanatory variables for households' behavior in sales decisions; that is, farmers who mainly grow maize (a more susceptible crop) and wheat are more likely to sell quickly than those who mainly grow teff (a less susceptible crop); and
- (vi) Households' need for immediate cash to meet various obligations explains why they are willing to dispose of their grain crops when prices are lowest.

8. Conclusions

8.1. Summary of major points

Ethiopia is a structurally food-deficit country that depends heavily on food aid. Production of adequate food crops to achieve food security at national and household levels is a strategic food policy objective of the country. Post-harvest crop loss is a problem that adds to the difficulty of meeting these objectives by reducing the quantity, quality, and hence value of the crops produced. In a sense, it is a waste of effort and resources. Farmers, not wanting to take the risk of losing large amounts of their output, tend to sell a large proportion of their marketable surplus during the season immediately following harvest, when prices are actually depressed. Despite their strategic significance, not much attention has been paid to post-harvest grain management practices. Studies are not generally available.

Efficient and effective grain management practices minimize post-harvest losses at household, community, and national levels. Apart from reducing crop loss, good management practices generate employment opportunities, add significant value to products, maintain quality, enhance competitiveness in the market place (at both the local and national levels), and help maintain market stability, to mention just a few.

The purpose of this study was to identify the post-harvest grain management techniques that are actually practiced by farmers and to determine the extent to which farmers' perception of risk (market and post-harvest grain loss) influences their grain marketing patterns. Three areas, each known for production of one of the three major grain crops in Ethiopia were selected for the study: Ada for teff, Bako for maize, and Hetosa for wheat. A survey of 300 sample farm households was conducted to collect the relevant data. Both descriptive and econometric (Tobit regression) analyses of the data were conducted.

Clearly crop losses are not limited to the post-harvest period. In fact, substantial grain losses also occur before and during mowing and threshing of crops. It should also be noted that the magnitude of post-harvest loss should go beyond the deterioration in quantity and quality of grain crops to include costs associated with of the inputs used to produce the lost grains. However, the scope of the present study is limited to what happens after harvest. The findings of the study are summarized below.

Storage capacities are found to be quite limited: fixed structures are available to store only about 58 percent of the average volume of total output. About 80 percent of households reported that they did not have adequate fixed storage structures; they use temporary packing materials such as sacks for storage. So, one of the reasons for immediate sales after harvest is the lack of adequate storage. Two-thirds of the households said they resort to such sales when production exceeds their storage capacity.

There is a widespread perception among farmers that post-harvest grain loss is an impending risk. Expected post-harvest grain losses per household varied substantially from a minimum of 150 kilograms to more than 2,000 kilograms, depending on crop type and season. Actual post-harvest grain losses per household reported during the 12 months preceding the study period varied from about 240 kilograms in the Ada area (where teff is the dominant crop) to about 700 kilograms in the Bako area (where maize prevails). On average, about 12 percent of grain production was reportedly lost after harvest while in storage. Assuming that this accurately portrays the proportion lost at the national level, prevention of this amount of loss could substantially reduce the food deficit.

Some crops such as maize cannot be stored longer than three months before they are attacked by storage pests (notably, weevils). Since processing is not common, treatment with chemicals and other indigenous techniques are practiced to reduce these grain losses. Aeration and treatment with chili peppers are the most common indigenous techniques used by farmers. Other stock management techniques exist but they are less important.

The proportion of marketed surplus to total grain output for Hetosa, Ada, and Bako was found to be 40 percent, 63 percent, and 48 percent, respectively. A considerably higher proportion of total production of the major crops, wheat, teff and maize, was marketed compared with other crops grown in Hetosa, Ada, and Bako. On aggregate levels, the proportion of actually marketed output during the first quarter of 2002 was about 51 percent of total marketable surplus for the entire year¹⁵. The average percentage of crops sold declines as one moves from the first quarter through the fourth quarter, while grain prices tend to rise as one moves from the first quarter through to the third and, in some cases, even during the fourth quarter.

