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Addis Ababa/Ethiopia

Does it Pay to Invest in Postharvest Management?

An Ex-Ante Cost Benefit Analysis of Reducing Maize Storage Losses in Darimu Woreda, Ethiopia

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Acronyms

BCR	Benefit Cost Ratio
CBA	Cost Benefit Analysis
CFS	Committee for World Food Security
CHF	Swiss Francs
CIMMYT	International Center for Maize and Wheat Improvement
COP	Community of Practice
DAI	An International Development Company
ERR	Economic Rate of Return
FAO	Food and Agriculture Organization
HPLE	High Level Panel of Experts
IFAD	International Fund for Agricultural Development
IRR	Internal Rate of Return
NPV	Net Present Value
PICS	Purdue Improved Cowpea Storage
PHM	Postharvest Management
SAA	Sasakawa Africa Association
SDC	Swiss Agency for Development and Cooperation
SGB	Super Grain Bag
WFP	World Food Program

Abstract

Experiences show that it is technically possible to reduce postharvest losses to a considerably low level. However, technical feasibility is just one of the factors determining adoption. One other decision making criteria for adopters is the profitability of the new alternatives vis-a-vis the already existing practices. In economic terms, it makes sense to promote/adopt the new technology if the benefit justifies the associated costs. This is why an ex-ante cost benefit analysis (CBA) was conducted in one of the 14 project woredas in Ethiopia where an SDC supported PHM project is under implementation.

The major source of data for this analysis was a household survey with a standardized questionnaire that was administered to a total of 90 farmers in Darimu Woreda of Oromia National Regional State. Sample farmers were categorized into small, medium and large based on their quantity of maize production since the costs and benefits of reducing maize storage losses are directly related to volume of production. The analysis was done both at household and woreda levels.

The parameters used in the analysis are the Net Present Value (NPV), the Internal Rate of Return (IRR), the Economic Rate of Return (ERR) and the Benefit Cost Ratio (BCR).

The NPV of using super grain bags and metal silo was Birr 32,859 and Birr 23,449 respectively for the large maize producers in Darimu Woreda assuming a discount rate of 15%.

Although metal silo resulted in higher incremental maize income as compared to super grain bag, super grain bag had a much higher NPV for all the three farmer categories. This is apparently because of the significantly higher cost associated with the purchase of metal silo.

While metal silo had an IRR of 49%, 45% and 51% for large, medium and small maize growers respectively, it was not possible to apply IRR to cash flows related to use of super grain bag since the net cash flow was positive from year one. With regards to Benefit Cost Ratio (BCR), again, super grain bag resulted in more than four times higher values as compared to metal silo.

For determining the NPV at Woreda level, an economic discount rate of 10% was used. The Net Present Value of the investment in Darimu Woreda was found to be Birr 998,379,379 or CHF 45,957,861. The Economic Rate of Return was 250% and the Benefit Cost Ratio was around 253. All these show that investing in improved storage management pays off significantly.

Sensitivity analysis was done to assess the changes in the value of CBA parameters, assuming the percentage of storage loss reported by farmers was overestimated. The CBA was rerun assuming the actual current loss was lower than what was reported by farmers by 25%. However, the conclusion made above that it pays to invest in storage improvement at household level remains unchanged. Similar result was also found for the sensitivity analysis at Woreda level.

The analysis of data collected from Darimu Woreda, which is a major maize growing area in Oromia Region, shows that improved storage practices have clear economic advantage over the traditional practices with super grain bags performing better than metal silos.

1 Introduction

Reducing postharvest losses has been given a particular attention since the food price crises of 2008, with food security experts determined not to leave any stone unturned in search of solutions. It has become one of the global food security related topics and has been reported on by the High Level Panel of Experts (HPLE) designated by the Committee for World Food Security (CFS) in 2014. The major impetus behind the argument for reengaging in reducing postharvest loss is its potential contribution many experts see in improving food security and household income. Consequently, in recent years, a number of organizations are scaling up their investment in Postharvest Management (PHM).

Building on its successful experience in Central America[2], the Swiss Agency for Development and Cooperation is supporting Post Harvest Management projects in Sub-Saharan Africa and Latin America in addition to the initiative to establish a Community of Practice (COP) at global level in collaboration with FAO, IFAD and WFP.

In Sub-Saharan Africa[3], the projects use a wide range of intervention strategies which span from purely technological approach to socio-economic perspectives, knowledge management as well as policy interventions.

Past experiences show that reducing postharvest losses to a significantly low level is technically feasible. However, uses of appropriate management practices have costs, and in economic terms, it makes sense to promote/adopt these practices if the benefit justifies the associated costs. This is why an ex-ante cost benefit analysis (CBA) was conducted in one of the 14 project woredas in Ethiopia where an SDC supported PHM project is under implementation.

A cost benefit analysis can be done at household, project, and national level and can serve different purposes. In general, it is a tool for decision making at various levels and it can also be used for advocacy purposes. Moreover, it is a useful tool for assessing aid effectiveness by showing whether value for money can be achieved through the selected interventions. However, it is important to note that CBA is one of the decision making tools and final decision to adopt a giving technology will require the adopter to consider other factors as well.

This study presents the analysis that was done at farm household and project (Woreda[4]) levels and provides insights into the payoffs that can be realized by investing in PHM, particularly improved maize storage, in Darimu Woreda of Oromia National Regional State. Specifically, this report presents the ex-ante cost benefit analysis of adoption of super grain bags and metal silos.

2 Methodology

The project in Ethiopia is being implemented in Tigray, Amhara, Oromia and Southern Nations Nationalities and People's Region on four crops – Maize, Wheat, Sorghum and Haricot Bean. This case study was carried out at one of the 14 project woredas in Ethiopia, Darimu, which is located in Illuababora Zone of Oromia Region, and is a major maize growing area in the country. Maize is one of the major staples and also the most susceptible grain to storage pests. According to the information from the Woreda Bureau of Agriculture, the total population size was estimated to be 186,464 in 2013.

The major source of data for this analysis was a survey done using a standardized questionnaire. The questionnaire was administered to a total of 90 farmers that were selected using purposive[5] random sampling from three Kebeles[6] in the Woreda. Data from six questionnaires were discarded during data

[2] http://www.sdc-foodsecurity.ch/en/Home/Focus_areas/Post_harvest/POSTCOSECHA
[3] Benin, Burkina Faso, DRC, Ethiopia, Kenya, Malawi, Mozambique, Tanzania, Uganda, Zambia, and Zimbabwe.
[4] The hierarchy of governance in Ethiopia is: Federal>Region>Zone>Woreda>Kebele.
[5] Farmers in the Woreda are categorized by the development agents in to A, B or C based on the level of improved inputs they use. Equal numbers of randomly selected farmers were interviewed from each of these categories.
[6] AKebele is the smallest local administrative unit of the government. The Kebeles covered in this study are Boto, Gobe and Jarso

entry and cleaning due to factual errors. The sample farmers were categorized into small, medium and large based on their quantity of maize production since the costs and benefits of reducing maize storage losses are directly related to volume of production. Those farmers who produce up to 15 quintals of maize were categorized as small maize growers and in the medium group were those who produce more than 15 quintals with the upper limit set at 32 quintals. The larger group was composed of those who produce more than 32 quintals of maize annually (Table 1).

Table 1: Categorization of farm households based on quantity of maize production

Farmer Category	Maize Production per Year (Quintals)	Sample Size (n)
Small	≤ 15	31
Medium	>15 & ≤32	23
Large	>32	30

Types of data collected from farmers using the questionnaire include household level annual production of maize as well as monthly data on maize consumption, sale, purchase and storage loss.

Data were also collected from the Woreda Office of Agriculture. The types of data obtained from this office include, but not limited to, area under maize production, maize yield and total volume of production and monthly average price for maize in Darimu.

The analytical method applied in this analysis draws on the models developed by DAI for the purpose of conducting a CBA on a similar project in Southern Africa. Adjustments have been made to this model to accommodate the reality in the study area.

The parameters used in this analysis are the Net Present Value (NPV), the Internal Rate of Return (IRR) and the Benefit Cost Ratio (BCR) using market prices in the case of households.

