# A COST BENEFIT ANALYSIS OF MAIZE PRODUCTION AND MARKETING IN UGANDA


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## Abstract

Maize is important in Uganda because of its dual function both as an income-generating cash crop and as a staple crop that improves food security. Three interventions on the maize sector are selected for a substantive cost-benefit analysis investigation, namely:

1. "Increasing the utilization of commercial inputs"- the focus of the intervention is to overcome the low maize yield situation in Uganda. The purpose of this study is to determine if financial and economic conditions allow the maize farmers to acquire and properly apply the commercial inputs.
2. "Maize storage"- Absence of adequate storage facilities forces majority of farmers to store maize at home resulting on 22 percent post-harvest loss of the commodity. This study explores the merits of sponsoring the expansion of the network of community warehouses for maize storage. The levelized cost of the investments required per kg of maize stored over the life of the facility is computed to approximate the charge required to amortize the initial investment costs of the facility over the project's lifetime.
3. "The expansion of the P4P initiative" – The objective of P4P intervention is to improve the market linkages of farmers so that they can obtain higher prices for their production.

The analysis shows that the increasing maize production intervention is promising for the agriculture sector and for the country. The "Maize Storage" intervention yields benefits to the farmers and other participants in the maize value chain. The analysis of P4P intervention shows that in the long-run this intervention is likely to damage the private sector trading and marketing institutions of the country.



## Acknowledgments

This study was financed by USAID's "Learning, Evaluation, and Analysis Project (LEAP). The report was prepared by Cambridge Resources International Inc., under a subcontract to Optimal Solutions Group. Contract Number: AID-OAA-C-11-00169. Special thanks for the comments and suggestions received from Joseph Kiirya and Christabel Dadzie during the completion of this study. The assistance received from many people during its field visit to Uganda, including Martin Fowler of USAID, Eric Derk of USAID LEAD, Rasid Kitili of World Bank, John Magnay of Africa at Opportunity International, Alex Rwego of Uganda Commodity Exchange (UCE), Dr. Godfrey Asea and Dr. Michael Ugen of National Crops Resources Research Institute (NaCRRI), Vincent Kiwanuka of World Food Programme (WFP), and Justus Kitili of UNGA Millers.

Key words: cost-benefit analysis, investment appraisal, stakeholder analysis, maize value chain, marketing, Uganda.
**JEL: D13, D31, D61, D62, E23, H42**

# LIST OF ACRONYMS

| | |
|---|---|
| CBA | Cost Benefit Analysis |
| CIT | Corporate income tax |
| EIRR | Economic internal rate of return |
| ENPV | Estimated net present value |
| FEP | Foreign-exchange premiums |
| FIRR | Financial internal rate of return |
| FNPV | Financial net present value |
| GDP | Gross domestic product |
| LEAD | Uganda Livelihoods and Enterprises for Agricultural Development |
| LEAP | Learning Evaluation and Analysis Project |
| MAAIF | Ministry of Agriculture, Animal Industry and Fisheries |
| NARO | National Agricultural Research Organisation |
| NPV | Net present value |
| P4P | Purchase for Progress |
| UBOS | Uganda Bureau of Statistics |
| UCA | Uganda Census of Agriculture |
| UCE | Uganda Commodity Exchange |
| VAT | Value-added tax |
| WFP | World Food Programme |

# COST BENEFIT ANALYSIS OF COMMODITY PRODUCTION AND MARKETING PROJECT IN UGANDA

## EXECUTIVE SUMMARY

### Project Description

Agriculture in Uganda is confronted with many challenges: slow rates of adoption of yield enhancing technologies and practices; limited availability and use of good quality inputs; poor post-harvest management practices and storage facilities; poor infrastructure; increased prevalence of pests and diseases; and limited access to markets and market information and appropriate support services and processing technologies.

USAID Feed the Future Program (FtF) has allocated a total of 24.7 million USD dollars to improve farm incomes and address poverty concerns in the coffee, maize and bean value chains. The specific interventions are still in the development stage. During the initial field visit to Uganda the study team in conjunction with USAID Uganda staff selected interventions in the maize sector as the focus of a series of cost benefit analysis (CBA). Maize is important in Uganda because of its dual function both as an income-generating cash crop and as a staple crop that improves food security. The target districts of Feed the Future Program cover all four regions in Uganda and account for about 79 percent of area under maize cultivation in Central Region, 63 percent in Eastern Region, 38 percent in Northern Region, and 27 percent in Western Region of Uganda. Approximately 1.98 million agricultural households live in the covered districts.

Three interventions on the maize sector are selected for a substantive cost-benefit analysis investigation. Each intervention covers a different aspect of agricultural activities at the farm household level.

**Increasing the utilization of commercial inputs** is the focus of the first intervention to overcome the low maize yield situation in Uganda. The Ugandan agricultural sector is best characterized by as a low input-low output system. At the present time, the use of herbicide, pesticide, fertilizer and the like is minimal. Multiple factors contribute to this. Households lack the trust in the quality of the items they purchase and the financial resources to pay for the inputs. Irregular and low demand, high transaction costs creating low profitability have discouraged inputs suppliers to cater to smallholder farmers. Therefore, the intervention calls for major and innovative changes in the existing input distribution system.

The purpose of this study is to explore the financial and economic consequences that ensue, if maize farmers are able to acquire and properly apply the commercial inputs. According to a study by LEAD (2011), commercial inputs can on average increase yield by around 200 percent, while their additional cost is around 226 USD per hectare per season. Although the study team discounted these potential yields a great deal, it still appears that this type of intervention is likely to be very worthwhile for the agriculture sector and for the country.

**Maize storage** follows immediately after production and harvesting. The analysis of the second intervention explores the merits of sponsoring the expansion of the network of community warehouses for maize storage. Since this is a hypothetical intervention, the number of warehouses to be constructed is unknown. The levelized cost of the investments required per kg of maize stored over the life of the facility is computed to approximate the charge required to amortize the initial investment costs of the facility over the project's lifetime. In this way the level of warehouse services can be expanded or contracted and the full costs of the facility appropriately accounted for in the cost benefit analysis.

Currently, an overwhelming majority of households store crops at home or in its surroundings. Home-stored maize is more exposed to the elements and vulnerable to pests. As a consequence, it is estimated that 22 percent of stored maize is spoiled or lost to pests. The benefits of the warehouse intervention are twofold. First, postharvest losses caused by home storage are reduced from around 22 to a low rate, and perhaps even to 0 percent. Savings in losses increases the disposable maize quantity in the next period after the harvest glut has been absorbed. It is assumed that warehouses are properly equipped and their operators properly trained, for a poorly managed centralized storage system can result in greater postharvest losses. Secondly, maize prices of actual sales in the covered districts are assumed to increase on average by a modest 3%. This is based on the view that the improved maize quality and the ability of maize depositors to retain the maize and time their sales appropriately should provide an opportunity to obtain a better price for the product sold. By assumption, households shift approximately 45 percent of their current production to the warehouses and pay warehouses charges (of around 80 UGX per kg per season) that finance both operating and the levelized investment costs through this charge.

This intervention yields substantial benefits to the farming households and the other participants in the maize value chain in Uganda. Although the gains to owners of the warehouses are small in absolute magnitudes, they indicate a fairly high level of profitability for the amounts invested.

**The expansion of the P4P initiative** for the direct purchase of maize from farmers and farmer cooperatives for the World Food Programme (WFP) is an intervention with the objective of improving the market linkages of farmers so that farmers can obtain better prices for their production. P4P had worked toward these objectives by introducing efficiencies in warehousing, and creation of satellite market collection points for maize in the rural areas.

While the P4P program has many laudable objectives, the analysis of its impact on the entire set of stakeholders in the maize value chain shows that it is not a very promising intervention, particularly for the longer term institutional development of the agricultural sector in Uganda. Its longer term impact is to damage the private sector trading and marketing institutions that are critical for the long term development of the agricultural sector in Uganda.

## Methodology

Because of the absence of identified interventions in the crop component of the FtF program at the time of the study team's field visit to Uganda, it was decided to try to identify promising areas for interventions by first mapping the current maize value chain to construct a base case scenario and then evaluate the benefits and costs of various interventions in a general equilibrium fashion considering the entire value chain using this model. This is in contrast to a traditional cost benefit analysis where one might evaluate a series of specific well defined interventions in detail and set aside many of the secondary impacts of the project on other stakeholders where the impacts are uncertain. The mapping of the current maize value chain was done taking into consideration the regional differences in productivity, maize disposition pattern of households, and the prices of maize grains and flour. The mapping keeps track of both the flow of physical goods and the amount of value-added that pass through various stakeholders, including agricultural households, small and medium traders, volume buyers, and the government who collects direct and indirect taxes from the transactions.

Given the variable quality of unpublished and officially published data in Uganda, a great deal of attention had to be taken to assure the veracity of the information obtained from the various sources. This was necessary in order to have confidence that the results of a cost benefit analysis completed following this approach would provide a sound basis for decision making.

Beginning at the farm gate, maize can be stored or consumed by the producing households, or sold in local markets after milling, or sold to small and medium traders or to volume buyers. The small and medium traders and volume buyers in turn sell the maize procurement to different outlets, including the non-producing population, feed manufacturers, or WFP. They may also engage in informal (small and medium traders) or formal (volume buyers) export.

In the second step, a subset of parameter values such as yield, farm budgets, postharvest loss percentage, and output prices are altered to forecast the intervention scenarios. The differences between the base case and intervention scenarios represent the incremental benefits brought about by the interventions. The overarching objective is to analyze how the interventions may affect the financial welfare of the major value chain participants.

Mapping of the existing maize value chain produces findings that corroborate with many stylized facts. Household own consumption and sales to small traders account for over 70% of maize disposition. The predominant form of storage is home storage. The sum of quantities sold to other channels is at most no more than one third of the quantity sold to small traders.

# Findings

## 1. HIGH-INPUT FARMING SCENARIO

Table A below reports the present value of the flows of net economic benefits that accrue over a 10 year period for each of the stakeholders in the maize value chain from the implementation of high input farming practices in Uganda. This table reports the present value of net benefits if such a revolution in farming practices were to take place in all the FtF districts and full potential yields were immediately realized. These values are clearly not likely to be achieved; however, this represents the potential from the implementation of a hybrid corn revolution in Uganda. The economic net present value from such a phenomenon would be 3.3 billion USD with 2.4 billion accruing to agriculture households.

**Table A: Incremental Present Value of Net Economic Benefits Over 10 Years by Value Chain Stakeholder from High Input Farming Intervention**

| Stakeholders | Million USD | |
|---|---|---|
| | Full potential yield (1) | Half potential yield (2) |
| Agricultural households | 2,427.3 | 765.6 |
| Small and medium traders | 367.0 | 183.5 |
| Warehouse operators | 3.5 | 1.8 |
| Volume buyers | 275.6 | 137.8 |
| Government | 249.5 | 124.7 |
| Economy | 3,322.9 | 1,213.4 |

A more  realistic set of outcomes in presented in Column 2 of Table A where it is assumed that only half of the potential yields will be achieved over the next ten year period if immediate implementation of this program were implemented by farmers in the FtF districts. This also assumes that the complementary infrastructure including traders, warehousing and transportation would be in place to handle this increase in production. In this case agriculture households would gain in net income about 776 million USD over the next 10 years with the other downstream actors gaining 341 million USD, with the government gaining 125 directly and indirectly in tax revenue. The total economic impact would be to increase incomes in Uganda by 1.2 billion USD.

The results in Table B show the net economic benefit flows when they are scaled back to reflect the likely size of the FtF intervention under the Commodity Production and Marketing (CPM) project. In this case, two assumptions are made. First, it is assumed that the funding under the CPM project will just be sufficient to bring about the change in maize farming practices for 100,000 farm households. In this case the net income gain to farm households is 167.8 million USD for this group, if full potential yields were achieved. They are reduced down to 61.3 million USD if a more realistic set of assumptions are made indicating that only 50 percent of the potential yields are achieved on average over the first 10 years after the project's implementation.

In Column 2 of Table B, the results of a potential FtF intervention was taken that could reach 200,000 farm households. In this case the figures are doubled. If 50 percent of potential yield is achieved over the first 10 years after introduction, the present value of the net economic benefits amount to 122.5 billion USD.

**Table B: Incremental ENPV of High input farming for 100,000 and 200,000 Farm Households**

| Percentage deviation in yield estimate | USAID Cost 200 USD per household (1) | | USAID Cost 100 USD per household (2) | |
|---|---|---|---|---|
| | HD covered | Economic benefit generated (million USD) | HD covered | Economic benefit generated (million USD) |
| **0%** | 100,000 | 167.8 | 200,000 | 335.6 |
| **-10%** | 100,000 | 146.5 | 200,000 | 293 |
| **-20%** | 100,000 | 125.2 | 200,000 | 250.4 |
| **-30%** | 100,000 | 103.9 | 200,000 | 207.8 |
| **-40%** | 100,000 | 82.6 | 200,000 | 165.1 |
| **-50%** | 100,000 | 61.3 | 200,000 | 122.5 |

Considering the impact on a per farm household basis Table C presents the incremental net income that each of the stakeholders receive when an additional farm household joins into the program. If a farm household experiences a 50 percent yield increase it is expected to enjoy an increase in its full income equal to a present value of 387 USD.  The total economic NPV for this level of yield is 613 USD with the other stakeholders in the value chain receiving 226 on a per farm household basis. On the other hand, if a farm household is able to obtain a yield equal to the potential obtained by model farms, the present value of the increase in the household's full income would be 1,226 USD. The other stakeholders net benefits amount to 452 USD, giving an overall economic benefit per farm household arising from their implementation of these practices of 1,678 USD.

**Table C: Average Incremental Benefit an Agricultural Household Generated for Downstream Stakeholders (USD)**

| % deviation in yield estimate | Agricultural households (1) | Small and medium traders (2) | Warehouse operators (3) | Volume buyers (4) | Govt (5) | Econ (6) |
|---|---|---|---|---|---|---|
| **0%** | 1,226 | 185 | 1.8 | 139 | 126 | 1,678 |
| **-10%** | 1,058 | 167 | 1.6 | 125 | 113 | 1,465 |
| **-20%** | 890 | 148 | 1.4 | 111 | 101 | 1,252 |
| **-30%** | 722 | 130 | 1.2 | 97 | 88 | 1,039 |
| **-40%** | 554 | 111 | 1.1 | 84 | 76 | 826 |
| **-50%** | 387 | 93 | 0.9 | 70 | 63.0 | 613 |

Table D and E report the incremental benefit for households by poverty and gender categories, assuming that the actual yield increase is only 50 percent of the estimated potential increase in yield. In this case the present value of the expenditure by USAID of 20 million USD would yield a present value of net benefits to the farm households of 38.7 million USD. In this case, the gain by the extremely poor is 23.5 million USD or 60.8 percent of the total net benefits. If the cost of the intervention can be successfully implemented at only 100 USD per household, allowing the coverage to expand to 200,000 households, then the present value of net benefits accruing to the extremely poor is increased to 47.1 million USD.