¹⁵ The figures for marketable surplus of grains are significantly higher than the national average reported elsewhere (26 percent), whereas the percentage of actually marketed grain crops during the first quarter immediately after harvest is lower than the national average reported elsewhere (79 percent). This reflects the upward bias in the selection of regions and sample households, which was on purpose.

Tobit regression was used to identify the factors that explain why farmers would resort to instant sales at lower prices. The proportion of actual sales during the first quarter (following harvest) was regressed on a number of explanatory variables including family size, sex of the household head, education level achieved, chemical usage to reduce pest attack, storage capacity, livestock ownership, expectation of loss, interseasonal price variations, and financial dues owed to the government including taxes and repayment of input loans.

Results indicate that sales of crops immediately after harvest are triggered by (1) a temporary need for cash to pay off debts or make purchases and (2) by concerns about impending post-harvest grain loss and the limited capacity to prevent it. Hence, the variables family size, female head of household, and tax and loan repayment schedules that coincide with the harvest were found to be significant and positively associated with early crop sales. However, livestock ownership and the capacity to apply chemicals (insecticides), both indicators of wealth, were also found to be significant but negatively associated with early crop sales. Cropping patterns suggest that those who cultivate crops that are more susceptible to pest attacks (such as maize) are more likely to dispose of their crops immediately after harvest at lower prices than those who cultivate less susceptible ones (such as teff).

8.2. Policy Implications

In Ethiopia, policy has focused on production and marketing of foodgrains, while post-harvest grain management practices have been almost completely neglected at both macro and micro levels. Therefore, very little capacity exists for efficient and effective post-harvest grain management systems at national, regional, community, or household levels. As a result, grain markets are characterized by high interseasonal and intertemporal volume and price fluctuations. Although the incidence of food insecurity is high, Ethiopia has lost an important opportunity to reduce post-harvest losses.

Hence, it is important for policymakers to consider post-harvest grain management a strategic policy concern. They must become more aware of the problem. In particular, they must view post-harvest grain management practices not only from the perspective of lost food security, but also as an economic activity with employment, value, and income linkages.

Liquidity constraints and impending risk of post-harvest grain losses were the two most important factors explaining farmers' tendencies to sell their grain crops instantly. The selling and repurchasing of grains as a post-harvest management practice was found to be less significant. As it stands now, neither grain credit or output markets can be relied upon, and market risks are substantial. Lending grains to others was also found to be less important as a stock management strategy in the context of an imminent risk of post-harvest loss, perhaps because the demand for grain on credit is lower during the period immediately after harvest. One would expect that the demand for borrowed grain would come from rural households whose grain production was inadequate or those with insufficient cash to buy grain at the market. Demand for grain credit is the least during

the first quarter and the highest during the third quarter after harvest—a pattern that strictly follows grain price levels.

Policies to relax liquidity constraints might include efforts to improve access to credit and rescheduling due dates for payments to the government so that they fall due later in the year, when crop prices are better. In other words, mechanisms linking credit markets to grain markets should be sought, enabling farmers, for example, to take cash loans in the post-harvest season to cover their various obligations. Repayment could be scheduled for later seasons when prices pick up. Diversification of cash sources and integration of the production process with markets would allow farmers to make decisions that are more market oriented rather than subsistence driven. Policies to support disadvantaged sectors such as female-headed households and the poor are also important, since they are more susceptible to shocks.

But these policies must be complemented by interventions to enhance the capacity of farmers to prevent post-harvest losses, at household, community, and national levels. Otherwise, farmers may dispose of their grains any way they can and as soon as they can to avoid storage losses, in which case they may be unable to repay their loans, making the matter even worse. Because chemical treatment has proved so effective, it is important to link input markets to future product markets. Interventions also need to take into account and build on farmers' resources and knowledge including indigenous techniques.