A NPV of an investment is the present (discounted) value of future cash inflows minus the present value of the investment and any associated future cash outflows. In this case study, NPV was calculated based on a stream of incremental benefits of improved maize storage practices and incremental costs of the same and using a social discount rate of 15%[7].

IRR is defined as the discount rate that causes the present value of the project costs to be equal to the present value of the benefits, in other words, it makes the NPV to be equal to zero. The IRR indicates the actual profit rate of the total investment outlay. The project is feasible if the IRR is greater than the agreed discount rate.

IRR is calculated using the following formula, where R is the IRR and n stands for the number of years

$$\sum_{i=1}^{n} \frac{netflow_i}{(1+R)^{i-1}} = 0$$

Household versus Project Level Analysis

A cost benefit analysis can be done at both household and project levels. The purpose of the household level analysis is to assess the economic feasibility of investing in improved storage from the perspective of the households whereas the project level analysis would provide useful information for policy makers and donors on whether or not the investment (project outlay) leads to a positive and significant return. The total project cost for the period of four years (2013/14 – 2016/17) was divided by 14, which is the total number of woredas where the project will be implemented, in order to roughly estimate project cost in Darimu Woreda. Moreover, the costs that would be incurred by farmers in purchasing super grain bags and metal silos were included as an additional cost of reducing loss. In addition, government subsidy on super grain bag was included as costs to the society. As a result the

[7] In Ethiopia, a social discount rate of 10% is commonly used in evaluating public investments. But in this case study, a discount rate of 15% is assumed for the analysis at household level, taking into consideration the high level of poverty among rural households and the associated high preference for income at present over income in the future.

analysis done at woreda level is an economic analysis as opposed to financial analysis which was done for the household level analysis.

Project benefit was calculated as reduction in storage loss by 20% in the Woreda as per the expected outcome of the project.

Sensitivity Analysis

Sensitivity analysis was done to see the effect of changes in some of the key variables on the results of the CBA. In this case, CBA was done assuming that the actual loss that occurs at storage level is 25% less than what was reported by farmers. In addition, the analysis was redone, assuming 20% higher prices of improved storage alternatives.

Limitations of the case study

One of the limitations of this study is that storage loss was quantified based on reports by farmers. The information obtained from farmers in this way may not be highly accurate but it is also believed to have value since it reflects the losses that matter to the farmers[8].

Although improved storage practices positively contribute to food safety and quality, no such benefits were taken into consideration. It is also believed that the benefit of reducing storage losses would be much higher if environmental impact and carbon foot prints of the losses due to improper management were included. However, this case study is limited to direct benefits and costs that can be easily monetized.

3 Results

Background Information on Darimu Woreda

With a total area of about 1,394 square kilometers, the Woreda is home to 186,464 people out of which about 97% earn their living from farming. The Woreda lies at an altitude range of 792 m –1800 m.a.s.l. and receives an annual rainfall of 1172 mm –1740 mm. Darimu Woreda is one of the major maize producing areas in the country. In 2012 cropping season, a total area of 20,511 ha of land was allocated to maize, giving maize the lion's share of cultivated area in the season (Table 2). The total maize production was reported to be 634,009 quintals.

Table 2: Crop Area and Production in Darimu Woreda, 2012 cropping season

Crop Type	Area in hectares (Meher season[9])	Production ((Quintals))
Maize	20,511	634,009
Sorghum	4,543	98,781
Millet	3,547	58,888
Beans	762	14,265

Source: Darimu Woreda office of Agriculture

In the woreda, maize is mainly stored in a traditional storage facility called Gubo (figure 1). Gubo is made of locally available materials and is reported to have a service life of 4-5 years depending on the quality of construction.

[8] Jonathan Kaminski, Luc Christiaensen, World Bank Policy Research Working Paper 6831, April 2014.
[9] Meher is the main rainy season and spans from July to September. Maize is rainfed and is grown in this season.

Figure 1: Gubo – local storage structure in Darimu

3.1 Household Level CBA

Consumption, sales and purchases of maize

According to the information obtained from the Woreda Office of Agriculture, the area receives a fairly similar and good rainfall distribution almost every year. Therefore, no annual variation was taken into consideration in calculating maize production per household. The total volume of average maize production was reported to be 10 quintals for small farmers, about 19 quintals for medium farmers and about 50 quintals for large farmers (table 3).

Table 3: Average maize production per household in Darimu Woreda, 2013/14

Farmer Category	Sample Size	Maize production in quintals
Small	31	10.11
Medium	23	18.46
Large	30	49.88

Maize is a major staple food and is consumed throughout the year by farm households. It is also a source of income to a limited extent. Mainly those in the large producers' category sell the grain whereas the smaller producers fill the gap between production and consumption by purchasing maize 6-7 months after harvesting time. According to the information obtained through a questionnaire survey, a considerable amount of maize grain is lost in storages as reported below.

Maize is consumed throughout the year by all categories. On the average about 681 Kg of maize is consumed in the small farmers category whereas about 891 Kg and about 1702 Kg of maize is consumed in the medium and large categories respectively (Table 4). In the case of the large maize growers group, almost all consumption is from own production whereas they are also the ones who have surplus production to sell on the market (Fig 2 & Fig 4). Maize is harvested in November. However, most of the transaction happens between May and August. The obvious reason for this is the relatively higher price at this time of the year (Fig 3).

Table 4: Monthly Average Household Maize Consumption in Kilo Grams

Farmer Category	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
Small	68	69	59	57	56	56	57	53	53	52	47	55	681
Medium	70	91	86	88	83	86	76	70	70	63	54	53	891
Large	109	156	149	146	139	153	156	157	149	146	127	117	1702