**Table D: Present Value of Incremental Full Income per Participating Household by Poverty Status from 10 Years of High-Input Maize Cultivation (50 Percentage Reduction in Yield)**

| Poverty status | 200 USD per household (1) | | 100 USD per household (2) | |
|---|---|---|---|---|
| | HD covered | Total agricultural household full income (Million USD) | HD covered | Total agricultural household full income (Million USD) |
| **Extremely Poor < $1.25** | 60,860 | 23.5 | 121,720 | 47.1 |
| **Very Poor $1.25 - $2** | 14,540 | 5.6 | 29,080 | 11.2 |
| **Near Poor $2 - $4** | 14,000 | 5.4 | 28,000 | 10.8 |
| **Non-Poor > $4** | 10,600 | 4.1 | 21,200 | 8.2 |
| **Total** | 100,000 | 38.7 | 200,000 | 77.3 |

When the anticipated yields are reduced to 50 percent of the potential and the size of the coverage is 100,000 households then the gain by household headed by females in reduced to 7.6 million (Table E

Column 2). If the coverage can be increased to 200,000 households the net benefits received by those headed by woman increases to 15.2 million USD.

**Table E: Present Value of Incremental Full Income per Participating Household by Household Head Gender Status from 10 Years of High-Input Maize Cultivation (50 % Reduction in Yield)**

| Household head gender | 200 USD per household (1) | | 100 USD per household (2) | |
|---|---|---|---|---|
| | HD covered | Total agricultural household full income (Million USD) | HD covered | Total agricultural household full income (Million USD) |
| **Female** | 19,640 | 7.6 | 39,280 | 15.2 |
| **Male** | 80,360 | 31.1 | 160,720 | 62.1 |
| **Total** | 100,000 | 38.7 | 200,000 | 77.3 |

## 2. WAREHOUSE SERVICES EXPANSION

The incremental financial net present values (NPVs) for various stakeholders are listed in Table F. The farming households are expected to gain in present value about 127.2 million USD over 10 years (Table F Column 2). The household gain approximately 58 percent of the total benefits from this intervention. The small and medium traders gain net income of 38.5 million USD, or approximately 30 percent of the incremental amount earned by the farmers from their reduction in postharvest losses.

Collectively, warehouse operators earn a financial NPV of 8.8 million USD. This value indicates that if a sufficient number of households deposit their maize in the warehouses, the revenue from the sale of warehouse services will be sufficient to cover the levelized costs of the initial warehouse construction cost (at a 12 percent real rate of return) as well as cover its recurring operating costs the operators will earn an additional surplus of 8.8 million. This is an attractive return on about 12.6 million USD of investment.

Volume buyers will also increase their net incomes by 22.6 million USD due to the additional business that comes to them from the additional farm maize sales. The government also gains tax revenues of 23.1 million USD from additional tax revenues from diverse sources. It would appear that about 40 percent of the net economic benefits are arising outside of both the warehousing and farmer stakeholders. It is likely that this value of net benefits might be somewhat overstated as additional investment will be required at the volume buyer and trader stages in order to handle the increased volume of sales do the reduction in postharvest losses.

**Table F: Incremental Economic Net Present Value of Warehouse Services Over 10 Years at 12 Percent Discount Rate**

| Stakeholders | Million UGX | Million USD |
|---|---|---|
| **Agricultural HD** | 318,097 | 127.2 |
| **Small and medium traders** | 96,322 | 38.5 |
| **Warehouse operators** | 22,063 | 8.8 |
| **Volume buyers** | 56,623 | 22.6 |
| **Government** | 57,781 | 23.1 |
| **Economy** | 550,885 | 220.4 |

Column 1 of Table G reports the average contribution of a satellite warehouse to the economy, for various home storage loss percentages. On a per warehouse basis the economic net present value ranges from 699 thousand USD when the postharvest losses from home storage are low at 17.8 percent as compared to a value of 1.1 million USD percent when the losses are high at 27.8%. To satisfy the demand for storage space at the current level of maize production, it is estimated that the full implementation of the intervention calls for the construction of 250 satellite warehouses, each with an annual holding capacity of 1,200 metric tons. Sponsoring the construction of 250 warehouses requires 12.6 million USD. At a 50 percent and 75 percent coverage, 125 and 188 warehouses are required, and the corresponding total construction costs are 6.3 and 9.5 million USD, respectively. With a coverage of 50 percent (125 warehouses) and an average home storage loss of 22.5 percent, the economic benefit across the entire value chain would be 110.2 million USD; with a coverage of 75 percent (188 warehouses), the economic benefit would be 165.3 million USD; with a 100 percent coverage (255 warehouses), the present value of the economic benefits would be 220.4 million USD.

These values of net economic impacts might be slightly exaggerated because the complementary investments to be made by the trading stakeholders to handle the additional business are not taken into account. Even with a substantial deduction for these investment costs, this intervention appears to have considerable promise. The net economic benefit generated is estimated to be 881,000 USD per warehouse. While the figure seems exaggerated, it is in fact quite modest considering that the benefit is spread over the 10 year of project life, and that each warehouse is designed to hold 1,200 metric tons per annual; the discounted economic benefits is only 7.34 US cents on a per kg basis (881,000 USD/10 years/1200MT/1000kg).

**Table G: Incremental ENPV per Warehouse and PV of Economic Net Benefits of Partial and Full Coverage by Post Harvest Loss Percentages Millions USD**

| Average postharvest losses | Economic NPV per warehouse (Thousand USD) (1) | Total Economic NPV 125 warehouses (50% storage) (2) | Total Economic NPV 188 warehouses (75% storage) (3) | Total Economic NPV 250 warehouses (100% storage) (4) |
|---|---|---|---|---|
| **17.80%** | 699 | 87.5 | 131.2 | 175 |
| **18.90%** | 744 | 93.2 | 139.7 | 186.3 |
| **20.00%** | 790 | 98.8 | 148.2 | 197.7 |
| **21.10%** | 835 | 104.5 | 156.8 | 209 |
| **22.20%** | 881 | 110.2 | 165.3 | 220.4 |
| **23.30%** | 926 | 115.9 | 173.8 | 231.7 |
| **24.40%** | 971 | 121.5 | 182.3 | 243 |
| **25.50%** | 1,017 | 127.2 | 190.8 | 254.4 |
| **26.50%** | 1,062 | 132.9 | 199.3 | 265.7 |
| **27.80%** | 1,107 | 138.5 | 207.8 | 277.1 |

## 3. PURCHASE FOR PROGRESS EXPANSION

Traditionally, WFP bought from volume buyers who acquired their maize from small and medium traders, who in turn bought from farmers. With the expansion of the P4P, farmers sell more to P4P and less to the intermediary agents. Row 1 of Table H presents the incremental economic NPV for participating households in for the scenario that P4P is able to divert 10 percent of the sales that normally go to the small and medium traders to its purchasing system. The results indicate that the impact on farm incomes is modest. The total increase in farm incomes arising from the P4P purchases is approximately 7.8 million USD as compared to a base line income of farm families from maize of 2.3 billion USD.

As a consequence of this intervention, small and medium traders lose 10 percent of the existing procurement amounting to 26,866 tons. In monetary terms, collectively they lose net income equal to 15.0 million USD (Table H Row 2). The net income losses (net of their labour opportunity costs) that the P4P direct purchases inflict on the small and medium traders is equal to about 200 percent of the net gains received by the maize cultivating households.

**Table H: Incremental Economic Net Present Value of P4P Expansion Intervention Over 10 Years at 12 Percent Discount Rate**

| Stakeholders | Million UGX | Million USD |
|---|---|---|
| **Agricultural HD (1)** | 19,401 | 7.8 |
| **Small and medium traders (2)** | -37,624 | -15.0 |
| **Warehouse operators (3)** | -402 | -0.2 |
| **Volume buyers (4)** | -28,571 | -11.4 |
| **Government (5)** | -7,867 | -3.1 |
| **Economy (6)** | -55,062 | -22.0 |

The reduced throughput is insufficient to sustain the same number of private traders, and it is estimated that up to 2,100 small and medium traders will be forced to switch to other ventures. Much of the job loss is in Central Region and Eastern Region where agricultural households are more commercialized and the maize trade is much more active. Perhaps more important for the long run is that the P4P direct purchase program is destroying the most competitive, and ultimately what could become the most efficient, part of the rural agriculture trading system.

The loss of throughput by small and medium traders triggers a chain reaction downstream. Volume buyers in turn acquire less maize, and so do domestic feed manufacturers and the non-producing population. The government also loses direct and indirect tax revenues. These losses are the surpluses that are present in the activities of the different actors of the value chain that are in excess of their costs. While the farm household gain by about 7.8 million USD, the other stakeholders in the value chain lose over three times as much in terms of net income. The total incremental loss for the economy in present value is estimated to be 45,062 million UGX (-22.0 million USD).

## Conclusion and Recommendations

Table I below summarizes the incremental economic NPV for each intervention.

**Table I: Incremental Economic Net Present Value of Different Interventions Over 10 Years at 12 Percent Discount Rate (Million USD)**

| Stakeholders | High-Input Farming | | Warehouse Services (3) | P4P Expansion (4) |
|---|---|---|---|---|
| | Full potential yield (1) | Half potential yield (2) | | |
| **Agricultural households** | 2,427.3 | 765.6 | 127.2 | 7.8 |
| **Small and medium traders** | 367.0 | 183.5 | 38.5 | -15 |
| **Warehouse operators** | 3.5 | 1.8 | 8.8 | -0.2 |
| **Volume buyers** | 275.6 | 137.8 | 22.6 | -11.4 |
| **Government** | 249.5 | 124.7 | 23.1 | -3.1 |
| **Economy** | 3,322.9 | 1,213.4 | 220.4 | -22 |

1. **High Input Farming:**
   Analysis results suggest that this intervention has substantial potential in Uganda. It is ultimately the only intervention that has the potential to substantially raise the income of poor farming households. It not only raises farmer's incomes but adds substantially to the net incomes of the other stakeholders in the maize value chain. It also raises the tax revenues accruing to the government. Unfortunately, raising production alone is not likely to lead to succeed. Farmers will be very cautious about entering into a campaign to increase output if the warehouses and trading system is very weak and they take the risk of experiencing very low prices.

   **It is recommended the USAID (FtF) consider interventions that will promote the use of high input techniques of maize farming.**

2. **Community Warehouses Construction:** This intervention focuses on construction of community warehouses to reduce postharvest loss by properly drying and cleaning maize deposit. This intervention shows substantial promise at improving the efficiency of the maize sector, even at the current baseline levels of production and sales. As maize production is increased in the country additional local warehouses for the drying, cleaning and storage of the product is likely to become even more critical for the success of the long term development of the maize sector.

   **It is recommended that the USAID (FtF) program in Uganda consider interventions that will promote the local warehouse and trader system to use such warehouses and to offer quality differentiated prices to encourage the farmers to utilize such services.**

3. **World Food Programme's (WFP) Purchase for Progress (P4P):** This intervention is based on the expansion of World Food Programme's (WFP) direct procurement from agricultural households through its Purchase for Progress (P4P) program. As a result of WFP competition, small traders lose throughput, which triggers a chain reaction downstream. Volume buyers, feed manufacturer and the non-producing population in turn acquire less maize; the government also loses tax revenues. The economy as a whole losses because, while WFP offers a higher farm gate price to agricultural households, the price is nonetheless less than what other actors can fetch in

many final markets.  Therefore, this application of P4P program of WFP does not add efficiency and creates losses for these actors in the maize value chain.

**It is recommended that USAID (FtF) does not continue to encourage the expansion of WFP's P4P program because it tends to destroy the financial viability of thousands of small and medium traders. Its activities reduce the net incomes of other downstream participants in the maize value chain. It also impedes the development of a set of private institutions at the district level that will over time become more efficient and as the infrastructure in the country improves.**

# INTRODUCTION

USAID/Uganda's Commodity Production and Marketing (CPM) project focuses on the production and marketing of maize, beans, and coffee. In the initial investigation carried out during the field visit by the Learning Evaluation and Analysis Project (LEAP) team, it was emphasized by many local experts that the maize value chain contained the most opportunities for fruitful interventions by the CPM project. Given the stage in the development of the CPM Project, the specific interventions or investments had not yet been specified. To assist in shaping the project in its implementation the LEAP team thought it would be most useful to model Uganda's maize value chain down to the regional level. Maize was selected because of its dual function, unique among the three crops, both as an income-generating cash crop and a staple crop that improves food security.[1]

According to the Uganda Census of Agriculture (UCA) 2008-09, maize is the most commonly cultivated crop in Uganda, followed by beans, banana, cassava and sweet potatoes. While about 1.5 million agricultural households grow maize throughout the year in both seasons, maize production largely remains at the subsistence level. Uganda's agricultural sector is dominated by smallholder farmers that are constrained to the low input-low output farming system. Farm equipment is limited to hand tools. The use of animal power for ploughing and other agricultural activities is uncommon, with only 11 percent of surveyed household reported having used it. Around the same percentage of households reported to use tractors. Irrigation is extremely rare – even the use of watering cans was reported to be a mere 6 percent. In addition, only 28 percent of households used improved or hybrid seeds for planting; 22 percent used organic fertilizer that was predominantly self-supplied, and less than 5 percent had access to inorganic fertilizer (UBOS 2009).

The immediate consequences of the low input-low output system are food shortages, which according to UCA 2008–09 are especially pronounced during the months from May to August, with 45 percent of households reported having experienced food shortages during this period. The percentage was around 20 percent for the rest of the year. Of those who experienced a food shortage, 71 percent cited loss of crops or insufficient production as the primary reason (UBOS 2009).

Another challenge raised by many interviewed respondents was the limited market access for farm produce. Because of low yield, each agricultural household produces little surplus for sales, beyond the subsistence requirement. In addition, the condition of feeder roads that connect villages to highway is such that the roads are largely impassable for heavy vehicles. Maize trade at the farm gate level is conducted mostly by itinerant small traders travelling on motorcycles or light vehicles, who earn a living by passing on to larger buyers the maize collected in small quantities from dispersed locations. These factors translate into high transaction costs. Local centralized markets are largely missing.

In view of these challenges confronted by the maize sector, the LEAP team considered three general ***classes*** of interventions related to crop productivity improvement, postharvest loss reduction, and increasing market access for farmers. Specific interventions were defined for substantive cost-benefit analysis. The first hypothetical intervention was switching from subsistence farming which requires minimal commercial agricultural and labor inputs to high input farming. The second was the construction of community warehouses that reduce postharvest losses by properly drying and cleaning maize deposits. The third intervention was the expansion of World Food Programme's (WFP) direct procurement from agricultural households through its Purchase for Progress (P4P) program. Details of the interventions are given below in the respective sections.

[1] Maize is not a traditional staple crop in Uganda but the population has gradually acquired a taste for maize since it is commonly served in government and educational institutions as well as in refugee camps.

# METHODOLOGY

Because of the absence of identified interventions in the crop component of the FtF program in Uganda at the time of the study teams field visit to Uganda, it was decided to try to identify promising areas for interventions by first mapping the current maize value chain to construct a base case scenario and then evaluate the benefits and costs of various interventions in a general equilibrium fashion considering the entire value chain using this model. This is in contrast to a traditional cost benefit analysis where one might evaluate a series of specific well defined interventions in detail and set aside many of the secondary impacts of the project on other stakeholders where the impacts are uncertain. The mapping of the current maize value chain was done taking into consideration the regional differences in productivity, maize disposition pattern of households, and the prices of maize grains and flour.