The problem is that quite often markets do not perform well. Hence, there is clearly a need for introducing and strengthening appropriate institutions to enable markets to work better. One viable option would be to introduce a grain warehouse receipt system, so that farmers would deposit their marketable surplus to be sold when prices are higher. There are legitimate reasons to suspect that increased production and availability could lead to an increase in household consumption, instead of in marketed surplus. We know that farmers produce grain primarily for their own consumption, not for sale. One reason why the warehouse receipt system of grain management and forward grain markets make a lot of sense, in addition to preventing post-harvest loss, is that they promote monetization of production and facilitate processing. As the experiences of other countries have shown, there are also a number of other advantages including easing access to financing at all levels in the marketing chain, moderating seasonal price variability, maintaining quality standards, and promoting instruments to mitigate price risks. They also help reduce the need for government intervention in grain markets as well as the costs of such interventions¹⁶ (see Coulter and Onumah 2002). Above all, the introduction of well-

¹⁶ In a warehouse receipt system (WRS), farmers store their marketable surplus (/or any part of their produce not required for immediate consumption) in a modern warehouse located in their village. To certify their deposit, they receive a receipt from warehouse managers that indicates the type and amount of produce they stored. A WRS facilitates the development of an efficient and accessible rural financial system and helps introduce an inventory credit system. farmers can obtain formal credit by pledging their grain deposits. This allows peasants to progress from being “pricetakers” to being “price negotiators” and to operate successfully in the local market economy. At present, due to high seasonal grain price fluctuation, inventory credit may be profitable because interseasonal price differences can adequately cover storage costs. Nevertheless, in the long run, as agricultural markets become more efficient, grain price fluctuations will be reduced, thereby making inventory credit infeasible. In the long –run, peasants

managed warehouses into rural villages would reduce post-harvest grain losses, ultimately supporting the country's effort to ensure national food security.

Although not reported as a variable in this study, the need to encourage attitudinal changes, regarding consumption versus saving and accumulation cannot be overemphasized. Expenditure and consumption of grain are quite high during the season immediately following harvest, compared with the farmers' standard of living the rest of the year. Farm households often sacrifice much of the grain they produce to pay for weddings and other social ceremonies. A shift of emphasis to saving could improve farmers' lives and the economic stability of the country as a whole. Finally, more in-depth studies are needed to inform policy on credit and saving options (including options for introducing grain warehouse receipt systems), traditional methods of grain treatment (including research on their effectiveness, economy, and health effects), and farm and nonfarm linkages and the scope for the development of agro-processing industries, including small-scale, farmer-managed grain processing technologies.

will become commercial farmers who may adopt a different way of running farm businesses. Therefore, it is important to note that the introduction of an inventory credit is a means to an end rather than an end in itself. The introduction of improved farmer-managed warehouses in rural areas may also improve agricultural marketing; it may help farmers to hold commodities for later sale when prices are higher. It will also enable peasants to supply raw materials year-round to small-scale food processors uniformly, which paves a way for the development of rural small-scale industries. Furthermore, the WRS will facilitate an efficient and effective grain marketing system, since marketing functions such as grading and standardization will be more applicable in rural areas. (Coulter and Onumah 2002). However, sufficient care needs to be exercised if grain warehouse systems are to achieve intended results. For example, Berg and Kent (1991) state that cereal banks were bound to fail because of basic misconceptions in their design and implementation. Gunther and Muck (1995) say that some conditions must be imposed if cereal banks are to operate successfully. They should (a) consider and help meet the needs of the users;(b) provide social cohesion in the target village; (c) provide human, financial, and technical resources with management support; and (d) be profitable.

Appendix: Supplementary Tables

Appendix Table 1: Descriptive statistics of the explanatory variables

Variable	Mean (Percentage with value 1 in case of dummy variable)	SD
SEX	94.50	-
FSIZE	8.00	2.6394
EDUC	7.58	3.6309
CHEM	56.60	-
STCAP	2.55	2.9747
TLU	8.44	5.4844
EXPLOSS	0.12	0.1827
PRICDIF	0.63	0.1419
TAXLOAN	654.40	753.5430

Appendix Table 2: TLU conversion factors

Type of Livestock	Conversion Factor
Ox	1.00
Cow	1.00
Heifer	.75
Young bull	.80
Calf	.20
Sheep	.13
Goat	.13
Horse	1.10
Donkey	.70
Mule	1.00

Source: Abebe 2000.

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