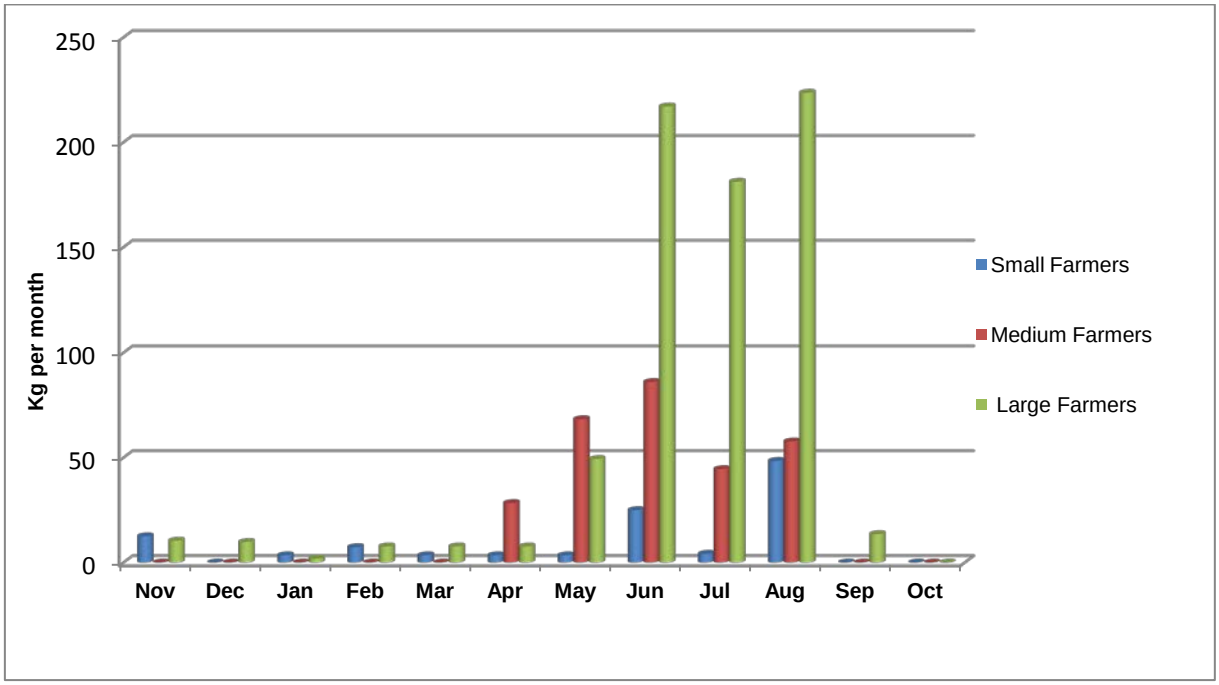

Figure 2: Monthly sales of maize by household category in kilograms

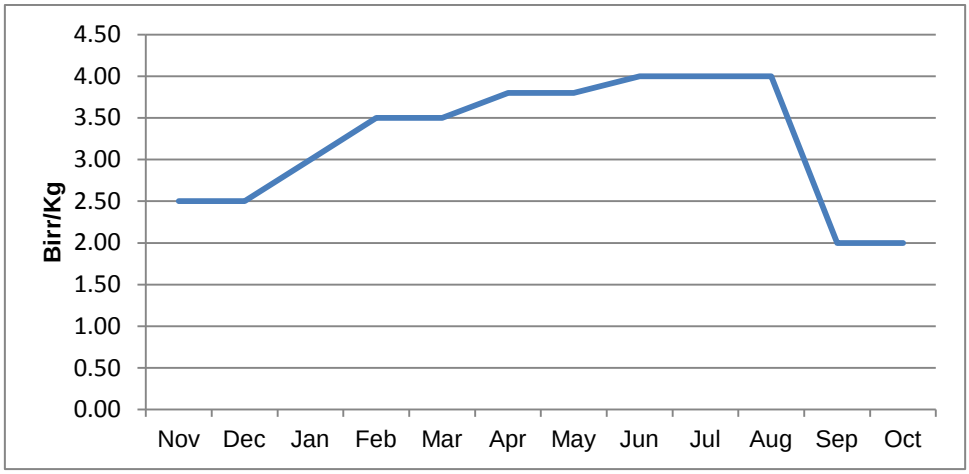

Figure 3: Monthly Market Price for Maize, Darimu, 2013

With regards to purchase of maize, small maize growers are the major buyers followed by the medium sized maize growers and then the large group (Figure 4). The total volume of grain purchased by the small group is 129 Kg and 46 Kg by the medium while the total quantity of purchase by large maize growers is negligible (8 Kgs/year). Reliance on purchased grain starts to rise from June and extends to October with the highest pick in July.

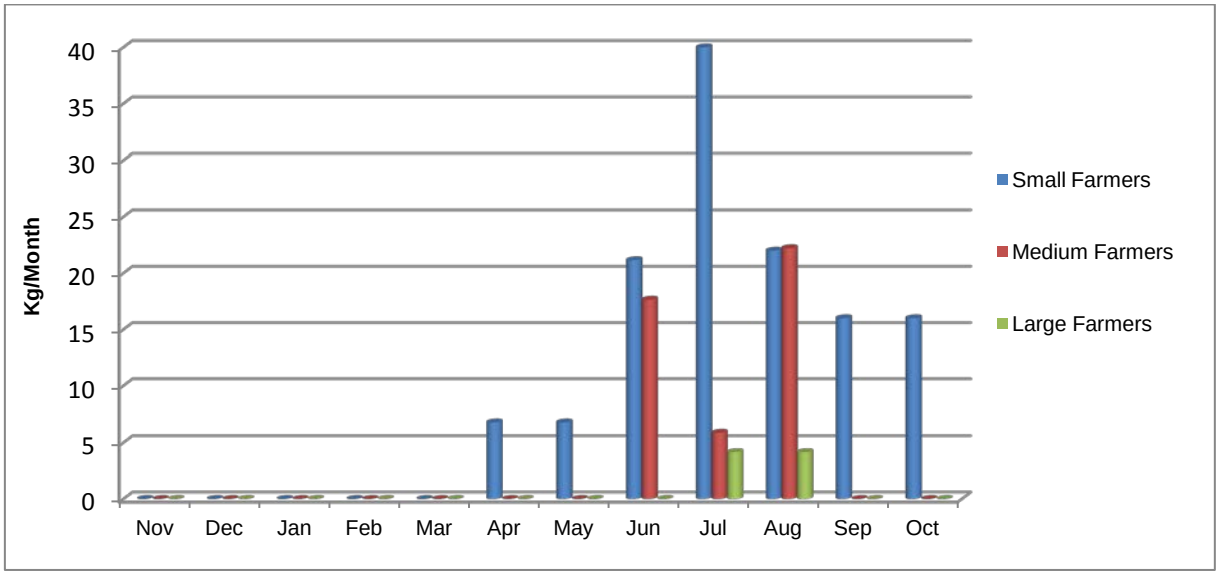

Figure 4: Average monthly purchase of maize by household category in kilograms

Storage losses and monthly maize income analysis under traditional practice

Although postharvest losses occur at different stages, other assessments[10] in the country have indicated that the biggest loss occurs in storages. This was, therefore, the reason for the SDC supported PHM project in Ethiopia to focus on reduction of losses that occur in storage.

In this analysis, the quantity of storage loss was obtained through interviews conducted with farmers. Farmers were asked to provide estimate of quantity of maize lost in storage from the total amount stored. Accordingly, the largest percentage loss (about 34%) was reported by small maize producers' category while storage loss was reported to be around 30% by medium and 29% by large category (Figure 5). In terms of volume of loss, however, highest loss is reported by larger maize farmers. Whilst the traditional storage facility is highly susceptible to storage pests, farmers have reported the use of chemicals, mainly actellic to prevent loss. Because of lack of knowledge, the chemicals are not properly applied in smallholder farmers' condition. As a result, low level of effectiveness is reported by farmers.

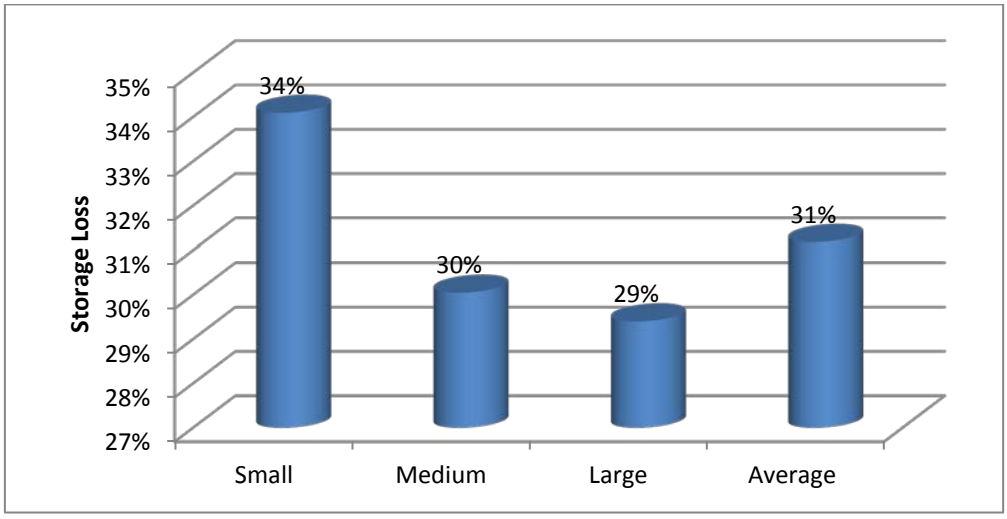

Figure 5: Maize storage loss in percent by farmer category

Farmers were also asked to give monthly estimate of storage loss. As depicted in figure 6 quantity of storage loss is the highest during the months of June, July and August[11]. This is seven to nine months

[10] Abraham Tadesse and Senait Regassa. 2013. Rapid Assessment of Status of Postharvest Loss in Grain Crops, Current Practices and Technologies for Loss Reduction among Smallholder Farmers in the Highlands of Ethiopia: The Case of Enebse Sar Midir and Enarj Enawga Woredas of East Gojam Zone of Amhara Region. Unpublished Report

after harvesting. The quantity lost declines during the following months. However, this can be attributed to the smaller quantity of maize that is available in the storages during that time of the year.