To map out the maize value chain, the cost benefit analysis model must keep track of two types of flows at the regional level. The first is the flow describing the disposition of the physical good, from farm production to various final destinations through different channels; the second is the amount of value-added as the good changes hands between the various value chain actors. Although disaggregating the mapping to the regional level is more laborious and requires stronger assumptions at times when accurate data are missing, this method is preferable given significant regional variations in many fundamental parameters, such as crop productivity and disposition channels.

The mapping employs a combination of micro-level data, such as a household survey (UCA 2008-09) on maize production and disposition, and macro-level data to track down the quantities of maize that reach various destinations: domestic maize consumption (by producing and nonproducing populations), domestic feed production, and neighboring countries (via formal and informal exports, and aid and relief). For some of the quantities, deduction is required because data are not available. The goal is to balance the total inflow (production or procurement) and total outflow (disposition) of maize for each major value chain actor and for the national system as a whole. At each level of the value chain, the percentages of disposition to different channels are computed by calibration; the percentages must be such that the quantities that reach various destinations must match macro-level statistics. The overall result is a two-dimensional mapping of the maize flow which captures the maize quantities flowed through different channels, as well as the amount of value added retained by different participants along the value chain. This mapping depicts the base case scenario against which intervention scenarios are measured.

## Value Chain Actors and Beneficiaries

Three major value chain actors are modeled explicitly.

Agricultural households can consume their own produce; store it (either in home storage or improved communal warehouses with proper drying and cleaning facilities) for disposition in the next period; sell it in local markets (to the nonproducing population); sell it to small and medium traders; sell it to volume buyers; or sell it to WFP through its P4P.

Small and medium traders have multiple market outlets for their maize procurement from agricultural households: warehouses, local markets, informal exports, small-scale feed producers, and volume buyers. In reality, this is a heterogeneous group that encompasses a wide spectrum of traders of varying financial capacity who operate in primary and secondary markets.

Volume buyers can sell to local markets, carry out formal exports, sell to large-scale feed producers, or sell to WFP.

### Other Stakeholders

In addition to the three stakeholders mentioned above, the government is the fourth stakeholder that draws benefits from an improvement in the maize sector. The government which receives tax revenue directly from the sector's transactions and indirectly from the taxes that make up the foreign exchange premium (FEP).[2] The two direct sources of tax revenue are the value-added tax (VAT) paid on inputs and corporate income tax (CIT) on large business enterprises. On the input side, VAT is applied to inputs used in the milling and transportation services related to small traders and to all inputs purchased by volume buyers. Given their small turnover, agricultural households and small and medium traders are exempted from VAT registration. They pay VAT on taxable inputs but do not receive refund on the VAT paid on inputs.

On the output side, agricultural households and small and medium traders are unlikely to collect VAT on any of their sales. Only the volume buyers collect VAT on sales to local markets (in the form of milled, packaged flour) and to feed manufacturers. By the destination principle, VAT is not applicable to exports or to sales to WFP by implication. Similarly, only volume buyers pay CIT, although the actual amount is likely to be less than the estimate due to prevalent tax evasion and weak tax administration in developing countries. The value of the FEP is applied to all transactions in foreign currencies – namely, informal exports by small and medium traders and formal exports and sales to WFP by volume buyers and agricultural households.

# I. BASE CASE (WITHOUT INTERVENTION) SCENARIO

Before assessing the incremental impacts of the various interventions, it is necessary to develop a set of base values that defines the situation and the sizes of the revenue and costs accruing to the various stakeholders in a situation without the intervention. The impacts of the interventions will be measured by comparing the values of the net incomes of the various stakeholders with the intervention as compared to the situation without the intervention.

Given the variable quality of unpublished and officially published data in Uganda, a great deal of attention had to be taken to assure the veracity of the information obtained from the various sources. This was necessary in order to have confidence that the results of a cost benefit analysis completed following this approach would provide a sound basis for decision making. Detailed findings for the base case scenario are reported in Annex 1. For the purpose of this study it suffices to note that, given the current real price level, in a 10 year period the maize value chain will generate for the economy as a whole about 7,267.6 billion UGX (2,907.0 million USD) in present value. The implied annual contribution of the maize sector to GDP is 422.8 million USD, or about 2.5 percent of 16.81 billion USD for the year 2011. The actual share should be slightly less, because the implied GDP includes informal exports.

Table 1 summarizes the NPV benefits for all stakeholders in the base case scenario. The total full income (the value of own maize consumption and maize sales) of Ugandan agricultural households amounts to 5,825.3 billion UGX (2.3 billion USD). The profit earned over a 10 year period by some 37,000 small

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[2] The foreign exchange premium is a measure of the taxes that are collected indirectly due to having additional foreign exchange to spend. Alternatively, it is a measure of the taxes lost if foreign exchange is used by the project. Since maize is an internationally traded exportable good, the production of maize to the degree it is sold creates additional foreign exchange for the country and hence more tax revenue.

and medium traders is 633.7 billion UGX (253.5 million USD)[3], and that by volume buyers is 380.0 billion UGX (152.0 million USD). The government collects tax revenue that is equal to 418.4 billion UGX (167.3 million USD). Tax revenue consists of CIT paid by volume buyers and VAT paid by small traders on inputs and by the nonproducing population and large-scale feed manufacturers on maize supplied by volume buyers. Agricultural households do not pay VAT, because commercial agricultural inputs are VAT exempt. In additional, the government also collects FEP from the informal export by small and medium traders, and formal export by volume buyers and agricultural households.

**Table 1: ENPV of Incomes for Major Stakeholders (Without Intervention)**

| Stakeholders | Million UGX | Million USD |
|---|---|---|
| **Agricultural households** | 5,825,260 | 2,330.1 |
| **Small and medium traders** | 633,672 | 253.5 |
| **Warehouse operators** | 10,269 | 4.1 |
| **Volume buyers** | 379,988 | 152.0 |
| **Government** | 418,364 | 167.3 |
| **Economy** | 7,267,553 | 2,907.0 |

# STUDY FINDINGS

## II. HIGH-INPUT FARMING SCENARIO

As a component of USAID/Uganda's Feed the Future Program, the CPM Project covers 34 districts that span all four regions and account for 79 percent of the area under maize cultivation in Central Region, 63 percent in Eastern Region, 38 percent in Northern Region, and 27 percent in Western Region. Approximately 1.98 million agricultural households live in the covered districts. For the classes of interventions to be analyzed in this study, it is initially assumed that they will be implemented in all target districts. Later in each section the impact of the intervention will be scaled down to size that is more likely to be realized by the activities that can be financed by size of the proposed USAID budgetary outlay.

**Table 2A: Feed the Future Program Covered Districts by Region**

| Region | Number of districts covered (1) | Approximate hectare of maize farmland covered (Ha) (2) | Annual production in covered districts (MT) (3) | Number of participating households (4) |
|---|---|---|---|---|
| **Central** | 5 | 148,876 | 177,053 | 635,366 |
| **Eastern** | 9 | 244,146 | 348,092 | 696,404 |
| **Northern** | 11 | 95,287 | 58,799 | 348,003 |
| **Western** | 12 | 50,407 | 66,522 | 300,636 |
| **Total** | 37 | 538,717 | 650,466 | 1,980,411 |

[3] According to a World Bank survey, farm gate and primary market traders in Eastern Region on average sell 13 tons of maize per season (World Bank 2009). Given that the quantities sold to small and medium traders are known from the UCA, it can be estimated that at least 36,663 individuals engage directly in the maize trade.

The first intervention aims to boast maize productivity by intensifying the usage of commercial inputs such as herbicide, pesticide, fertilizer and top dressing. This intervention will require major changes in the way commercial inputs are marketed to agricultural households. At the present time, the international inputs suppliers in Kampala cater mostly to large agricultural enterprises and by and large are uninterested in reaching out to agricultural households. Individual traders who operate at a much reduced scale with less overhead expenses may earn a reasonable margin from supplying to agricultural households, but intermittent demand makes supplying inputs to agricultural households an unattractive business overall for them. USAID/Uganda's Learning Evaluation and Analysis Project (LEAD) project has launched initiatives that work towards linking farmers groups with commercial inputs suppliers, to try to overcome these market deficiencies.

Agricultural households rely overwhelmingly on hand tools for farming. Supplementary commercial inputs usage is minimal, and irrigation is almost non-existent. According to the UCA 2008-09, commercial inputs usage is more common in Eastern Region than elsewhere. For instance, of the 0.29 million households (or around 7 percent of all agricultural households) who reported the use of inorganic fertilizer, 37 percent was from Eastern Region; Eastern Region households also accounted for 45 percent of those reported to have used pesticides, and 40 percent of those reported to have used fungicides. However, Central Region households top their Eastern Region counterparts in the use of herbicides. They account for 42 percent and 29 percent of the 0.34 million that used herbicides, respectively. The fact that more households in Eastern Region apply more commercial inputs helps to explain the higher maize yield in that region.

To maximize the yield potential, more labor input will be required in the application of commercial inputs and in tending the crop. Similar to the base case scenario, households supply their own labor. Agricultural households are assumed to have sufficient labor available in the household to engage in intensive farming. Hence, in the assessment of this intervention the additional compensation accruing to the additional effort of the household is included as an increase in the net income of the household.

The farm budgets are identical to subsistence farming, except for the addition of commercial inputs costs; Table 2B presents the seasonal commercial inputs costs on a per hectare basis. It is assumed that there is no liquidity constraint and agricultural households can obtain all necessary commercial inputs by either credit or by cash. Subsequent analysis results indicates that, if the yields are fully realized from this intervention, sufficient cash income will be generated for farmers to repay the loans taken to purchase commercial inputs.

**Table 2B: Incremental Increase in Farm Budget for High-Input Farming per Season (UGX/Ha)**

| Region | Herbicide and pesticide | Fertilizer | Top dressing | Total |
|---|---|---|---|---|
| **Central** | 175,445 | 494,210 | 24,711 | 694,365 |
| **Eastern** | 53,942 | 435,033 | 19,866 | 508,841 |
| **Northern** | - | 522,618 | 24,711 | 547,328 |
| **Western** | - | 494,210 | 24,711 | 518,921 |

Source: own calculation based on LEAD (2011)

The analysis undertaken to assess the impact of high-input farming has indicated that this intervention if fully implemented could improve yields in Central Region by 233 percent, in Eastern Region by 259 percent, in Northern Region by 245 percent, and in Western Region by 214 percent, respectively (LEAD 2011). It is expected that, except for Northern Region, households will retain 20 percent of incremental production for own production and sell the surplus to various markets. Northern Region households are assumed to retain 50 percent because of the low quantity of production in the base case scenario.

Table 2C reports that the full and immediate implementation of the high input-high yield intervention would increase maize production by about 1.9 million tons. Of this total, 24 percent is provided by Central Region and about 58 percent is provided by Eastern Region. As compared to the base case (without intervention, Table 1C in Annex 1), this represents a 136 percent increase in maize production for the country. It should be noted that the CPM budget of 20.0 million USD in present value, even if it is allocated entirely to the maize sector, is insufficient to finance the intervention at a scale that covers all 1.98 million maize-cultivating households in 37 FtF districts. Therefore, an increase in production by 136 percent is a highly unlikely possibility due to budget constraint. Even with sufficient budgeting to facilitate the expansion of maize production, a full implementation of the intervention would need to be accompanied by a major expansion of the maize trading and warehousing capacity in order to stabilize the domestic price of maize. Given the present limited trading and warehousing capacity, such an increase in production, if it occurs too quickly, could lead to a collapse in the domestic price of maize.

**Table 2C: Agricultural Household Incremental Annual Maize Production and Disposition from High-Input Maize Cultivation in USAID FtF Districts (MT)**

| Region | Incremental annual production and storage from previous period (1) | Incremental losses (2) | Incremental own consumption (net of spoilage) (3) | Incremental sales (4) | Incremental storage deposit (5) |
|---|---|---|---|---|---|
| **Central** | 462,285 | 39,226 | 113,137 | 260,760 | 49,162 |
| **Eastern** | 1,109,778 | 126,613 | 378,933 | 395,979 | 208,252 |
| **Northern** | 176,418 | 23,049 | 73,696 | 47,270 | 32,403 |
| **Western** | 165,212 | 17,046 | 51,287 | 74,214 | 22,665 |
| **Total** | 1,913,694 | 205,934 | 617,053 | 778,224 | 312,482 |

**Table 2D: Incremental FNPV of Full Income for Participating Agricultural Households from 10 Years of High-Input Maize Cultivation**

| Region | Cash income (1) | | Value of own consumption (2) | | Regional full income (3) = (1) + (2) | |
|---|---|---|---|---|---|---|
| | Million UGX | Million USD | Million UGX | Million USD | Million UGX | Million USD |
| **Central** | 791,089 | 316.4 | 720,460 | 288.2 | 1,511,549 | 604.6 |
| **Eastern** | 1,547,657 | 619.1 | 2,132,417 | 853.0 | 3,680,074 | 1,472.0 |
| **Northern** | 76,807 | 30.7 | 393,173 | 157.3 | 469,980 | 188.0 |
| **Western** | 133,219 | 53.3 | 272,896 | 109.2 | 406,115 | 162.4 |
| **Total** | 2,548,771 | 1,019.5 | 3,518,946 | 1,407.6 | 6,067,718 | 2,427.1 |

Table 2D presents the incremental financial benefits in present-value terms by region, if the intervention is fully implemented and its potential fully realized. All the incremental costs except for additional labor used are deducted from the incremental gross income. The present value of the impact on income over a

10 year period would be 2,548.8 billion UGX or 1.02 billion USD (Table 2D Column 1) in terms of cash income and 6,067.7 billion UGX or 2.43 billion USD in terms of full income (Table 2D Column 3). All regions benefit substantially from the intervention, with Eastern Region receiving the highest incremental NPV of 1,472.0 million USD.

Since the benefits of the high-input farming interventions hinge critically on the size of the incremental production, a sensitivity analysis is conducted to test the impact of percentage deviation in yield-improvement estimates on agricultural households. The analysis results are presented in Table 2E. Overall, the intervention would yield positive incremental benefits for all regions even if the yield improvements were reduced by 50 percent of potential.