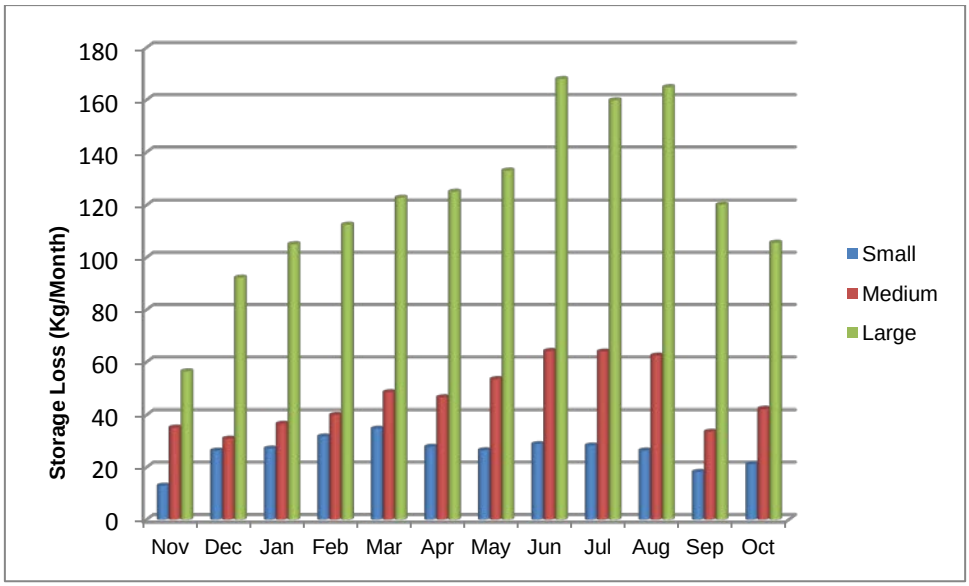

Figure 6: Monthly maize storage loss in kilograms by farmer category

Following the model set by DAI, monthly maize inventory analysis was done to estimate the quantity of maize available each month in the household. The maize inventory analysis goes from November, the month in which maize is harvested, to October. Beginning inventory in November is assumed to be zero. Ending inventory of each month is calculated as the sum of beginning inventory, amount harvested and amount purchased minus amount sold, amount consumed and storage loss. See Annex 1a-1c for maize inventory and income analysis in the 'without the project' situation.

As one would expect, maize is abundantly available in the households at the time of harvesting and declines thereafter with ending inventory of 1089 Kg for the large group and 169 Kg for the medium group. The result for the small group was observed to be a negative number. We, therefore, assume that a variable that has not been considered in this analysis such as support from relatives and friends would best explain this result which seems strange at the first sight.

Monthly household income from maize, in this case study and also following the model set by DAI, is defined as the difference between revenues obtained from sale of grain and expenses incurred to purchase the same. In addition, monetary value was also attached to the ending inventory and then added to the sales during the last month of the annual cycle, October. The rational for focusing on this partial analysis is the fact that effect of introduction of postharvest management practices will directly be seen on maize available for consumption, sale and the need for purchasing grain thorough its effect on reduction of storage losses.

In the 'without the project' situation, the large maize producers group gets an average annual income of Br 4631 from maize whereas the medium group earns Br 1104 per year. However, the smaller group of maize producers incurs an annual loss of Br 198.

Benefits and costs of using improved storage practices at household level

Net Benefits Analysis was done considering the changes in costs incurred and benefits accrued due to use and/or adoption of improved storage facilities. In this case, the analysis was done for Super Grain Bag and metal silo. The basic concept of the benefit estimation is comparison of incomes that could be obtained by using improved practices (with the project situation) with the incomes that are being earned using traditional practice (without the project situation). In this analysis, loss rates for super grain bag and metal silo was taken from CIMMYT's recommendation to DAI and are 1.9% for super grain bag and 0.5% for metal silo. Although PICS bags and plastic containers are being demonstrated

[11] This is because heavy infestations occur 4-6 months after storage

in the country by SAA, it was not included in this analysis, since we lack data on the effectiveness of these storage alternatives.

In order to quantify the benefits of using super grain bags and metal silos, a similar analysis of maize inventory and household maize income analysis was done for both super grain bags and metal silos as in the case of traditional practices above. This provides us with maize inventory and household maize income in the 'with the project' situation.

The annual income from maize calculated as the difference between revenues from sales and expenditures on purchases plus monetary value of ending inventory is presented for traditional practice, super grain bag and for metal silo in Figure 7 below. The annual maize income for super grain bag and metal silos were almost double the value for the traditional practice. The higher maize income in the case of super grain bag and metal silo is because of reduced loss of maize grain. For more details on the monthly gross income analysis of super grain bag and metal, the reader is referred to annex 2a – 2f.

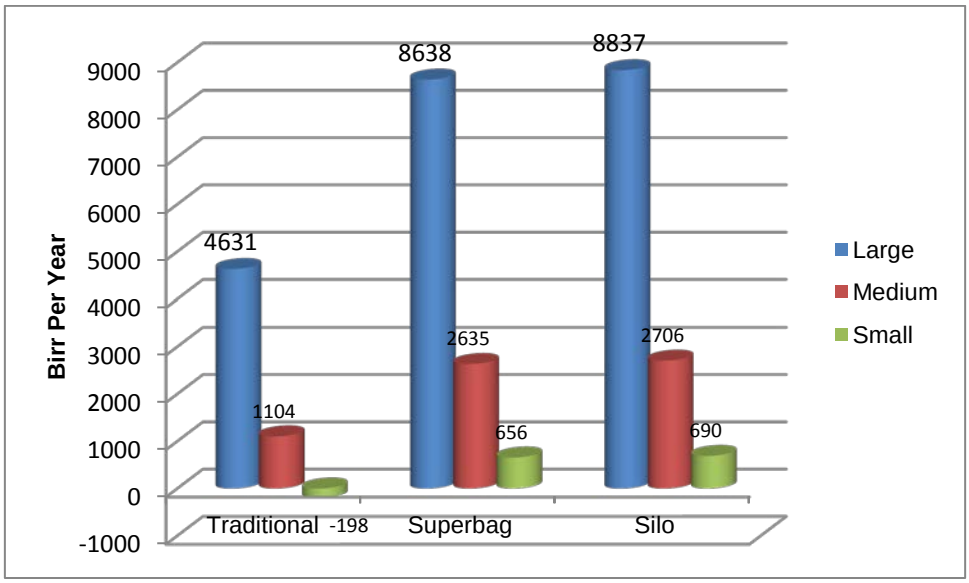

Figure 7: Annual income from maize for traditional storage, super grain bag and metal silo

The incremental income of using improved storage is calculated as the difference between income obtained when using improved storage and income obtained in the without the project context, where the traditional storage – *Gubo* - is used. As shown in Figure 8, for larger maize growers the incremental annual maize income is more than Birr 4000 for both super grain bag and metal silo. For the medium group, incremental income is about Birr 1500 and Birr 1600 for super grain bag and metal silo respectively. About Birr 850 and close to Birr 900 is obtained as incremental income for super grain bag and metal silo in the case of the small maize producers. This implies that the incremental income to be obtained by using improved practices is proportional to the volume of grain produced.

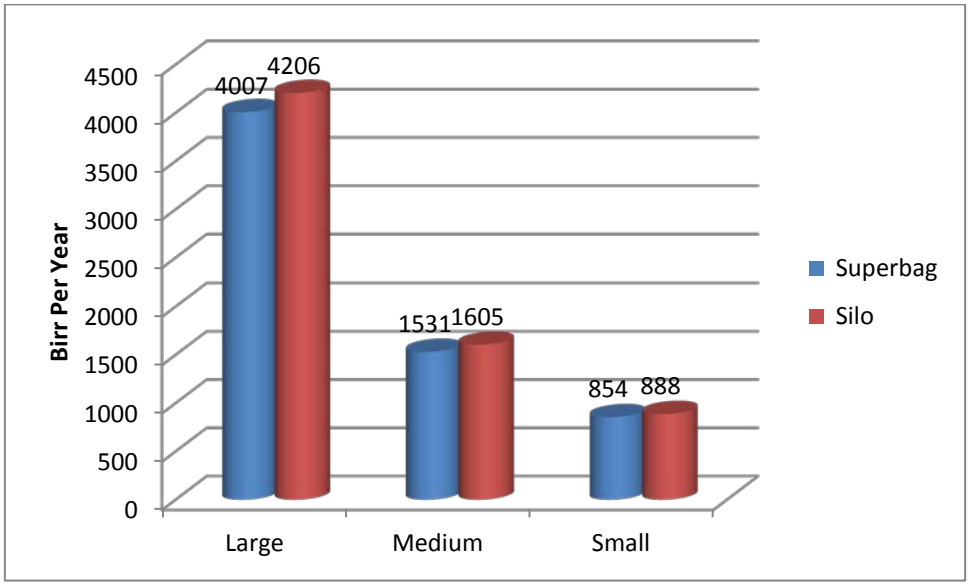

Figure 8: Incremental maize income per year

Incremental Costs

At household level, reduction of storage loss comes with the associated cost of using the improved practices. In this specific case, it includes cost of acquisition of super bags or metal silos as well as maintenance cost for the latter.

In Ethiopia, super grain bag with a capacity of 100 Kgs is being sold to farmers at a price of 35 Birr[12]. Metal silos can be made to have various sizes and the price was reported to be Birr 1,800 for 300 Kg capacity, Birr 2,500 for 500 Kg capacity and Birr 3,200 for a 1000 Kg capacity[13]. In this analysis, it was decided to use the 1000 Kg metal silo since the average maize production of all the three categories of farmers requires them to use at least two of the 500 Kg capacity. In addition, the 1000 Kg silo has lowest price per unit of grain it can hold[14].

The durability of super grain bag and metal silo is an important factor that determines costs of using them over years. The number of effective service life of a super bag was assumed to be 3 years[15]. Given that Larger Grain Borer is not considered a challenge in Ethiopia, this is believed to be a reasonable estimate. It was also assumed that a metal silo needs to be replaced after 15 years and the cost of maintenance was assumed to be 75 Birr/year.

In order to obtain incremental costs of using super grain bags and metal silos each year, the cost of traditional storage was deducted from the cost of the improved practices[16]. The average acquisition cost of a traditional storage, *Gubo*, was Birr 230 and has a service life of 4-5 years.

Net Present Value, Internal Rate of Return and Benefit Cost Ratio

Decisions on what kind of facility to use for storing grain extends over a number of years since most facilities can be used at least for three years. Analysis of such kinds of investments whose costs and benefits are spread over several years requires taking inflation into account. Consequently, a consumer price index was calculated using an inflation rate of 8.5%[17] for the year 2014 and a base year of 2013.

The incremental net benefit of using improved storage practices was calculated as the difference between the inflationary incremental income of using super grain bag and metal silo; and the inflationary incremental cost of using these storages. This was done over a projected period of 15

[12] Source: Personal communication with GrainPro Representative for Africa.
[13] Source: Personal communication with Sasakawa Africa Association staff.
[14] Division of prices of the silos to their respective capacity gives 6 Birr/Kg, 5 Birr/Kg and 3.2 Birr/Kg for the 300 Kg, 500 Kg and 1000 Kg silos respectively.
[15] This is a conservative estimate compared to the information obtained from GrainPro continent manager - which is five years.
[16] Cost of storage pesticides used by farmers were not included since there was no clear data and since the amount is negligible.
[17] Source: Central Statistical Authority

years which is a modest estimate of service life of metal silos based on the experience in central America[18]. Salvage Value of metal silo was estimated at 5% of the original price .TNet Present Value (NPV) was calculated using the stream of inflationary incremental net benefits and a social discount rate of 15%.

In general, a positive NPV means that the investment makes sense financially and an investment that brings higher NPV is preferred. In our case, the NPV of using super grain bags and metal silo was Birr 32,859 and Birr 23,449 respectively for the large maize producers in Darimu Woreda (Table 5).

Although metal silo resulted in higher incremental maize income as compared to super grain bag, super grain bag had a much higher NPV. This is apparently because of the significantly higher cost associated with the purchase of metal silo. Likewise, NPV was higher for super grain bags in the case of both medium and small maize producers' groups.

While metal silo had an IRR of 49%, 45% and 51% for large, medium and small maize growers respectively, it was not possible to apply IRR to cash flows related to use of super grain bag since the net cash flow was positive from year one[19]. With regards to Benefit Cost Ratio (BCR), again, super grain bag resulted in more than four times higher values as compared to metal silo.

Table 5: NPV, IRR and BCR at household level

	Super Grain Bag			Metal Silo		
Farm Size	**NPV**	**IRR**	**BCR**	**NPV**	**IRR**	**BCR**
Large	32,859	NA	11.84	23,449	49%	2.65
Medium	12,485	NA	11.18	8,507	45%	2.45
Small	7,044	NA	12.66	5,122	51%	2.81

3.2 Project (Woreda) Level CBA

The annual production of maize in the Woreda is reported to be about 635,009 quintals (see table 2 above). Assuming a storage loss of about 31% annually[20], it is estimated that about 198,683 quintals is lost in Darimu every year due to poor storage practices.

According to the logical framework matrix of the project document, an outcome of 20% reduction on storage loss is expected by 2017/18 and 50% reduction by 2022. At the current level of production a 20% reduction in storage loss amounts to saving 39,537 quintals of maize each year. For this analysis, a reduction of storage loss by 20% is used in the calculation of benefits of loss reduction from the year 2017/18 to 2032/33. For the years 2013/2014 – 2016/2017 (the first four years of the project), no reduction of storage loss was assumed.

For a long-term (15 years) projection of cash inflows, the inflationary benefit of saved storage loss is calculated as the quantity saved times maize price and then each figure was adjusted for inflation using the consumer price index indicated above over a period of 15 years.

Determining project cost and costs of technology adoption by farmers in Darimu Woreda

The total cost of the project for 14 Woredas in four Regions is CHF 3,190,000.00 for four years starting from 2013/2014 with a budget of CHF 540,000 for year 1; CHF 1,200,000 for year 2; CHF 970,000 for year 3 and CHF 470,000 for year 4 (Table 6). Project cost for Darimu Woreda was estimated on a pro – rata base, i.e by dividing the yearly budget by the number of project Woredas. Costs to the farmers, such as cost of metal silos and super grain bags were adjusted for inflation and included in the overall

18 Bravo, J. 2009. Metal Silos and Food Security: Lessons learned from Central American Postharvest Program

[19] The ERR metric, expects a situation where net cash out flow exceeds net cash inflow in the early years. However when the stream deviates substantially from this profile, however, it may not be possible to find an ERR for the stream. **http://www.business-case-analysis.com/internal-rate-of-return.html**

[20] Using data from the questionnaire survey, average rate of maize storage loss was calculated to be a bit more than 31%.

woreda cost[21] (Table 7). In addition, government subsidy (tax waiver) which is 33% of the full price was estimated to be Birr 5'382'720 was added to woreda cost.

Table 6: Project cost at Woreda level

	2013/14	2014/15	2015/2016	2016/2017
Total Project Costs - 4 Regions, 14 Woredas (CHF)	540,000	1,210,000	970,000	470,000
Project cost per Woreda (CHF)	38,571	86,429	69,286	33,571
Project cost (Birr)[22] per Woreda	837,918	1,877,557	1,505,149	729,299

Table 7: Farmers' cost of adopting Metal Silos and SGBs, Birr

	2017/18-2027/28
Farmer costs assuming 1/3 of adopters adopt Metal Silos	10,928,552
Farmer costs assuming 2/3 of adopters adopt Super Bag	312,244,354
Total	323,172,906

For determining the NPV at project (Woreda) level, an economic discount rate of 10%[23] was used. As presented in table 7, the Net Present Value of the investment in Darimu Woreda was found to be Birr 998,379,379 Birr or CHF 45,957,861. The Economic Rate of Return was 250% and the Benefit Cost Ratio was around 253. All these show that investing in improved storage management pays off significantly (table 8).

Table 8: Project (Woreda) Level Cost Benefit Analysis

Parameters	BIRR
NPV	998,379,379
ERR	250%
BCR	253.24

3.3 Sensitivity Analysis

Sensitivity analysis was done to assess the changes in the value of CBA parameters, assuming the percentage of storage loss reported by farmers was overestimated. As has been presented above, the percentage storage loss was reported to be 34% for small maize growers, 30% for medium group and 29%for the large maize producers. The CBA was rerun assuming the actual current loss was lower than what was reported by farmers by 25%. In other words, a CBA was redone assuming storage loss of 25.5% for small maize growers, 22.5% for medium group and 21.75%for the large maize producers. However, the conclusion made above that it pays to invest in storage improvement at household level remains unchanged (table 9).