**Table 2E: Results of a Sensitivity Analysis on Full Income of Participating Agricultural Households for Percentage Reduction in Yield-Improvement**

| % deviation in yield estimate | Regional full income (Million USD) | | | | All agricultural households |
|---|---|---|---|---|---|
| | Central | Eastern | Northern | Western | |
| | **604.6** | **1,472.0** | **188.0** | **162.4** | **2,427.1** |
| **0%** | 604.6 | 1,472.0 | 188.0 | 162.4 | 2,427.1 |
| **-10%** | 507.4 | 1,293.3 | 159.1 | 134.9 | 2,094.8 |
| **-20%** | 410.2 | 1,114.6 | 130.2 | 107.4 | 1,762.4 |
| **-30%** | 313.0 | 935.8 | 101.4 | 79.9 | 1,430.1 |
| **-40%** | 215.8 | 757.1 | 72.5 | 52.4 | 1,097.8 |
| **-50%** | 118.6 | 578.3 | 43.6 | 24.9 | 765.5 |

Table 2F presents the results for the intervention that could be potentially realized at the individual household level, the incremental benefits range from 5.3 million UGX (2,114 USD) in Eastern Region to 1.4 million UGX (540 USD) in Western Region (Table 2F Column 3)[4]. The results indicate that households generate sufficient cash income to pay for commercial inputs used in the production of marketed maize. Barring deliberate non-repayment, the risk of genuine default is minimal if a program is set up to enable households to buy commercial inputs on credit.

Currently, agricultural households have very limited access to credit. According to the UCA 2008-09, only 10 percent or around 0.36 million households countrywide had obtained credit in the five years before the survey was conducted. Furthermore, for those who managed to obtain loans, trading in agricultural produce was the most common purpose for such financing, followed by labor hiring and the purchasing of seeds. The purchasing of fertilizer and agricultural chemicals, however, was cited by less than 10 percent of households as the purpose of borrowing.

[4] It is a coincidence that there is the exact same income gain per household in the Northern and Western regions. Because of the different number of farmers, each with fixed costs associated with the program, the net income increases are not equal when the yield rate is reduced below 100 percent of potential. (Table 2G).

**Table 2F: Incremental FNPV of Aggregated Regional and Per Participating Agricultural Household Full Income for 10 Years of High-Input Maize Cultivation**

| Region | Number of participating households (1) | Regional full income (2) | | Full income per participating household (3) | |
|---|---|---|---|---|---|
| | | Million UGX | Million USD | Thousand UGX | USD |
| **Central** | 635,367 | 1,511,548.7 | 604.6 | 2,379.0 | 952 |
| **Eastern** | 696,405 | 3,680,073.7 | 1,472.0 | 5,284.4 | 2,114 |
| **Northern** | 348,003 | 469,980.0 | 188.0 | 1,350.5 | 540 |
| **Western** | 300,636 | 406,115.1 | 162.4 | 1,350.9 | 540 |
| **Total** | 1,980,411 | 6,067,717.5 | 2,427.1 | Average 3064.5 | 1247 |

Table 2G reports the results of the sensitivity analysis on individual agricultural household income for the percentage reduction in yield-improvement. With a reduction in yield by 40 or 50 percent below the full potential, the improvement on individual household incomes is quite small except for the Eastern Region. The increase in full income falls to approximately 25 percent of the potential when the increase in yields reduces by 50 percent. Furthermore, given that the imputed labor cost is not included in the farm budget, it seems that, for all but the Eastern Region, much of the incremental benefits (if evaluated net of the additional labor opportunity costs) is likely to be eroded away if the actual yield-improvement is reduced by 30 to 50 percent below its full potential. Eastern Region is special in that it has a relatively high yield in the base case scenario and continues to appear attractive with incremental yield improvements of as little as 50 percent of the stated potential yield improvement.

**Table 2G: Results of a Sensitivity Analysis on the Percentage Reduction in Yield-Improvement for Individual Participating Household by Region**

| % deviation in yield estimate | Per participating household (USD) | | | |
|---|---|---|---|---|
| | Central | Eastern | Northern | Western |
| **0%** | 952 | 2,114 | 540 | 540 |
| **-10%** | 799 | 1,857 | 457 | 449 |
| **-20%** | 646 | 1,601 | 374 | 357 |
| **-30%** | 493 | 1,344 | 291 | 266 |
| **-40%** | 340 | 1,087 | 208 | 174 |
| **-50%** | 187 | 831 | 125 | 83 |

In Table 2H we find that the additional flow of maize through the small traders and volume buyers to various final destinations generates additional VAT, CIT, and FEP for the government. The change in maize production of this magnitude brings an incremental benefit of 917.4 billion UGX (367.0 million USD) in present-value terms to small and medium traders; of 8.8 billion UGX (3.5 million USD) to warehouse operators; of 689.0 billion UGX (275.6 million USD) to volume buyers; and of 623.7 billion UGX (249.5 million USD) to the government. At the national level, the additional maize production yields an incremental expected net present value of 8,307.2 billion UGX (3.32 billion USD).

The results of the stakeholder analysis are rather surprising. While agricultural households bear the additional costs of commercial inputs and labor costs along with the production and marketing risk of undertaking the high-input farming investment, downstream private value chain stakeholders reap a considerable share of the net benefits. The distribution of returns is especially unbalanced considering that the downstream traders incur only the variable costs of procurement if the program succeeds, but incur no costs if the farmers are not successful at increasing yields.

**Table 2H: Incremental FNPV for Major Stakeholders from 10 Years of High-Input Maize Cultivation**

| Stakeholders | Million UGX | Million USD |
|---|---|---|
| **Agricultural households** | 6,068,215 | 2,427.3 |
| **Small and medium traders** | 917,431 | 367.0 |
| **Warehouse operators** | 8,835 | 3.5 |
| **Volume buyers** | 689,055 | 275.6 |
| **Government** | 623,685 | 249.5 |
| **Economy** | 8,307,221 | 3,322.9 |

## USAID Intervention to Promote High-Input Cultivation of Maize

Table 2I reports the results of the sensitivity analysis for the reduction in output and incomes for the estimated yield-improvements. . All the stakeholders will benefit from this intervention even if yields are reduced by 30 or 40 percent of their potential. With the exception of the farmers, the other stakeholders in the value chain will clearly benefit, even if the yield falls to only 50 percent of the potential. In table 2I, it also appears that the farmers also benefit, but it should be noted that the opportunity cost of the farmer's own labour has not been deducted in these calculation of the value of the incremental benefits received the farming households. Overall we find that the economy as a whole could benefit from between 1.2 and 3.3 million USD in present value terms from the full implementation of this program across all the FtF districts in Uganda.

Table 2I also shows that the incremental benefits for downstream stakeholders fluctuate somewhat less for changes in yields than that for agricultural households. The reason for this is because the farmers will be required to undertake expenditures for the increased inputs before the crop is harvested and before the yield is known. On the other hand, for the traders, warehouse operators and volume buyers their costs will rise and fall roughly proportionally with the size of the increase in maize sales that come into their hands for further processing or trade. This finding echoes the previous discussion regarding the distribution of risks between value chain participants. It is the farmers who bear a disproportionate share of the risks arising from the high input farming intervention.

USAID/Uganda has earmarked $24.7 million for the implementation of interventions on the coffee, bean and maize sectors over the five year life of the project (Year 1: 5.3 million USD, Year 2: 4.9 million USD, Year 3: 5.0 million USD, Year 4: 5.1 million USD, Year 5: 4.4 million USD). The present value of the total CPM budget (at a 12 percent discount rate) at the beginning of the project is 20.0 million USD. Present values of the USAID financing are taken in order to facilitate the comparison with the present value of the benefits over the 10 years of the intervention. At the current stage of the project's development, it is unclear how this 20.0 million USD will be split among the three sectors. Hence, in the analysis that follows it is assumed that all of the funding will be allocated to the maize sector. Considering the costs of such agriculture USAID interventions, it is assumed that the average intervention cost could vary from 100 to 200 USD per household.

**Table 2I: Results of a Sensitivity Analysis on the Percentage Deviation in Yield-Improvement Estimate for Stakeholders (Million USD)**

| % deviation in yield estimate | Agricultural households (1) | Small and medium traders (2) | Warehouse operators (3) | Volume buyers (4) | Govt (5) | Economy (6) |
|---|---|---|---|---|---|---|
| **0%** | 2,427.3 | 367.0 | 3.5 | 275.6 | 249.5 | 3,322.9 |
| **-10%** | 2,094.9 | 330.3 | 3.2 | 248.1 | 224.5 | 2,901.0 |
| **-20%** | 1,762.6 | 293.6 | 2.8 | 220.5 | 199.6 | 2,479.1 |
| **-30%** | 1,430.3 | 256.9 | 2.5 | 192.9 | 174.6 | 2,057.2 |
| **-40%** | 1,097.9 | 220.2 | 2.1 | 165.4 | 149.7 | 1,635.3 |
| **-50%** | 765.6 | 183.5 | 1.8 | 137.8 | 124.7 | 1,213.4 |

As previously discussed, the high-input farming intervention will generate positive downstream externalities as these private actors acquire more maize from agricultural households for trading and processing. The government collects additional tax revenue from the increased volume of transactions and exports of maize. Table 2J reports the average benefit that a single agricultural household participating in the intervention will bring to the different downstream stakeholders along the value chain.

The figures in Table 2J are computed by dividing the incremental benefit for each class of stakeholders (Table 2I) by the total number of participating farm households, estimated to be 1.9 million (Table 2A Column 4). In addition to the 1,226 USD generated for itself over the 10 year time horizon, an agricultural household would create additional benefits for downstream value chain participants by supplying them with more maize throughput. On average, with full potential yield improvement, each household creates an additional 185 USD for small and medium traders; 2 USD for warehouse operators; 139 USD for volume buyers and 126 USD for the government. In total, each participating household will generate 1,678 USD for the economy. In this scenario where the yields reach their full potential the analysis finds that the farming households receive approximately 75 percent of the total income generated by the intervention, while the downstream traders, warehouse operators, volume buyers and government capture the remaining 25 percent of the surplus.

Again using the information in Table 2I, consider the situation when the yield is only 50 percent of its potential. In this case the total economic benefit falls to 613 million USD, and the share that the farm household receives falls to 63 percent of the total surplus. This arises because it is the farmers who make the additional expenditures on seeds, fertilizer and chemicals for pest and weed control, and these costs are fixed, up-front expenses regardless of the later yield.

Given the present value of the CPM budget of 20.0 million USD, the next task is to set out a series of alternative scenarios of how these funds might be spent to promote this intervention. It is envisaged that the intervention will concentrate on providing training and extension services, but not offering a direct subsidy to cover the cost of the additional inputs. The assumption is that with 5 years of technical support the farmers would continue with this program on their own for at least the next 10 years. The farmers themselves, with perhaps receive some credit support, are expected to cover the costs of the additional inputs. The USAID funding of 20.0 million USD in present value will be sufficient to cover the costs of technical support of between 100,000 and 200,000 household as the actual cost per household of the intervention averages between 200 to 100 USD per household.

**Table 2J: Average Incremental Benefit an Agricultural Household Generated for Downstream Stakeholders (USD)**

| % deviation in yield estimate | Agricultural households (1) | Small and medium traders (2) | Warehouse operators (3) | Volume buyers (4) | Govt (5) | Economy (6) |
|---|---|---|---|---|---|---|
| **0%** | 1,226 | 185 | 1.8 | 139 | 126 | 1,678 |
| **-10%** | 1,058 | 167 | 1.6 | 125 | 113 | 1,465 |
| **-20%** | 890 | 148 | 1.4 | 111 | 101 | 1,252 |
| **-30%** | 722 | 130 | 1.2 | 97 | 88 | 1,039 |
| **-40%** | 554 | 111 | 1.1 | 84 | 76 | 826 |
| **-50%** | 387 | 93 | 0.9 | 70 | 63 | 613 |

Assuming that the entire amount of 20.0 million USD is allocated to the maize sector, an average spending of 200 USD per household could cover 100,000 households. If all farmers are able to reach the full potential of this new method of farming the total incremental economic benefit generated in present-value terms is 167.8 million USD (Table 2K Column 2), minus the 20 million USD cost of the USAID intervention, for a net benefit of 147.8 million USD over a 10 year period. This represents a 7 fold return on the USAID budget allocation.

**Table 2K: Results of a Sensitivity Analysis of the Net Benefits of Intervention to Farm Households as to percentage deviation in Yield-Improvement Estimate for (Million USD)**

| Percentage deviation in yield estimate | 200 USD per household (1) | | 100 USD per household (2) | |
|---|---|---|---|---|
| | HD covered | Economic benefit generated (million USD) | HD covered | Economic benefit generated (million USD) |
| **0%** | 100,000 | 167.8 | 200,000 | 335.6 |
| **-10%** | 100,000 | 146.5 | 200,000 | 293 |
| **-20%** | 100,000 | 125.2 | 200,000 | 250.4 |
| **-30%** | 100,000 | 103.9 | 200,000 | 207.8 |
| **-40%** | 100,000 | 82.6 | 200,000 | 165.1 |
| **-50%** | 100,000 | 61.3 | 200,000 | 122.5 |

Perhaps a more realistic set of assumptions would be for the yields to increase on average by 50 percent of the potential increase. In this case the benefits accruing to the farmers and the participants along the maize value chain would be equal to 61.3 million USD, or evaluated net of the USAID contribution the present value of the net benefit would be 41.3 million (Table 2K Column l)

If USAID/Uganda's intervention was twice as efficient, so that the same results could be obtained (assuming the full potential yield is obtained) at an outlay of 100 USD per household, twice as many households can be covered. The total incremental economic benefit generated will double to 335.6 million USD (Table 2K Column 3). After the 20 million USAID expenditures have been deducted, the present value of the net benefits would be 315.6 million. Again, perhaps a more realistic outcome would be that over a five year period a 50 percent of potential yield response would be achieved. If 50 percent of the potential yield is realized then the total incremental economic benefit generated would be 122.5 million, which evaluated net of the cost of the USAID intervention would be in the range of 102.5 million USD. This is a fivefold return on the cost of the USAID intervention over the 10-year period.

The outcomes for different percentage reduction in actual yield, as compared to the full potential estimates are reported in Table 2K for per household USAID costs of bringing about this change ranging from 200 USD to 100 USD.

This analysis points out the high potential for introducing better farming practices and better inputs to the Uganda maize farming sector. The hybrid corn revolution and modern farming practices have transformed this sector in many countries of the world. At the same time it is not a simple task, many elements in the value chain on both the side of input supply and the handling and marketing of the output must be put in place in order to realize a result that even approximates the theoretical potential. USAID has tried to promote modern farming practices with interventions in the past that yielded mixed results. If additional maize production is realized then the necessary storage must be available so that the crop can be moved off the farm and out of the country without suffering a collapse of the local prices for maize. It is such an intervention for the expansion of warehousing capacity that is addressed in the next section.

Tables 2L and 2M provide findings from a poverty and gender analyses of such a program on a limited scale that reflects USAID budgetary capacity to finance the management of such an intervention. However, in these tables the intervention is assumed to reach its full potential in terms of increasing the yields per hectare for maize. Tables 2N and 2O contain the results using a less optimistic increase in yields.