Table 9: Household Level Sensitivity Analysis assuming 25% lower current storage loss

	Super Grain Bag			Metal Silo		
Farm Size	**NPV**	**IRR**	**BCR**	**NPV**	**IRR**	**BCR**
Large	29,861	*NA*	10.85	20,450	44%	2.44

[21] For this analysis it was assumed that 1/3 of adopters adopt metal silos whereas the 2/3 will adopt SGB,
[22] 1 CHF = 21.7238 Birr (August 5, 2014)
[23] This is the discount rate commonly used for public investments in Ethiopia.

Medium	11,336	*NA*	10.25	7,358	41%	2.25
Small	6,422	*NA*	11.63	4,499	46%	2.59

Prices of metal silo and/or super grain bag might change due to various reasons, and this makes one to ask how changes in prices of metal silos and/or super grain bags will affect the profitability of storage loss reduction. Therefore, the CBA was redone assuming 20% higher price for super grain bags (table 10) and 20% price increase for metal silo (Table 11). Nevertheless, reduction of storage loss remains profitable and the same is true for the relative profitability of the two methods.

Table 10: Household Level Sensitivity Analysis assuming 20% higher prices for Super Grain Bags

	Super Grain Bag			Metal Silo		
Farm Size	**NPV**	**IRR**	**BCR**	**NPV**	**IRR**	**BCR**
Large	31,756	*NA*	8.68	23,449	49%	2.65
Medium	12,076	*NA*	8.39	8,507	45%	2.45
Small	6,821	*NA*	9.24	5,122	51%	2.81

Table 11: Household Level Sensitivity Analysis assuming 20% higher prices for metal silo

	Super Grain Bag			Metal Silo		
Farm Size	**NPV**	**IRR**	**BCR**	**NPV**	**IRR**	**BCR**
Large	32,859	*NA*	11.84	20,686	39%	2.22
Medium	12,485	*NA*	11.18	7,402	36%	2.06
Small	7,044	*NA*	12.66	4'569	41%	2.35

Likewise, project (Woreda) level sensitivity analysis assuming 20% higher price for super grain bag results in a NPV of Birr 997,161,385 or CHF 45,901,794; an ERR of 250% and a BCR of 253 (Table 12). The same table shows that a 20% increase in the price of metal silo will not lead to change of the conclusion made above.

Table 12: Woreda Level Sensitivity Analysis assuming 20% higher prices for SGB and Metal Silo

	20% Higher Price for SGB	20% Higher Price for Metal Silo
NPV	997,161,385	975,063,500
ERR	250%	248%
BCR	252.93	247.33

4 Conclusions

As the return on investment of a given technology is an important factor that determines the decision of the adopter to adopt or not to adopt, a CBA was done to compare a traditional maize storage structure with a metal silo and super grain bag as alternative technologies. From this analysis which was conducted in Darimu Woreda of Oromia Region in Ethiopia, the following conclusions and recommendations are drawn.

- The analysis of data collected from Darimu Woreda, which is a major maize growing area in Oromia Region, shows that super grain bags and metal silos have clear economic advantage over the traditional practices.

- Among the two improved practices for which CBA was done, Super Grain Bag had a higher Net Present Value and Benefit Cost Ratio because of lower costs.
- As opposed to metal silos, Super Grain Bag was not explicitly included in the project activities. However, the CBA has shown a clear advantage of using SGB. Therefore, project implementers, FAO and the four Regional Bureaus of Agriculture, should consider inclusion of SGB in the demonstration and popularization particularly to those whose maize production is modest.
- It has to be noted that the current price of SGB does not include import tariffs since the government has waived import duties on SGB. This is because the government is convinced of the critical challenge the farming community and the nation in general are facing in relation to post harvest management. This is a commendable commitment by the government and the project must push for the sustainability of this import tariff waiver through engagement at policy level. Applying similar incentive for promotion of metal silos would significantly contribute to achieving household and national food security. Although this was not the focus of this report, it is important to note that local manufacturing of metal silos would also have other benefits such as creation of employment opportunities for the youth.
- Given the current price of metal silos and the low financial capacity of farmers, the road ahead for dissemination and adoption of metal silos will be challenging. Negotiations with the government for tax waivers on the metal sheets, which constitute the major component of the cost, will be crucial. On the supply side, availability of the silos on credit basis, as envisioned in the project document through the engagement of micro-finance institutions will be of paramount importance.
- Other types of bags such as PICS bags of Perdu University which can be produced locally[24] have to be tested for their effectiveness and food safety and then considered for dissemination based on the findings of the tests.

[24] Personal communication with staff of Sasakawa Africa Associaiton in Addis Ababa.

Annex 1a: Maize Inventory and Income Analysis, Large Farms –Darimu, Ethiopia (Without Project)

Maize Inventory Analysis (Large Farms)

Total Production Kg	4988			***Total Consumption***	1702.13							
Total Loss in Gotera Kg	1466		29%	***Total Sales***	729.85	15%						
	Nov	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**
Beginning Inventory	0	2318	4554	4299	4032	3762	3477	3139	2597	2111	1581	1320
Harvest % of total	50%	50%										
Add: Harvest amount	2494	2494	0	0	0	0	0	0	0	0	0	0
Add: Amount purchased	0	0	0	0	0	0	0	0	4	4	0	0
Total Available	2494	4812	4554	4299	4032	3762	3477	3139	2601	2115	1581	1320
Less: Amount sold	-10	-10	-2	-8	-8	-8	-49	-217	-181	-224	-14	0
Less: Amount consumed	-109	-156	-149	-146	-139	-153	-156	-157	-149	-146	-127	-117
Less: Storage loss	-56	-92	-105	-113	-123	-125	-133	-168	-160	-165	-120	-106
Total reduction	-176	-258	-256	-266	-270	-285	-338	-542	-490	-534	-261	-222
Ending Inventory (Maize in Kg)	2318	4554	4299	4032	3762	3477	3139	2597	2111	1581	1320	1098

Household Income Analysis (Large Farms)

	Nov	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**
Amount sold	10	10	2	8	8	8	49	217	181	224	14	1098
Sales price	2.00	2.50	2.80	3.00	3.00	3.00	3.00	3.50	3.50	3.50	1.80	2.00
Revenue from sales	21	24	5	23	23	23	148	760	634	783	24	2196
Amount purchased	0	0	0	0	0	0	0	0	4	4	0	0
Purchase price	2.50	2.50	3.00	3.50	3.50	3.80	3.80	4.00	4.00	4.00	2.00	2.00
Expense from purchases	0	0	0	0	0	0	0	0	17	17	0	0
Household Net Income (Br)	21	24	5	23	23	23	148	760	618	766	24	2196

Annex 1b: Maize Inventory and Income Analysis, Medium Farms –Darimu, Ethiopia (Without Project)

Maize Inventory Analysis (Medium Farms)

Total Production Kg	1858		***Total Consumption***	891.16		
Total Loss in Gotera Kg	558	30%	***Total Sales***	284.99	15%	

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Beginning Inventory	0	816	1628	1508	1387	1259	1102	905	702	529	366	276
Harvest % of total	50%	50%										
Add: Harvest amount	929	929	0	0	0	0	0	0	0	0	0	0
Add: Amount purchased	0	0	0	0	0	0	0	18	6	22	0	0
Total Available	929	1745	1628	1508	1387	1259	1102	922	708	551	366	276
Less: Amount sold	0	0	0	0	0	-28	-68	-86	-45	-58	0	0
Less: Amount consumed	-77	-86	-83	-81	-79	-82	-76	-70	-70	-65	-56	-65
Less: Storage loss	-35	-31	-37	-40	-49	-47	-54	-64	-64	-62	-34	-42
Total reduction	-113	-117	-119	-121	-128	-157	-198	-220	-179	-186	-89	-107
Ending Inventory (Maize in Kg)	816	1628	1508	1387	1259	1102	905	702	529	366	276	169

Household Income Analysis (Medium Farms)

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Amount sold	0	0	0	0	0	28	68	86	45	58	0	169
Sales price	2.00	2.50	2.80	3.00	3.00	3.00	3.00	3.50	3.50	3.50	1.80	2.00
Revenue from sales	0	0	0	0	0	85	205	301	156	202	0	338
Amount purchased	0	0	0	0	0	0	0	18	6	22	0	0
Purchase price	2.50	2.50	3.00	3.50	3.50	3.80	3.80	4.00	4.00	4.00	2.00	2.00
Expense from purchases	0	0	0	0	0	0	0	71	24	89	0	0
Household Net Income (Br)	0	0	0	0	0	85	205	231	132	113	0	338