**Table 2L: Present Value of Incremental Full Income by Poverty Status from 10 Years of High-Input Maize Cultivation (Full Potential)**

| Poverty status | 200 USD per household (1) | | 100 USD per household (2) | |
|---|---|---|---|---|
| | HD covered | Total agricultural household full income (Million USD) | HD covered | Total agricultural household full income (Million USD) |
| Extremely Poor < $1.25 | 60,860 | 74.6 | 121,720 | 149.2 |
| Very Poor $1.25 - $2 | 14,540 | 17.8 | 29,080 | 35.6 |
| Near Poor $2 - $4 | 14,000 | 17.2 | 28,000 | 34.3 |
| Non-Poor > $4 | 10,600 | 13 | 21,200 | 26 |
| Total | 100,000 | 122.6 | 200,000 | 245.1 |

The financial figures by poverty or gender categories are computed by first dividing agricultural households' total benefit from 100 percent intervention coverage in all the FtF districts (2.43 billion USD) if the full yield potential was realized (Table 2I Column 1), by the total number of households that could be potentially covered (1.98 million, from Table 2A Column 4). This result is then multiplied by the number of households from the much more restricted coverage of 100,000 or 200,000 households that belong to a particular poverty or gender category. If the intervention covers in total 100,000 households, the extremely poor households with income of less than 1.25 USD per day number 60,860 households, and receive an additional 74.6 million USD collectively as a group (Table 2L Column 1). This represents 60.9 percent of the total increase in full income. The next poorest group with incomes between $1.25 and $2.00 gain an amount of $17.8 million or 14.5 percent of the total. The near poor and the non-poor receive 14.0 and 10.6 percent, respectively.

If instead 200,000 households are covered, the incremental benefits for the extremely poor doubles to 149.2 million USD (Table 2L Column 2). Again the proportions of the gain in full income between the very poor, the near poor, the poor, and the non-poor are 60.9, 14.5, 14.0 and 10.6 percent, respectively, of the total incremental income accruing to agricultural households.

In Table 2M the analysis is carried out with respect to the gender of the head of the households. Considering female-headed households when the total number of households impacted are 100 thousand, the female heads of households represent 19.6 percent of the total households and collectively receive an incremental 24.1million USD of the total increment increase in full income (Table 2M Column 2). Per household figures are not listed separately because they are identical – estimated at a present value of 122.6 US per household for this intervention – across categories.

When the cost per successful intervention is 100 USD per household, hence 200,000 could potentially be impacted by this program of increasing the use of inputs in the cultivation of maize. In this case the benefits received by households headed by females increased to a total of 48.1 million USD, but the proportional gain by females would still remain at 19.6 percent of the total.

**Table 2M: Present Value of Incremental Full Income by Household Head Gender Status from 10 Years of High-Input Maize Cultivation (Full Potential)**

| Household head gender | 200 USD per household (1) | | 100 USD per household (2) | |
|---|---|---|---|---|
| | HD covered | Total agricultural household full income (Million USD) | HD covered | Total agricultural household full income (Million USD) |
| **Female** | 19,640 | 24.1 | 39,280 | 48.1 |
| **Male** | 80,360 | 98.5 | 160,720 | 197 |
| **Total** | 100,000 | 122.6 | 200,000 | 245.1 |

Table 2N and 2O report the incremental benefit for households by poverty and gender categories, assuming that the actual yield increase is only 50 percent of the estimated potential increase in yield as shown by the field trials. In this case the present value of the expenditure by USAID of $20 million would yield a present of net benefits to the farm households of 38.7 million USD. In this case, the gain by the extremely poor is 23.5 or 60.8 percent of the total net benefits. If the cost of the intervention can be successfully implemented at only 100USD per household, allowing the coverage to expand to 200,000 households, then the present value of net benefits accruing to the very poor is increased to 77.3 million USD.

**Table 2N: Present Value of Incremental Full Income per Participating Household by Poverty Status from 10 Years of High-Input Maize Cultivation (50 Percentage Reduction in Yield)**

| Poverty status | 200 USD per household (1) | | 100 USD per household (2) | |
|---|---|---|---|---|
| | HD covered | Total agricultural household full income (Million USD) | HD covered | Total agricultural household full income (Million USD) |
| **Extremely Poor < $1.25** | 60,860 | 23.5 | 121,720 | 47.1 |
| **Very Poor $1.25 - $2** | 14,540 | 5.6 | 29,080 | 11.2 |
| **Near Poor $2 - $4** | 14,000 | 5.4 | 28,000 | 10.8 |
| **Non-Poor > $4** | 10,600 | 4.1 | 21,200 | 8.2 |
| **Total** | 100,000 | 38.7 | 200,000 | 77.3 |

When the anticipated yields are reduced to 50 percent of the potential and the size of the coverage is 100,000 households, the gain by female-headed households is reduced to 7.6 million USD (Table 2O, column 2). If the coverage can be increased to 200,000 households the net benefits received by those headed by woman increases to 15.2 million USD.

**Table 2O: Present Value of Incremental Full Income per Participating Household by Household Head Gender Status from 10 Years of High-Input Maize Cultivation (50 Percentage Reduction in Yield)**

| Household head gender | 200 USD per household (1) | | 100 USD per household (2) | |
|---|---|---|---|---|
| | HD covered | Total agricultural household full income (Million USD) | HD covered | Total agricultural household full income (Million USD) |
| **Female** | 19,640 | 7.6 | 39,280 | 15.2 |
| **Male** | 80,360 | 31.1 | 160,720 | 62.1 |
| **Total** | 100,000 | 38.7 | 200,000 | 77.3 |

## Conclusions and Recommendations on High-Input Farming Intervention

Given the low yield rates for maize production in Uganda, it is not surprising that there are substantial net benefits to be realized from interventions that will enable maize farming households to use more and better inputs. Even if the entire FtF budget of 20 million USD were spent to increase the production of only 100,000 households, and the actual yields were half of the potential yields as derived from model farms, this would be a very good use of resources. The net present value would be significantly positive, using a real discount rate of 12 percent.

While the high input intervention is worthy of USAID support, attention must also be given to the post harvest handling of the additional production so that the farmers will not suffer severe price depressions due to the shortage of storage facilities, and perhaps weakness in the rural grain trading systems. It is these components of the maize value chain that we now turn to.

# III. WAREHOUSE SERVICES EXPANSION

The second intervention to be appraised is the construction of community warehouses for maize storage. The Ugandan agricultural sector suffers from a lack of local grain storage warehouses as well as cleaning and drying facilities to clean the grains and reduce the moisture content sufficiently for storage. Of the existing warehouses, most are located near urban centers and are owned and managed by large traders or governmental and international development agencies.

Ordinary agricultural households in rural areas have very limited access to warehouses. According to the UCA 2008-09, only 2.5 percent of agricultural households used improved granaries, and the rest stored grain at home or in unimproved granaries. Without proper drying and cleaning treatment, stored grains are vulnerable to fungal or pest attack, resulting in maize quality deterioration and post-harvest storage losses. Coupled with the overlapping of the first harvest season with the rainy season in July and August, and a general lack of awareness or ability to implement proper postharvest handling practices, it is estimated that postharvest losses amount to about 20 percent of total production (Post Harvest Losses Informative System 2012).

Initiatives have been launched to make warehouse storage more accessible to rural farmers. In 2011, USAID/Uganda and WFP jointly donated a 1.4 million USD warehouse of 2000 tons holding capacity to farmer groups in Kapchorwa. The warehouse is registered with the Uganda Commodity Exchange (UCE) so that farmers groups can sell their stored produce to large buyers via UCE auctions. The UCE is also encouraging the constructions and integration of more warehouses to its system, as a strategy to combat postharvest losses and to increase market access for farmers.

The present study is not considering thus type of warehouses, but satellite warehouses of considerably smaller capacity of 400 tons. Building large warehouses in areas that are typically characterized by low yield or low surplus is uneconomical. Smaller, satellite warehouses are less costly to build and serve the same purposes for agricultural households as do large warehouses. This warehouse construction and operation innovation being considered here does not alter the amount of maize being produced in Uganda, it simply services to reduce the amount of maize that gets stored in a modern warehouse conditions that reduced the amount of postharvest losses.

Because this is a potential intervention, the number of warehouses to be constructed is unknown. Hence the levelized construction cost is computed as a proxy for the actual construction cost. The levelized cost per kilogram of storage is derived from dividing the present value of the construction cost of a properly equipped warehouse by the discounted sum of expected yearly storage volume over its economic life (using a 12 percent discount rate). The inflation-adjusted construction cost of a warehouse building is estimated to be around 125.8 million UGX (Roberts and Ocaya 2010), and the annual turnover volume is taken to be 1200 tons. This implies that the levelized cost of the investment in the building alone is 16.5 UGX per kilogram of maize stored. It is assumed that the warehouse operators are properly trained; for a poorly managed centralized storage would only result in greater losses than if maize is stored at home.

The benefits of the warehouse intervention are multifold. Proper drying and cleaning reduces post-harvest loss resulting from spoilage during storage. Savings in spoilage loss thus increases the disposable quantity in the next period. In addition, warehousing services significantly extend the storage life of maize which enables agricultural households to time their sales depending on the market conditions. In the absence of such services, households will be forced to sell the produce en masse immediately after harvest at depressed prices, lest the maize losses value because of quality deterioration. The dried and cleaned maize are of better quality and thus fetch a higher price. To capture these benefits, postharvest loss reduces from 20 to 0 percent for the quantity stored in warehouses. In addition, it is assumed that the average maize price obtained by farmers in the covered districts increase by a modest 3 percent, due to the improved quality and the better timing of their sales. Maize prices in intermediary and final markets also increase proportionately.

This analysis is carried out using the working assumption that the farm households will consume the same amount of maize (net of spoilage) as in the base case scenario. The balance is sold to various market channels, including the additional grain that is sold because of reduced spoilage. It is projected that if such facilities were available, the participating households would reallocate from traditional storage to warehouse storage an amount equal to 80 percent of the amount currently retained at home for present own-consumption plus the amount stored to facilitate sales. The total amount going into storage each year is equal to approximately 45 percent of the current production of the maize farmers in the FtF districts.

It is assumed in this study that private operators invest in warehouse construction and charge farmers for the storage and processing services. The warehouse fee that the farmers are expected to pay are set at a level where they will defray the operating and levelized construction costs of the warehouse. The storage tariff structure is based on that of Agroways Ltd., a UCE-registered warehouse in Jinja. The exact tariff paid depends on a combination of factors such as the moisture content of arrival maize, the type of services (drying, cleaning or both) required, and the length of storage.

This analysis assumes that an average storage period of 4 months. This assumption implies an annual turnover of 1200 tons per warehouse with 400 tons of holding capacity.

Furthermore, 90 percent of the deposit in the first season requires both drying and cleaning and 10 percent requires only cleaning in the first season. In the second season, 80 percent of the deposit requires both drying and cleaning and 20 percent requires only cleaning. The moisture content is assumed to be 18 percent for the first season and 15 percent for the second. The moisture content of maize deposit is unlikely to exceed 18 percent since UCE-registered warehouses typically do not accept maize if the moisture content is above this threshold. However, it is not uncommon that, during the first season, the harvested crop's moisture content reaches upward of 20 percent. Therefore, training of agricultural households in the postharvest handling procedures may be a complementary component of the intervention.

Given these assumptions, the warehouse charge is estimated to be 95 UGX and 71 UGX per kilogram for the first and second season, respectively. After drying and cleaning, the moisture content will be reduced to 13.5 percent, and the total foreign and broken or defective grain content will be reduced to 6.5 percent. The final processed maize will accord to the grade 1 standard for maize.

Table 3A presents the metric tons savings in home storage losses and spoilage. If 80 percents of current home storage is reallocated to warehouses, this implies an annual storage quantity of 300,305 tons in the FtF-covered districts. Under the assumptions that warehouses have a holding capacity of 400 tons, and that the turnover is 3 times per year, about 250 satellite warehouses are required to hold 300,305 tons of maize (Table 3A Column 5).

The savings is the highest in Eastern Region because this is the region where maize yields are the highest. These results point to the fact that if yields were increased as outlined as in the high input farming intervention analysed earlier, this would have a very positive impact on any intervention to expand local maize warehousing services.

**Table 3A: Annual Storage Quantity and Incremental Loss Savings of Warehouse Construction by Region (MT)**

| Regional incremental maize consumption | Incremental own consumption (1) | Incremental loss savings (2) | Incremental sales (3) | Incremental annual warehouse storage quantity (4) | Number of warehouses required (5) |
|---|---|---|---|---|---|
| **Central** | 0 | 13,449 | 13,449 | 60,581 | 51 |
| **Eastern** | 0 | 39,110 | 39,110 | 176,170 | 147 |
| **Central** | 0 | 7,529 | 7,529 | 33,913 | 28 |
| **Western** | 0 | 6,364 | 6,364 | 28,665 | 24 |
| **Total** | 0 | 66,451 | 66,451 | 299,328 | 249 |

Table 3B reports the findings at the regional level. The incremental FNPVs for agricultural households are modest, ranging from 26.9 billion UGX (10.8 million USD) in Western Region to 171.3 billion UGX (68.5 million USD) in Eastern Region. Table 1B of Annex 1 indicates that at harvest, households retain between 50 to 70 percent of produce in storage for own consumption and sales. Without the intervention, households may loss up to 18.6 percent (26.5 percent of 70 percent) of what they produce, which, depending on the regions, approximates 165 UGX (0.066 USD) to 196 UGX (0.078 USD) per kilogram of production in monetary value. With the intervention, the warehouses tariff is on average around 83 UGX per kilogram. The marginal benefit is around 100 UGX (0.04 USD) for every kilogram stored. This is a substantial benefit to the farmer if the transportation costs to the warehouse are not too great.

**Table 3B: Incremental FNPV of Increased Warehouse Services for Participating Maize Producing Households Over 10 years**

| Region | Cash income (1) | | Value of own consumption (2) | | Regional total (3) = (1) + (2) | |
|---|---|---|---|---|---|---|
| | Million UGX | Million USD | Million UGX | Million USD | Million UGX | Million USD |
| **Central** | 81,208 | 32.5 | 0 | 0.0 | 81,208 | 32.5 |
| **Eastern** | 171,324 | 68.5 | 0 | 0.0 | 171,324 | 68.5 |
| **Northern** | 38,631 | 15.5 | 0 | 0.0 | 38,631 | 15.5 |
| **Western** | 26,934 | 10.8 | 0 | 0.0 | 26,934 | 10.8 |
| **Total** | 318,097 | 127.2 | 0 | 0.0 | 318,097 | 127.2 |

Table 3C presents the results of a sensitivity analysis on the percentage of home storage losses, currently estimated at 26.5 and 17.9 percent for the first and second seasons, respectively. A reduction in home storage loss improves the base case scenario and reduces the incremental benefits of warehouse construction. Conversely, the greater the losses of home storage, the greater are the benefits of warehouse construction. Overall, the actual amount home storage losses have a significant impact on the incremental financial NPVs for this intervention. When the home storage losses increase from 17.8 percent to 27.8

percent, the net benefits of the additional warehouse services increase from 94.4 million USD to 168.3 million USD for participating households.

**Table 3C: Sensitivity Analysis of FNPV of Net Benefits to Participating Agricultural Households by Region for the Percentage Home Storage Losses**

| Average home storage loss | Regional full income (Million USD) | | | | All households (5) |
|---|---|---|---|---|---|
| | Central (1) | Eastern (2) | Northern (3) | Western (4) | |
| **17.8%** | 25.3 | 49.9 | 11.3 | 7.9 | 94.4 |
| **18.9%** | 27.1 | 54.5 | 12.3 | 8.6 | 102.6 |
| **20.0%** | 28.9 | 59.2 | 13.4 | 9.3 | 110.8 |
| **21.1%** | 30.7 | 63.9 | 14.4 | 10.1 | 119.0 |
| **22.2%** | 32.5 | 68.5 | 15.5 | 10.8 | 127.2 |
| **23.3%** | 34.3 | 73.2 | 16.5 | 11.5 | 135.5 |
| **24.4%** | 36.1 | 77.9 | 17.5 | 12.2 | 143.7 |
| **25.5%** | 37.9 | 82.5 | 18.6 | 12.9 | 151.9 |
| **26.6%** | 39.7 | 87.2 | 19.6 | 13.6 | 160.1 |
| **27.8%** | 41.5 | 91.9 | 20.6 | 14.3 | 168.3 |

The next sensitivity analysis is conducted on the hypothetical price increase due to the farmer being able dry the maize and store for sale until sometime after the harvest glut is over and price have recovered. As is evidenced from Column 5 of Table 3D, the incremental financial NPVs (after storage costs are paid for) of additional warehouse services will increase as the average maize price received by the farmer increases. The greatest benefit of additional warehouses, however, is from the quantity of maize saved from spoilage.

**Table 3D: Results of a Sensitivity Analysis on the Financial NPV of Participating Agricultural Households for Changes in the Average Sales Prices Received by Maize Farmers by Region**

| Percentage change in maize price | Regional full income (Million USD) | | | | All households (5) |
|---|---|---|---|---|---|
| | Central (1) | Eastern (2) | Northern (3) | Western (4) | |
| **0%** | 22.8 | 55.9 | 13.6 | 8.3 | 100.6 |
| **1%** | 26.0 | 60.1 | 14.2 | 9.1 | 109.5 |
| **2%** | 29.3 | 64.3 | 14.8 | 10.0 | 118.4 |
| **3%** | 32.5 | 68.5 | 15.5 | 10.8 | 127.2 |
| **4%** | 35.7 | 72.7 | 16.1 | 11.6 | 136.1 |
| **5%** | 38.9 | 76.9 | 16.7 | 12.4 | 145.0 |
| **6%** | 42.1 | 81.2 | 17.3 | 13.2 | 153.8 |
| **7%** | 45.4 | 85.4 | 18.0 | 14.0 | 162.7 |
| **8%** | 48.6 | 89.6 | 18.6 | 14.9 | 171.6 |

Table 3D indicates that if farmers can obtain an average price that is 8 percent higher due to the ability to store their crop, the net benefits from storage will increase by more than 70 percent from about 100 million USD to 171.6 million USD.

Tables 3E and 3F report the findings from financial and sensitivity analyses regarding the incremental financial NPVs at the individual household level. Warehousing services would on average add approximately 64 USD to the present value of income of individual households. It can also be easily seen that the households from regions with the higher grain yields, such as the Eastern Region, receive substantially higher incomes from having access to the storage facilities.

**Table 3E: Incremental FNPV of Warehouse Construction per Participating Household**

| Region | Number of participating households (1) | Regional full income (2) | | Full income per participating household (3) | |
|---|---|---|---|---|---|
| | | Million UGX | Million USD | Thousand UGX | USD |
| **Central** | 635,367 | 81,207.7 | 32.5 | 127 | 51 |
| **Eastern** | 696,405 | 171,324.1 | 68.5 | 246 | 98 |
| **Northern** | 348,003 | 38,631.2 | 15.5 | 111 | 44 |
| **Western** | 300,636 | 26,933.6 | 10.8 | 90 | 36 |
| **Total** | 1,980,411 | 318,096.5 | 127.2 | Average: 161 | 64 |

From Table 3F we find that for individual farm households the value of the additional storage services is directly related to the level of losses they incur from home storage. While the value of additional storage confers almost twice as many benefits per household in the Eastern region (because the average yields are higher) the net benefits from storage also increase directly with the rate of losses associated with in home storage. With a 10 percentage point increase in home storage losses the net full income gains from proper storage facilities increases by 63% in the Central region, but increases by more than 84% in the Northern and Western Regions. As storage deals directly with the postharvest losses problem facing maize farmers in Uganda, the benefits of additional storage services is quite sensitive to the rate of postharvest losses in the baseline case without the additional facilities.

The results reported in Tables 3E and 3F point out the important fact that the benefits of storage are much greater in regions where the maize yields are higher, and where a substantial amount of maize is stored for either home consumption for later sale. For example in the Eastern Region the yields for maize are much higher in the base case and as a result the present value of the net benefits of additional storage facilities are from 80 percent to 1.76 percent bigger on an individual farm household basis than the for farmers in other regions in Uganda. Also if the high yield regions are now suffering from greater losses due to the lack of storage facilities, then these net income impacts will be further positively correlated with the production yields that farmers achieve.

**Table 3F: Results of NPV of C in Net Full Income due to the Percentage Deviation in Home Storage Loss for Individual Participating Households**

| Average home storage loss | PV of Increase in Full income per participating household (USD) | | | |
|---|---|---|---|---|
| | Central (1) | Eastern (2) | Northern (3) | Western (4) |
| **17.8%** | 40 | 72 | 32 | 26 |
| **18.9%** | 43 | 78 | 35 | 29 |
| **20.0%** | 45 | 85 | 38 | 31 |
| **21.1%** | 48 | 92 | 41 | 33 |
| **22.2%** | 51 | 98 | 44 | 36 |
| **23.3%** | 54 | 105 | 47 | 38 |
| **24.4%** | 57 | 112 | 50 | 41 |
| **25.5%** | 60 | 119 | 53 | 43 |
| **26.6%** | 62 | 125 | 56 | 45 |
| **27.8%** | 65 | 132 | 59 | 48 |

The results of poverty and gender analysis are provided in Tables 3G and 3H. Assuming that households will have access to warehouse storage regardless of wealth or gender status, collectively the extremely poor would earn from this intervention an incremental financial NPV of 193.6 billion UGX (77.4 million USD) or 60.8 percent of the net benefits warehouse services provide to agricultural households. The very poor, near poor, and the non-poor receive 14.5 percent, 14.0 percent and 10.6 percent, respectively, of the total net benefits generated by the additional warehouse services.

**Table 3G: Incremental FNPV of Increased Warehouse Services per Participating Household by Poverty Status**

| Poverty status | Number of participating HD (1) | Million UGX (2) | Million USD (3) |
|---|---|---|---|
| **Extremely Poor < $1.25** | 1,205,278 | 193,593 | 77.4 |
| **Very Poor $1.25 - $2** | 287,952 | 46,251 | 18.5 |
| **Near Poor $2 - $4** | 277,258 | 44,534 | 17.8 |
| **Non-Poor > $4** | 209,924 | 33,718 | 13.5 |
| **Total** | 1,980,411 | 318,097 | 127.2 |

Table 3H shows that the 389 thousand female-headed households who are growing maize in the FtF districts would earn an additional 62.5 billion UGX (25.0 million USD) or about 20 percent of the total net benefits from the increase in warehouse services. As a reminder, this benefit arises because if they are able to reduce the amount of home storage spoilage, they will have more maize for own consumption and sales. Also, the maize will also fetch a higher price because maize grain quality improves and farmers are able to time their sales. The average incremental benefit is 161 thousand UGX (64 USD) per household.

**Table 3H: Incremental FNPV of Warehouse Construction per Participating Household by Gender**

| Household head gender | Number of participating HD (1) | Million UGX (2) | Million USD (3) |
|---|---|---|---|
| **Female** | 388,953 | 62,474.2 | 25.0 |
| **Male** | 1,591,458 | 255,622.4 | 102.2 |
| **Total** | 1,980,411 | 318,096.5 | 127.2 |

The increase in sales of maize brought about by the reduction of the losses from on-farm storage also increases the volume of business by all the rest of the stakeholders in the downstream value chain.

The incremental FNPVs for various stakeholders are listed in Table 3J. The small and medium traders, as expected, gain net income of 96.3 billion UGX (38.5 million USD), or approximately 30 percent of the incremental amount earned by the farmers from the additional trade in maize due to the reduced postharvest losses.

Recall the assumption that the initial warehouse construction cost is bore by private warehouse operators. Collectively, they earn a financial NPV of 22.1 billion UGX (8.8 million USD). In other words, if the intervention is able to attract a sufficient number of households to deposit in warehouses, the revenue from the provision of warehouse services generates 8.8 million USD in excess of the amount required to recoup the levelized costs of the initial warehouse construction cost as well as its recurring operating costs. If warehouses charge agricultural households a lower, breakeven price for the services they provide, there will be an additional financial benefit of 8.8 million USD that can be reallocated to farmers.

Volume buyers will also increase their net incomes by 56.6 billion UGX (22.6 million USD) due to the additional business that comes to them from the additional farm maize sales. The government also gains tax revenues of 57.7 billion UGX (23.1 million USD) from additional tax revenues from diverse sources.

Taken all together the net economic impact of this major expansion of warehouse services in the FtF districts would be approximately 550.8 billion UGX (220.4 million USD). It would appear that about 40 percent of the net economic benefits are arising outside of both the warehousing and farmer stakeholders. Given the quality of the maize value chain data available in Uganda, one should treat the economic surplus originating from the traders and volume buyers (20 percent of the total net economic benefit) with a degree of skepticism. In a competitive environment one should not expect these groups to be earning economic rents in excess of the real rate of return of 12 percent. Alternatively, this surplus may be just part of the returns they must receive to remain in this business and the model understates their true costs.

**Table 3J: Incremental Economic NPV of Warehouse Construction for Major Stakeholders**

| Stakeholders | Million UGX | Million USD |
|---|---|---|
| **Agricultural HD** | 318,097 | 127.2 |
| **Small and medium traders** | 96,322 | 38.5 |
| **Warehouse operators** | 22,063 | 8.8 |
| **Volume buyers** | 56,623 | 22.6 |
| **Government** | 57,781 | 23.1 |
| **Economy** | 550,885 | 220.4 |

Sensitivity analyses are conducted on changes in home storage loss percentage estimate and the percentage change in maize price. The findings are in line with the previously discussion. A 10 percentage point reduction in the amount of postharvest losses results in an approximately a 60 percent increase in the overall benefits of the intervention.

**Table 3K: Results of a Sensitivity Analysis on the Percentage Deviation in Home Storage Loss for Stakeholders**

| Average home storage loss | Agricultural households | Small and medium traders | Warehouse operators | Volume buyers | Govt | Econ |
|---|---|---|---|---|---|---|
| **17.8%** | 94.4 | 32.4 | 8.8 | 19.9 | 19.4 | 175.0 |
| **18.9%** | 102.6 | 34.0 | 8.8 | 20.6 | 20.4 | 186.3 |
| **20.0%** | 110.8 | 35.5 | 8.8 | 21.3 | 21.3 | 197.7 |
| **21.1%** | 119.0 | 37.0 | 8.8 | 22.0 | 22.2 | 209.0 |
| **22.2%** | 127.2 | 38.5 | 8.8 | 22.6 | 23.1 | 220.4 |
| **23.3%** | 135.5 | 40.1 | 8.8 | 23.3 | 24.0 | 231.7 |
| **24.4%** | 143.7 | 41.6 | 8.9 | 24.0 | 24.9 | 243.0 |
| **25.5%** | 151.9 | 43.1 | 8.9 | 24.7 | 25.9 | 254.4 |
| **26.6%** | 160.1 | 44.6 | 8.9 | 25.4 | 26.8 | 265.7 |
| **27.8%** | 168.3 | 46.1 | 8.9 | 26.1 | 27.7 | 277.1 |

## USAID Warehouse Services Expansion Intervention

At the current level of production, and given the assumption that households will reallocate to communal warehouses about 45 percent of total production, the analysis indicates that the intervention calls for the construction of 250 warehouses, each with a holding capacity of 400 metric tons (Table 3A Column 5). The actual construction cost of a properly equipped, rural satellite warehouse is around 50,300 USD (Roberts and Ocaya, 2010).

If USAID/Uganda is to partially finance the construction of the 250 warehouses, as it did for the 60 satellite warehouses around Kapchorwa, this would encourage investment in the construction of local warehouses that are closer and more accessible to agricultural households.

Column 1 of Table 3L reports the average contribution of a satellite warehouse to the economy, for various home storage loss percentages. Of course the warehouse (at 50,300 USD each) will not be the only investment made along the value chain in response to the increased flow of maize. This economic NPV per warehouse is 880,520 USD over the entire value chain (when the on-farm postharvest losses is 22 percent of the amount stored). If the economic NPVs of the farmers, the warehouse operators and the government are netted out, the NPV of small and medium traders and volume buyers is 244,462 USD. Expressed as an annuity payment over 10 years at a 12 percent discount rate, the payment would be approximately 47,000 USD per year. If the true private opportunity cost of the private sector’s funds is 25 percent gross of all taxes, a total of 208 thousand USD could be invested by others to complement each warehouse built by this intervention. Each of these complementary private sector investments would earn an economic IRR of 25 percent.

Fully sponsoring the construction of 250 warehouses requires 12.6 million USD. The financial and economic outcomes for 100 percent coverage have been discussed extensively above. The total cost of building 125 and 188 warehouses is 6.3 and 9.4 million USD, respectively. This number of local warehouses is sufficient to service 50 percent and 75 percent of the volume set out for full coverage.

**Table 3L: Sensitivity Analysis of ENPV Generated by the Number of Warehouses for the Percentage Home Storage Losses (million USD)**

| Average postharvest losses | Economic NPV per warehouse (Thousand USD) (1) | Total Economic NPV 125 warehouses (50% storage) (2) | Total Economic NPV 188 warehouses (75% storage) (3) | Total Economic NPV 250 warehouses (100% storage) (4) |
|---|---|---|---|---|
| **17.80%** | 699 | 87.5 | 131.2 | 175 |
| **18.90%** | 744 | 93.2 | 139.7 | 186.3 |
| **20.00%** | 790 | 98.8 | 148.2 | 197.7 |
| **21.10%** | 835 | 104.5 | 156.8 | 209 |
| **22.20%** | 881 | 110.2 | 165.3 | 220.4 |
| **23.30%** | 926 | 115.9 | 173.8 | 231.7 |
| **24.40%** | 971 | 121.5 | 182.3 | 243 |
| **25.50%** | 1,017 | 127.2 | 190.8 | 254.4 |
| **26.50%** | 1,062 | 132.9 | 199.3 | 265.7 |
| **27.80%** | 1,107 | 138.5 | 207.8 | 277.1 |

It is not advisable for USAID/Uganda to provide a 100 percent subsidy for the construction of such warehouses as they will likely need to be run by private sector operators to be operated efficiently. If warehouses are too heavily subsidized, both efficient and inefficient warehouse operators will find it profitable to partner up with USAID/Uganda, making it difficult to identify the best operators of these facilities. In addition, a too high a rate of subsidy is likely to encourage investment in warehousing capacity that is too large for the need of the communities. Both factors contribute to a less efficient warehousing system.