Annex 1c: Maize Inventory and Income Analysis, Small Farms –Darimu, Ethiopia (Without Project)

Maize Inventory Analysis (Small Farms)

Total Production Kg	912		***Total Consumption***	672.89		
Total Loss in Gotera Kg	311	34%	***Total Sales***	111.33	12%	

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Beginning Inventory	0	373	728	633	527	429	345	265	181	137	36	-10
Harvest % of total	50%	50%										
Add: Harvest amount	456	456	0	0	0	0	0	0	0	0	0	0
Add: Amount purchased	0	0	0	0	0	7	7	21	40	22	16	16
Total Available	456	828	728	633	527	436	352	286	221	159	52	6
Less: Amount sold	-13	0	-3	-7	-3	-3	-3	-25	-4	-48	0	0
Less: Amount consumed	-58	-74	-64	-66	-60	-60	-57	-51	-51	-48	-43	-40
Less: Storage loss	-13	-26	-27	-32	-35	-28	-27	-29	-28	-26	-18	-21
Total reduction	-83	-101	-95	-105	-98	-91	-87	-105	-84	-123	-62	-61
Ending Inventory (Maize in Kg)	373	728	633	527	429	345	265	181	137	36	-10	-55

Household Income Analysis (Small Farms)

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Amount sold	13	0	3	7	3	3	3	25	4	48	0	-55
Sales price	2.00	2.50	2.80	3.00	3.00	3.00	3.00	3.50	3.50	3.50	1.80	2.00
Revenue from sales	25	0	10	22	10	10	10	88	15	170	0	-109
Amount purchased	0	0	0	0	0	7	7	21	40	22	16	16
Purchase price	2.50	2.50	3.00	3.50	3.50	3.80	3.80	4.00	4.00	4.00	2.00	2.00
Expense from purchases	0	0	0	0	0	26	26	85	160	88	32	32
Household Net Income (Br)	25	0	10	22	10	-15	-15	3	-145	82	-32	-141

Annex 2a: MONTHLY ANALYSIS >> With Project

Consumption Rates	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Large	6.39	9.16	8.73	8.59	8.18	8.97	9.15	9.21	8.74	8.56	7.46	6.86
Medium	8.68	9.68	9.28	9.11	8.91	9.24	8.50	7.86	7.86	7.33	6.26	7.30
Small	8.58	11.06	9.55	9.83	8.92	8.88	8.45	7.58	7.59	7.20	6.46	5.92
Sales Rates												
Large	1.43%	1%	0%	1%	1%	1%	7%	30%	25%	31%	2%	0%
Medium	0.00%	0.00%	0.00%	0.00%	0.00%	9.94%	23.98%	30.20%	15.63%	20.26%	0.00%	0.00%
Small	11.23%	0.00%	3.12%	6.59%	3.12%	3.12%	3.12%	22.46%	3.74%	43.51%	0.00%	0.00%
Loss Rates												
Superbag	15.00%	15.00%	2.50%	2.50%	2.50%	15.00%	10.00%	10.00%	10.00%	7.50%	7.50%	2.50%
Silo	10.00%	10.00%	7.50%	7.50%	7.50%	7.50%	7.50%	7.50%	7.50%	7.50%	7.50%	7.50%

Pricing (pricing worksheet)	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Farm gate price / kg	2.00	2.50	2.80	3.00	3.00	3.00	3.00	3.50	3.50	3.50	1.80	2.00
Market price /kg	2.50	2.50	3.00	3.50	3.50	3.80	3.80	4.00	4.00	4.00	2.00	2.00

Annex 2a: Maize Inventory and Income Analysis, Super Grain Bags (Large Farms) (With Project)

Total Production	***4988***	kg			***Total Consumption***	1702	kg						
Total Loss	95	kg	***1.90%***		***Total Sales***	2101	kg	-42%					
	Nov	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	
Beg inventory	0	2318	4554	4299	4032	3762	3477	3139	2597	2111	1581	1320	
Harvest % of total	50%	50%											
Add: Harvest amount	2494	2494	0	0	0	0	0	0	0	0	0	0	
Add: Amount purchased	0	0	0	0	0	0	0	0	4	4	0	0	
Total available	2494	4812	4554	4299	4032	3762	3477	3139	2601	2115	1581	1320	
Less: Amount sold	(53)	(88)	(105)	(118)	(128)	(119)	(173)	(376)	(332)	(381)	(127)	(103)	
Less: Amount consumed	(109)	(156)	(149)	(146)	(139)	(153)	(156)	(157)	(149)	(146)	(127)	(117)	
Less: Storage loss	(14)	(14)	(2)	(2)	(2)	(14)	(9)	(9)	(9)	(7)	(7)	(2)	
Total reduction	(176)	(258)	(256)	(266)	(270)	(285)	(338)	(542)	(490)	(534)	(261)	(222)	
Ending inventory	2318	4554	4299	4032	3762	3477	3139	2597	2111	1581	1320	1098	

Household Income Analysis (Super Grain Bag – Large Farms)													
	Nov	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Total**
Amount sold	53	88	105	118	128	119	173	376	332	381	127	1201	3199
Sales price	2.00	2.50	2.80	3.00	3.00	3.00	3.00	3.50	3.50	3.50	1.80	2.00	
Revenue from sales	105	220	293	354	384	356	519	1'315	1'161	1'335	228	2'402	8'671
Amount purchased	0	0	0	0	0	0	0	0	4	4	0	0	8
Purchase price	2.50	2.50	3.00	3.50	3.50	3.80	3.80	4.00	4.00	4.00	2.00	2.00	
Expense from purchases	0	0	0	0	0	0	0	0	17	17	0	0	33
Household Net Income	105	220	293	354	384	356	519	1'315	1'144	1'318	228	2'402	**8'638**

Annex 2b: Maize Inventory and Income Analysis, Metal Silo (Large Farms) (With Project)

Total Production	***4988***	kg			***Consump.***		***1702***	kg				
Total Loss	5	kg	***0.5%***		***Sales***		***2191***	Kg				
	Nov	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**
Beg inventory	0	2318	4554	4299	4032	3762	3477	3139	2597	2111	1581	1320
Harvest % of total	50%	50%										
Add: Harvest amount	2494	2494	0	0	0	0	0	0	0	0	0	0
Add: Amount purchased	0	0	0	0	0	0	0	0	4	4	0	0
Total available	2494	4812	4554	4299	4032	3762	3477	3139	2601	2115	1581	1320
Less: Amount sold	(64)	(100)	(105)	(118)	(129)	(131)	(181)	(383)	(339)	(387)	(132)	(104)
Less: Amount consumed	(109)	(156)	(149)	(146)	(139)	(153)	(156)	(157)	(149)	(146)	(127)	(117)
Less: Storage loss	(2.49)	(2.49)	(1.87)	(1.87)	(1.87)	(1.87)	(1.87)	(1.87)	(1.87)	(1.87)	(1.87)	(1.87)
Total reduction	(176)	(258)	(256)	(266)	(270)	(285)	(338)	(542)	(490)	(534)	(261)	(222)
Ending inventory	2318	4554	4299	4032	3762	3477	3139	2597	2111	1581	1320	1098

Household Income Analysis (Metal Silo – Large Farms)													
	Nov	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Total**
Amount sold	64	100	105	118	129	131	181	383	339	387	132	1202	3270
Sales price	2.00	2.50	2.80	3.00	3.00	3.00	3.00	3.50	3.50	3.50	1.80	2.00	
Revenue from sales	129	249	294	355	386	393	542	1'341	1'187	1'353	237	2'403	8'870
Amount purchased	0	0	0	0	0	0	0	0	4	4	0	0	8
Purchase price	2.50	2.50	3.00	3.50	3.50	3.80	3.80	4.00	4.00	4.00	2.00	2.00	
Expense from purchases	0	0	0	0	0	0	0	0	17	17	0	0	33
Household Net Income	129	249	294	355	386	393	542	1'341	1'171	1'337	237	2'403	**8'837**

Annex 2c: Maize Inventory and Income Analysis, Super Grain Bag (Medium Farms) (With Project)