## Conclusion on Warehouse Services Expansion Intervention

As compared to the high-input farming intervention, warehouse construction yields approximately the same incremental economic NPV per dollar of investment. Warehouse construction however has the additional advantage that it yields immediate results. The achievement of a reduction in postharvest losses is more certain and its success is less susceptible to the influences of less controllable, exogenous factors such as weather or infestation. In other words, this intervention is associated with a lower rate of risk for agricultural households.

A critical factor contributing to the success of the warehouse construction intervention concerns the training of warehouse staff on the warehouse operations and the proper handling of stored grain. Agricultural households may also require some training in agronomic or harvesting or post-harvesting practices that help to reduce the moisture content to the 18 percent threshold set by UCE-registered warehouses. This concludes the analysis on the warehouse construction intervention. The next section switches attention to the marketing aspect of the maize value chain.

# IV. PURCHASE FOR PROGRESS EXPANSION

World Food Programme (WFP) is the largest single buyer of maize and other grains in Uganda, and its total procurement volume is on the rise. From 2008 to 2010, the quantity of grains purchased raised by 16 percent, from 109,689 to 126,896 tons. In the past, WFP acquired most of its grains almost exclusively from large private enterprises through competitive tender. With the launching of the Purchase for Progress (P4P) initiative in 2008, WTP began obtaining grains from farmer groups by competitive tenders, direct purchases or forward contracting, in an attempt to link them directly to the national market. It is hoped that increased direct access to a larger market that rewards quality produce with higher prices will incentivize agricultural households to invest in yield-enhancing or quality-enhancing activities. The objective in this section is to investigate the implications of the further expansion of P4P for various stakeholders.

In carrying out this analysis there are a number of different scenarios that are possible which link the exact change in market structure that is being proposed and what is the overall volume of WFP purchases that are being exported from the country. In the scenario we postulate here an increase in WFP purchases is carried out through the P4P direct purchase program.

In 2011, some 30 community warehouses and a central warehouse in the town of Kapchorwa were constructed using funds jointly provided by USAID/Uganda and WFP. The Kapchorwa warehouse is registered with UCE and its depositors can tender for WFP procurement contracts. For this analysis, it is assumed that households in FtF-covered districts redirect 10 percent of the quantities currently sold to small and medium traders to WFP. Table 4A describes the new disposition pattern for participating households, which is largely identical to the pattern in the base case scenario as described in Table 1B of Annex 1, except that the percentages sold to small and medium traders are decreased by 10 percent of the previous percentage and the amount is added to the P4P purchases of WFP.

**Table 4A: Participating Household Maize Disposition as a Percentage of Production (P4P Expansion)**

| Region | Own consumption | Local market | Small and medium traders | Volume buyers | P4P | Home storage | Warehouse storage |
|---|---|---|---|---|---|---|---|
| **Central** | 31% | 2% | 43.1% | 7% | 5.0% | 12% | 0% |
| **Eastern** | 41% | 2% | 28.5% | 2% | 3.2% | 22% | 1% |
| **Northern** | 51% | 6% | 15.1% | 3% | 1.7% | 21% | 1% |
| **Western** | 39% | 2% | 31.3% | 8% | 3.7% | 15% | 1% |

Estimated at 26,866 tons, the loss of throughput for small and medium traders triggers a ripple effect down the supply chain. Small and medium traders reduce their informal exports and supplies to the non-producing population, and also to small-scale feed manufacturers and volume buyers. The volume buyers in turn reduce their formal exports and supply to the non-producing population, large scale feed manufacturers and WFP. Table 4B reports the impacts of this scenario on the throughput loss for small and medium traders of 26,866 tons (Column 1) as well as changes in the volume of maize that reach various final destinations (Columns 2 to 4). The latter reductions in purchases include the non-producing population of 11,533 tons and the reduction is sales to feed manufacturers and informal exports of 11,669 tons per year. The loss in purchases by the small traders results in an incremental WFP procurement quantity of 23,202 tons that is less than the total throughput losses of 26,866 tons, because volume buyers cut back their supply to WFT (or from WFP's perspective it cuts back its purchases from the volume buyers).

**Table 4B: Incremental Changes in Throughput for Small and Medium Traders and in the Volume of Maize that Reach Various Final Destinations of Consumption.**

| Region | Loss of throughput for small and medium traders (1) | Reduction in non-producing population consumption (2) | Other losses - formal and informal export, feed manufacturing (3) | WFP net procurement (4) = (2) + (3) |
|---|---|---|---|---|
| **Central** | 9,365 | 4,957 | | |
| **Eastern** | 13,627 | 5,046 | | |
| **Central** | 1,215 | 560 | | |
| **Western** | 2,659 | 971 | | |
| **Total** | 26,866 | 11,533 | 11,669 | 23,202 |

During an interview with a WFP representative and subsequent correspondence, the LEAP team asked WFP to provide its historical procurement volume and price for maize bought from large traders and farmer groups, respectively. The data however was not delivered. This analysis takes as the WFP procurement price the average of maize grain prices in local markets, on the premise that the WFP will not pay more to its suppliers (farmers and cooperatives) than what it can otherwise buy from local markets. This local market price is somewhat higher than the farm gate price and is here estimated to be 1068 UGX per kilogram, as compared to an average farm gate price of 921 UGX per kilogram offered by small and medium traders. Participating households that supply to WFP thus earn an extra of 147 UGX (0.058 USD) per kilogram.

Tables 4C and 4D present the incremental FNPV for participating households in the first scenario. The results indicate that the impact on farm incomes is modest. For every kilogram sold to WFP, agricultural households on average earn a mere 147 UGX (0.058 USD) extra as comparing to selling to small and medium traders. A very substantial amount must be sold for substantive difference. The total increase in farm incomes arising from the P4P purchases is approximately 7.8 million USD. The small incremental income is due to the small increase in margins and the small volume of sales. This potential final benefit is somewhat offset by the fact that the P4P are not administratively able to pay the farmers immediately with cash and hence creating a delay in the cash inflow to the farmers.

**Table 4C: Incremental FNPV of P4P Expansion for Participating Households**

| Region | Cash income (1) | | Value of own consumption (2) | | Regional total (3) = (1) + (2) | |
|---|---|---|---|---|---|---|
| | Million UGX | Million USD | Million UGX | Million USD | Million UGX | Million USD |
| **Central** | 1,820 | 0.7 | 0.0 | 0.0 | 1,820 | 0.7 |
| **Eastern** | 12,780 | 5.1 | 0.0 | 0.0 | 12,780 | 5.1 |
| **Northern** | 1,495 | 0.6 | 0.0 | 0.0 | 1,495 | 0.6 |
| **Western** | 3,306 | 1.3 | 0.0 | 0.0 | 3,306 | 1.3 |
| **Total** | 19,401 | 7.8 | 0.0 | 0.0 | 19,401 | 7.8 |

Table 4D reports the findings of a sensitivity analysis on the percentage of sales redirected from small and medium traders to P4P. A diversion of 0 percent gives one back the base case scenario with no incremental benefits for households. If P4P were to dramatically expand it purchases (Table 4D Column 1) so that farmers diverted 30 percent of their sales to P4P and away from the small and medium traders, the incremental benefits triple from the base case where they diverted 10 percent of their sales. Even in this case the incremental income to the farmers would be just 23.3 million USD.

**Table 4D: Results of a Sensitivity Analysis on Incremental Full Income of Farmers for Changes in the Percentage of Sales Diverted from Small and Medium Traders to WFP**

| Percentage of sales diverted to WFP | Incremental WFP procurement (MT) (1) | Regional full income (Million USD) | | | | |
|---|---|---|---|---|---|---|
| | | Central (2) | Eastern (3) | Northern (4) | Western (5) | All Regions (6) |
| **0%** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **5%** | 11,601 | 0.4 | 2.6 | 0.3 | 0.7 | 3.9 |
| **10%** | 23,202 | 0.7 | 5.1 | 0.6 | 1.3 | 7.8 |
| **20%** | 46,404 | 1.5 | 10.2 | 1.2 | 2.6 | 15.5 |
| **30%** | 69,606 | 2.2 | 15.3 | 1.8 | 4.0 | 23.3 |

If P4P is to expand its direct procurement from farmers, it is likely to buy from concentrated areas that cover a subgroup of households in the regions. Therefore, household level results that are computed based on the total number of agricultural households in FtF-covered districts are not meaningful indicators since the incremental benefits thin out to a negligible amount given the large number of households. Nonetheless, they are reported in Table 4E for completeness.

As a consequence of this intervention, small and medium traders lose 10 percent of the existing procurement amounting to 26,866 tons. In monetary terms, collectively they lose net income equal to 37.6 billion UGX or 15.0 million USD (Table 4D Column 3). The net income losses (net of their labour opportunity costs) that the P4P direct purchases inflict on the small and medium traders is equal to more than 192 percent of the net gains received by the maize cultivating households.

**Table 4E: Incremental FNPV of P4P per Participating Household**

| Percentage of sales diverted to WFP | Per participating household (USD) | | | |
|---|---|---|---|---|
| | Central | Eastern | Northern | Western |
| **0%** | 0.0 | 0.0 | 0.0 | 0.0 |
| **5%** | 0.6 | 3.7 | 0.9 | 2.2 |
| **10%** | 1.1 | 7.3 | 1.7 | 4.4 |
| **20%** | 2.3 | 14.7 | 3.4 | 8.8 |
| **30%** | 3.4 | 22.0 | 5.2 | 13.2 |

The reduced throughput is insufficient to sustain the same number of private traders, and it is estimated that up to 2,100 small and medium traders will be forced to switch to other ventures. Much of the job loss is in Central Region and Eastern Region where agricultural households are more commercialized and the maize trade is much more active. In comparison, the adverse impact on Northern Region is the least for the opposite reason. Perhaps more important for the long run is that the P4P direct purchase program is destroying the most competitive, and ultimately what could become the most efficient, part of the rural agriculture trading system. Uganda badly needs an efficient private sector based agriculture commodity trading network. This system will only get built up over time with private traders competing with each other for the farm products. Subsidizing a bureaucratic heavy organization such as the WFP to drive this dynamic set of agents out of business hardly seems to be a preferred development strategy.

**Table 4D: Loss in Incremental FNPV for Small and Medium Traders from P4P Expansion**

| Region | Loss of throughput (MT) (1) | Number of job loss (2) | Total regional loss for traders (3) | |
|---|---|---|---|---|
| | | | Million UGX | Million USD |
| **Central** | 9,365 | 733 | 15,457 | 6.2 |
| **Eastern** | 13,627 | 1,072 | 17,489 | 7.0 |
| **Northern** | 1,215 | 96 | 1,169 | 0.5 |
| **Western** | 2,659 | 208 | 3,510 | 1.4 |
| **Total** | 26,866 | 2,109 | 37,624 | 15.0 |

The loss of throughput by small and medium traders triggers a chain reaction downstream. Volume buyers in turn acquire less maize, and so do domestic feed manufacturers and the non-producing population. The government also loses direct and indirect tax revenues. These losses are the surpluses that are present in the activities of the different actors of the value chain that are in excess of their costs. While the farm household gain by about 7.8 million USD, the other stakeholders in the value chain lose over four times as much in terms of net income. The total incremental loss for the economy in present value is estimated to be 55.1 billion UGX (22.0 million USD).

**Table 4E: Incremental FNPV of P4P Expansion for Major Stakeholders**

| Stakeholders | Million UGX | Million USD |
|---|---|---|
| **Agricultural HD** | 19,401 | 7.8 |
| **Small and medium traders** | -37,624 | -15.0 |
| **Warehouse operators** | -402 | -0.2 |
| **Volume buyers** | -28,571 | -11.4 |
| **Government** | -7,867 | -3.1 |
| **Economy** | -55,062 | -22.0 |

### Conclusions on P4P Procurement Expansion

The results of the cost benefit analysis of this intervention are strikingly different than that of the other interventions evaluated. This is a program that is largely driven by many of the ingrained prejudices against the essential role of the middle men in the agriculture value chain. The results point to a misdirected rural development initiative along many dimensions. Scarce international assistance is being spent to subsidize the costs of a bureaucratic organization whose object is to replace an indigenous service oriented rural agriculture commodity trading system. Every international assistance program comes to an end at some point in time. P4P will not be an exception.

Enhancing efficiencies in providing market bases price information, promoting quality differentiated pricing and improving transportation efficiencies are all worthy goals of P4P program. The P4P program, however, appears to not have addressed any of these objectives effectively. Even with the best efforts of the study team, the bureaucratic rules of the WFP system prevented us from obtaining any meaningful procurement price data. The P4P procurement prices are not quality differentiated and not publically known to farmers prior to the final sale at the time of the harvest. The WFP purchase prices are never known by the farmers if its purchases are made via tender through volume buyers. The promotion of a system of providing meaningful farm gate level quality differentiated price information on which maize farmers can make their production and sales plans is something that needs to be addressed by USAID FtF initiatives.

## CONCLUSIONS AND RECOMMENDATIONS

This study has analyzed three classes of interventions: high-input farming, expansion of local warehouse services and, the expansion of P4P direct maize purchases

Production is the bottleneck in the improvement of the maize value chain and deserves prioritized attention. The cost benefit analysis undertaken here points to a substantial potential for increasing farm incomes through the increasing yields with the use of improved inputs. This is hardly surprising, given the great success of hybrid corn varieties around the world and improved fertilizer and farming practices. While our ex-ante analysis points to substantial opportunities in this area, several challenges remain for successful implementation in Uganda that may interfere with the successful implementation of the high-input farming intervention.

Uganda currently lacks a commercial-inputs logistics network that actively reaches out to agricultural households. Secondly, the purchasing of commercial inputs requires immediate outlays early in the season, and households may not have the financial means at that time to obtain the necessary commercial inputs. Even if the analysis shows that the incremental NPVs are substantial and that the incremental cash income generated is potentially more than sufficient to pay for the inputs, the purchases might not be made. Fraudulent suppliers of agriculture inputs have created uncertainty for farmers concerning the true quality of the inputs available for purchase, Furthermore, the amounts of credit required might not be available.

In making the initial investment of buying and applying commercial inputs, households bear considerable marketing risk owing to the unpredictable future maize price. Although the international prices for maize have been very strong in recent years and are likely to remain so for considerable time in the future, the price volatility in Uganda is very great. The perceived risk is likely to discourage household participation.

These are issues that USAID's FtF interventions should address One potential solution to the problem of price volatility is the increased provision of warehousing services so that farmers could hold their crop to the period when prices have stabilized after the harvest.

The high rate of post-harvest losses and the high volatility of local maize prices are problems that are often sighted when studying the maize value chain in Uganda. To investigate appropriate interventions that might address these problems this study has undertaken a cost benefit analysis of adding additional local warehouse services in the maize growing districts of Uganda. It is found that such warehouses, if they run in a way that they are effective in reducing the post-harvest losses from improper home storage, could make a significant contribution to the sector and farm household incomes. The benefits from additional warehouse services are directly related to the volume of maize being produced by the farms. Hence, this intervention is complementary to the initial intervention studied of promoting the use of high input farming practices in maize cultivation.