Total Production	***1858***	kg			***Total Consumption***		***891***	kg				
Total Loss	35	kg	***1.90%***		***Total Sales***		0	kg	***0.00%***			
	Nov	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**
Beg inventory	0	816	1628	1508	1387	1259	1102	905	702	529	366	276
Harvest % of total	50%	50%										
Add: Harvest amount	929	929	0	0	0	0	0	0	0	0	0	0
Add: Amount purchased	0	0	0	0	0	0	0	18	6	22	0	0
Total available	929	1745	1628	1508	1387	1259	1102	922	708	551	366	276
Less: Amount sold	(30)	(26)	(36)	(39)	(48)	(70)	(118)	(147)	(105)	(118)	(31)	(41)
Less: Amount consumed	(77)	(86)	(83)	(81)	(79)	(82)	(76)	(70)	(70)	(65)	(56)	(65)
Less: Storage loss	(5)	(5)	(1)	(1)	(1)	(5)	(4)	(4)	(4)	(3)	(3)	(1)
Total reduction	(113)	(117)	(119)	(121)	(128)	(157)	(198)	(220)	(179)	(186)	(89)	(107)
Ending inventory	816	1628	1508	1387	1259	1102	905	702	529	366	276	169

Household Income Analysis (Super Grain Bag – Medium Farms)													
	Nov	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Total**
Amount sold	30	26	36	39	48	70	118	147	105	118	31	210	977
Sales price	2.00	2.50	2.80	3.00	3.00	3.00	3.00	3.50	3.50	3.50	1.80	2.00	
Revenue from sales	60	64	100	118	143	209	355	514	368	412	56	421	2'818
Amount purchased	0	0	0	0	0	0	0	18	6	22	0	0	46
Purchase price	2.50	2.50	3.00	3.50	3.50	3.80	3.80	4.00	4.00	4.00	2.00	2.00	
Expense from purchases	0	0	0	0	0	0	0	71	24	89	0	0	183
Household Net Income	60	64	100	118	143	209	355	443	344	323	56	421	**2'635**

Annex 2d: Maize Inventory and Income Analysis, Metal Silo (Medium Farms)

Maize Inventory Analysis - Silo												
Total Production	***1858***	kg			***Total Consumption***		***891***	kg				
Total Loss	2	kg	***0.5%***		***Total Sales***		841	kg	***45.29%***			
	Nov	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**
Beg inventory	0	816	1628	1508	1387	1259	1102	905	702	529	366	276
Harvest % of total	50%	50%										
Add: Harvest amount	929	929	0	0	0	0	0	0	0	0	0	0
Add: Amount purchased	0	0	0	0	0	0	0	18	6	22	0	0
Total available	929	1745	1628	1508	1387	1259	1102	922	708	551	366	276
Less: Amount sold	(34)	(30)	(36)	(39)	(48)	(74)	(121)	(150)	(108)	(120)	(33)	(42)
Less: Amount consumed	(77)	(86)	(83)	(81)	(79)	(82)	(76)	(70)	(70)	(65)	(56)	(65)
Less: Storage loss	(0.93)	(0.93)	(0.70)	(0.70)	(0.70)	(0.70)	(0.70)	(0.70)	(0.70)	(0.70)	(0.70)	(0.70)
Total reduction	(113)	(117)	(119)	(121)	(128)	(157)	(198)	(220)	(179)	(186)	(89)	(107)
Ending inventory	816	1628	1508	1387	1259	1102	905	702	529	366	276	169

Household Income Analysis (Metal Silo – Medium Farms)													
	Nov	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Total**
Amount sold	34	30	36	39	48	74	121	150	108	120	33	211	1003
Sales price	2.00	2.50	2.80	3.00	3.00	3.00	3.00	3.50	3.50	3.50	1.80	2.00	
Revenue from sales	69	75	101	118	143	223	363	524	378	418	59	421	2'892
Amount purchased	0	0	0	0	0	0	0	18	6	22	0	0	46
Purchase price	2.50	2.50	3.00	3.50	3.50	3.80	3.80	4.00	4.00	4.00	2.00	2.00	
Expense from purchases	0	0	0	0	0	0	0	71	24	89	0	0	183
Household Net Income	69	75	101	118	143	223	363	453	354	329	59	421	**2'709**

Annex 2e: Maize Inventory and Income Analysis, Super Grain Bag (Small Farms)

Maize Inventory Analysis – Super Grain Bag (Small Farms)												
Total Production	***912***	kg			***Total Consumption***		***673***	kg				
Total Loss	17	kg	***1.90%***		***Total Sales***		406	kg	***44.50%***			
	Nov	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**
Beg inventory	0	373	728	633	527	429	345	265	181	137	36	(10)
Harvest % of total	50%	50%										
Add: Harvest amount	456	456	0	0	0	0	0	0	0	0	0	0
Add: Amount purchased	0	0	0	0	0	7	7	21	40	22	16	16
Total available	456	828	728	633	527	436	352	286	221	159	52	6
Less: Amount sold	(24)	(25)	(29)	(38)	(37)	(30)	(29)	(53)	(31)	(74)	(17)	(20)
Less: Amount consumed	(58)	(74)	(64)	(66)	(60)	(60)	(57)	(51)	(51)	(48)	(43)	(40)
Less: Storage loss	(2)	(2)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Total reduction	(83)	(101)	(95)	(105)	(98)	(91)	(87)	(105)	(84)	(123)	(62)	(61)
Ending inventory	373	728	633	527	429	345	265	181	137	36	(10)	(55)

Household Income Analysis (Super Grain Bag – Small Farms)													
	Nov	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Total**
Amount sold	24	25	29	38	37	30	29	53	31	74	17	-35	351
Sales price	2.00	2.50	2.80	3.00	3.00	3.00	3.00	3.50	3.50	3.50	1.80	2.00	
Revenue from sales	48	62	82	114	111	90	86	184	109	258	31	-69	1'104
Amount purchased	0	0	0	0	0	7	7	21	40	22	16	16	129
Purchase price	2.50	2.50	3.00	3.50	3.50	3.80	3.80	4.00	4.00	4.00	2.00	2.00	
Expense from purchases	0	0	0	0	0	26	26	85	160	88	32	32	448
Household Net Income	48	62	82	114	111	64	60	100	-51	170	-1	-101	**656**

Annex 2f: Maize Inventory and Income Analysis, Metal Silo (Small Farms)

Total Production	***912***	kg				***Total Consumption***	***673***	kg				
Total Loss	1	kg	***0.5%***			***Total Sales***	421	kg	***46.21%***			
	Nov	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**
Beg inventory	0	373	728	633	527	429	345	265	181	137	36	(10)
Harvest % of total	50%	50%										
Add: Harvest amount	456	456	0	0	0	0	0	0	0	0	0	0
Add: Amount purchased	0	0	0	0	0	7	7	21	40	22	16	16
Total available	456	828	728	633	527	436	352	286	221	159	52	6
Less: Amount sold	(25)	(26)	(30)	(39)	(38)	(31)	(30)	(54)	(32)	(75)	(18)	(21)
Less: Amount consumed	(58)	(74)	(64)	(66)	(60)	(60)	(57)	(51)	(51)	(48)	(43)	(40)
Less: Storage loss	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Total reduction	(83)	(101)	(95)	(105)	(98)	(91)	(87)	(105)	(84)	(123)	(62)	(61)
Ending inventory	373	728	633	527	429	345	265	181	137	36	(10)	(55)

Household Income Analysis – Metal Silo (Small Farms)													
	Nov	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Total**
Amount sold	25	26	30	39	38	31	30	54	32	75	18	-34	363
Sales price	2.00	2.50	2.80	3.00	3.00	3.00	3.00	3.50	3.50	3.50	1.80	2.00	
Revenue from sales	50	65	85	116	114	93	89	187	113	261	32	-67	1'138
Amount purchased	0	0	0	0	0	7	7	21	40	22	16	16	129
Purchase price	2.50	2.50	3.00	3.50	3.50	3.80	3.80	4.00	4.00	4.00	2.00	2.00	
Expense from purchases	0	0	0	0	0	26	26	85	160	88	32	32	448
Household Net Income	50	65	85	116	114	67	63	103	-47	173	0	-99	**690**