In view of the challenge of moving the crops efficiently from the farm gate to the final buyers the direct purchase program by the WFP through its P4P initiative has been in operation in Uganda for the past 4 years. From the analysis undertaken in this study it would appear that this initiative is misplaced. The benefit to the farm households is minimal. It is recommended that USAID (FtF) does not continue to encourage the expansion of WFP's P4P program because it tends to destroy the financial viability of thousands of small and medium traders. Its activities reduce the net incomes of other downstream participants in the maize value chain. It also impedes the development of a set of private institutions at the district level that will over time become more efficient as the infrastructure in the country improves. Instead every effort should be made to promote the dissemination of transparent market prices and market information in order for farmers and traders alike to make informed decisions.

# ANNEX 1 — BASE CASE (WITHOUT INTERVENTION) SCENARIO

To develop these base line values the first task is to determine the current levels of production by region. This is done by reference to the data available from the Uganda Census of Agricultural (UCA). The UCA was conducted from the second half of 2008 to the first half of 2009, spanning two harvest seasons. The average production volume, area of cultivation, and implied productivity are given in the following table.

The statistics conform with several stylized facts. Historically, Eastern Region has been a major maize production center that accounts for about 50 percent of the volume of national production. Not only is productivity there higher, the area of farmland under maize cultivation in Eastern Region also doubles that of the other regions. In contrast, years of civil conflict has left Northern Region with low agricultural productivity that lags substantially behind other regions. It is these values that are used to defined the without intervention base line values. Comparing the aggregate production value for maize in 2008-09 with macro-level data for recent years, the UCA values appear to be still representative.

**Table 1A: Maize Production and Area of Cultivation (Without Intervention)**

| Region | Production per season (MT) | Hectares (Ha) | Average productivity per season (MT/Ha) |
|---|---|---|---|
| **Central** | 112,464 | 189,133 | 0.59 |
| **Eastern** | 277,139 | 388,763 | 0.71 |
| **Northern** | 76,449 | 247,780 | 0.31 |
| **Western** | 124,436 | 188,583 | 0.66 |
| **Total** | 590,488 | 1,014,259 | |

The next step is to empirically calibrate the channels allocating the farm production into the value chain system. The UCA 2008-09 reveals that households' own consumption and sales to small traders account for more than 70 percent of maize disposition. The sum of quantities sold to other outlets is at most no more than one-third of the quantity sold to small traders (Table 1B, Columns 2 to 5). The predominant form of storage is home storage. [5]

Storage is not a final destination for maize but a stop on its way to be consumed or sold. In this analysis, the quantity of stored maize on the farm (as reported in the UCA survey) is treated as a final destination in one period. Once the postharvest on-farm losses are deducted from the volume of maize stored, the balance is included in the amount of maize that is available for consumption and sales in the following period.

Maize consumption occurs continuously throughout the period. Before it is actually consumed by the households, the quantity that is set aside for own consumption is kept at home storage and is exposed to fungal or pest attack. Therefore, in any one period, the actual amount consumed is less than the amount reserved for own consumption on account of losses and spoilage in storage.

Postharvest maize losses in home storage and in Uganda are estimated to be 26.5 percent and 17.9 percent of the amount for the first and second seasons, respectively (Post Harvest Loss Information System

[5] The UCA data was obtained through a census type of survey that asks the level of storage maize on that given day. The total amount stored is likely to be higher than that amount over the season between the two harvests.

Network, 2012). The difference is explained by the overlapping of the first harvest with the rainy season in July and August. The amount of postharvest losses is expressed here as a percentage of the amount of own consumption (gross of losses) and the amount stored for consumption or sales in the next period. These losses do not need to occur because of storage. The following table summarizes the disposition pattern at the household level before considering postharvest losses.

**Table 1B: Agricultural Household Maize Disposition as Percentage of Production (Without Intervention)**

| Region | Own consumption (1) | Local market (2) | Small and medium traders (3) | Volume buyers (4) | WFP (5) | Home storage (6) | Warehouse storage (7) |
|---|---|---|---|---|---|---|---|
| **Central** | 31% | 2% | 48% | 7% | 0% | 12% | 0% |
| **Eastern** | 41% | 2% | 32% | 2% | 0% | 22% | 1% |
| **Northern** | 51% | 6% | 17% | 3% | 0% | 21% | 1% |
| **Western** | 39% | 2% | 35% | 8% | 0% | 15% | 1% |

The regional quantities of annual maize production and disposition are given in Table 1C. A comparison of total production and home consumption (Table 1C Columns 1 and 3) finds that annual own consumption amounts to approximately 33 percent of annual disposable quantity which includes the current period's production and the amount stored in the last period.

**Table 1C: Agricultural Household 2008-09 Annual Maize Production and Disposition in Metric Tons (Without Intervention)**

| Region | Annual production and storage from previous period (1) | Storage Losses (2) | Own consumption (net of spoilage) (3) | Sales (4) | Storage deposit (5) |
|---|---|---|---|---|---|
| **Central** | 251,696 | 21,357 | 61,599 | 141,973 | 26,767 |
| **Eastern** | 682,316 | 77,845 | 232,976 | 243,457 | 128,038 |
| **Northern** | 187,300 | 24,471 | 78,241 | 50,186 | 34,402 |
| **Western** | 288,443 | 29,760 | 89,542 | 129,571 | 39,571 |
| **Total** | 1,409,754 | 153,432 | 462,358 | 565,187 | 228,777 |

Table 1D reports the average quantity of households' own consumption by region. Northern Region is particularly noteworthy. The average annual maize consumption there is only 17 kilograms per person which is the second lowest across regions, despite the fact that Northern Region households retain slightly more than 50 percent of maize for own consumption, and another 21 percent for storage (Table 1B Columns 1, 6 and 7). Households in other regions either consume considerably more maize or retain a smaller share of their production.

The existing disposition pattern is the combined result of household taste preferences and constrained allocation. Limited market access may restrict households' disposition options to own consumption and storage. However, for the case of the Northern Region, the disposition pattern and the quantity of annual maize consumption seem to suggest that the 71 percent retention rate is attributable less to limited market access than to insufficient yield: The quantity produced in Northern Region is marginally sufficient and therefore households retain a very high share of maize to meet subsistence requirement. This finding has implications for the efficacy of the high-input farming intervention, to be discussed in the next section.

**Table 1D: Agricultural Household 2008-09 Annual Maize Consumption for Subsistence Farming (Without Intervention)**

| Region | Own consumption (MT) | Per household (kg) | Average number of HD members (person) | Per person (kg) |
|---|---|---|---|---|
| **Central** | 61,599 | 76 | 4.10 | 19 |
| **Eastern** | 232,976 | 210 | 5.60 | 38 |
| **Northern** | 78,241 | 86 | 5.20 | 17 |
| **Western** | 89,542 | 80 | 5.10 | 16 |

Across the regions, the implied per-capita consumption is around 29.2 kilograms per year. The nonproducing population consumes about 244,457 metric tons of maize each year, which translates to 50.2 kilograms per capita. The difference in consumption quantity between agricultural households and the non-producing population can be explained by the fact that the latter mostly live in urban areas where maize is more popular and commonly consumed in governmental or educational institutions. At the national level, annual per-capita consumption is 29.2 kilograms, which approximates the Food and Agriculture Organization's (FAO) estimate of 30.0 kilograms. This result provides some confidence regarding the accuracy of the base case scenario.

Table 1E quotes the prices agricultural households receive in different market outlets. Unweighted regional average maize prices are computed based on information taken from a private market information provider, InfotradeUganda.com, which collects and disseminates flour and grain prices in 18 major markets in Uganda on a weekly basis. This study assumes that all sales in local markets are in the form of milled flour.[6] Average flour prices are taken to be the price agricultural households and small and medium traders receive for sales in local markets. A survey by the National Agricultural Research Organization (NARO) finds that, on average, the difference between farm gate prices and local market prices to be 16%.[7] Combining this piece of information with InfotradeUganda.com's grain prices in local markets yields approximate grain prices at the farm gate. Since WFP procurement price is not made available, it is taken as an assumption to be the average of maize grain prices in local markets.

**Table 1E: Average Market Outlet Prices by Region (UGX/kg)**

| Region | Local market (maize flour) | Local market (maize grain) | Small and medium traders at farm gate (maize grain) | Volume buyers at farm gate (maize grain) | WFP |
|---|---|---|---|---|---|
| **Central** | 1,928 | 1,201 | 1,036 | 1,036 | 1,068 |
| **Eastern** | 1,925 | 1061 | 915 | 915 | 1,068 |
| **Northern** | 2,017 | 1006 | 868 | 868 | 1,068 |
| **Western** | 1,947 | 1003 | 866 | 866 | 1,068 |

[6] Agricultural households, small and medium traders, and volume buyers pay for milling costs.

[7] Own calculation based on Bashaasha (2009).

Table 1F reports the financial net present value (in 2012 prices) of the projected income for 10 years (2013-2022) from maize cultivation by region in Uganda.

In the calculation of the full income, the value of own consumption is derived using the farm gate prices of maize if sold to small and medium traders, while cash income is valued using the actual sales prices to the various purchasers.

Overall, the value of cash income and the value of own consumption each account for approximately 55 and 45 percent respectively of the full farm income from maize cultivation. The present value of the full income for maize cultivation at the agricultural households' level amounts to 5,825 billion UGX (2.33 billion USD) in 2012 prices using a discount rate of 12 percent.

Cash income is defined as the difference between cash revenue received and the cash costs incurred to produce marketed maize. Imputed labor cost is not counted as an actual cost since households provide own labor inputs. The present values of cash income may appear to be lower than expected, because households' own consumption accounts for at least one third of maize production in all regions, and in Northern Region, the share reaches slightly above 50 percent.

**Table 1F: FNPV of Income from 10 Years of Subsistence Maize Cultivation for Agricultural Households by Region (Without Intervention)**

| Region | Cash income (1) | | Value of own consumption (2) | | Regional full income (3) = (1) + (2) | |
|---|---|---|---|---|---|---|
| | Million UGX | Million USD | Million UGX | Million USD | Million UGX | Million USD |
| **Central** | 796,620 | 318.6 | 392,261 | 156.9 | 1,188,881 | 475.6 |
| **Eastern** | 1,407,650 | 563.1 | 1,311,057 | 524.4 | 2,718,708 | 1,087.5 |
| **Northern** | 318,454 | 127.4 | 417,425 | 167.0 | 735,879 | 294.4 |
| **Western** | 705,723 | 282.3 | 476,448 | 190.6 | 1,182,171 | 472.9 |
| **Total** | 3,228,447 | 1,291.4 | 2,597,191 | 1,038.9 | 5,825,638 | 2,330.3 |

Table 1G presents the values of the regional breakdown of the 10 year present value of net incomes are presented along with the average per household income earned from maize cultivation. Central and Western Region each accounts for about 20 percent of the total farm income from maize cultivation; Eastern Region accounts for about 47 percent of the total with Northern Region accounting for 13 percent.

The present value of the 10 years of subsistence farming yields income consisting of cash and the value of own maize consumption. In present-value terms, the income streams range from 813 thousand UGX (325 USD) for households in Northern Region to 2,451 thousand UGX (980 USD) for households in Central Region (Table 1G Column 3).

**Table 1G: FNPV per Agricultural Household from 10 Years of Subsistence Maize Cultivation (Without Intervention)**

| Region | Number of households (1) | Regional full income (2) | | Full income per household (3) | |
|---|---|---|---|---|---|
| | | Million UGX | Million USD | Thousand UGX | USD |
| **Central** | 807,173 | 1,188,867 | 475.5 | 1,473 | 589 |
| **Eastern** | 1,108,909 | 2,718,474 | 1,087.4 | 2,451 | 980 |
| **Northern** | 904,931 | 735,832 | 294.3 | 813 | 325 |
| **Western** | 1,124,740 | 1,182,088 | 472.8 | 1,051 | 420 |
| **Total** | 3,945,753 | 5,825,260 | 2,330.1 | | |

For the same reference period, Table 1H reports on the income situation of the small and medium traders groups, in terms of profits after subtracting out their operating costs. Collectively, they earn 633.7 billion UGX (253.5 million USD) in profits in present value (Table 1H, col 1). If traders' imputed labor costs are included in their income, the amount of their total compensation increases to 1,093.7 billion UGX (437.5 million USD), (Table 1H Column 3).

**Table 1H: FNPV for Small and Medium Traders from 10 Years of Subsistence Maize Cultivation (Without Intervention)**

| Region | Profit (1) | | Imputed labor (2) | | Regional full income (3) = (1) + (2) | |
|---|---|---|---|---|---|---|
| | Million UGX | Million USD | Million UGX | Million USD | Million UGX | Million USD |
| **Central** | 195,629 | 78.3 | 117,192 | 46.9 | 312,821 | 125.1 |
| **Eastern** | 277,142 | 110.9 | 213,754 | 85.5 | 490,896 | 196.4 |
| **Northern** | 30,196 | 12.1 | 31,126 | 12.5 | 61,322 | 24.5 |
| **Western** | 130,705 | 52.3 | 97,987 | 39.2 | 228,692 | 91.5 |
| **Total** | 633,672 | 253.5 | 460,059 | 184.0 | 1,093,731 | 437.5 |

Table 1I considers the situation of the small and medium traders in more detail. According to a World Bank survey, farm gate and primary market traders in Eastern Region on average sell 13 tons of maize per season (World Bank 2009). Given that the quantities sold to small and medium traders are known from the UCA, it can be estimated that at least 36,663 individuals engage directly in the maize trade. The present value of profits a typical trader receive over a ten year period is between 12.2 million UGX (4,862 USD) to 21.0 million UGX (8,401 USD) (Table 1I Column 3).

**Table 1I: FNPV per Small and Medium Trader from 10 Years of Subsistence Maize Cultivation (Without Intervention)**

| Region | Implied number of traders (1) | Regional profit (2) | | Profit per trader (3) | |
|---|---|---|---|---|---|
| | | Million UGX | Million USD | Thousand UGX | USD |
| **Central** | 9,314 | 195,629 | 78.3 | 21,003 | 8,401 |
| **Eastern** | 17,066 | 277,142 | 110.9 | 16,240 | 6,496 |
| **Northern** | 2,484 | 30,196 | 12.1 | 12,154 | 4,862 |
| **Western** | 7,799 | 130,705 | 52.3 | 16,759 | 6,704 |
| **Total** | 36,663 | 633,672 | 253.5 | | |

Table 1J summarizes the NPV benefits for all stakeholders in the base case. The profit earned over a 10 year period by volume buyers is 380.0 billion UGX (152.0 million USD). The government collects tax revenue that is equal to 418.4 billion UGX (167.3 million USD). Tax revenue consists of CIT paid by volume buyers and VAT paid by small traders on inputs and by the nonproducing population and large-scale feed manufacturers on maize supplied by volume buyers. Agricultural households do not pay VAT, because commercial agricultural inputs are VAT exempt.

For the economy as a whole, the maize value chain generates about 7,267.6 billion UGX (2,907.0 million USD) in present value. The implied annual contribution of the maize sector to GDP is 422.8 million USD, or about 2.5 percent of 16.81 billion USD for the year 2011. The actual share should be slightly less, because the implied GDP includes informal exports.

**Table 1J: FNPV of Incomes for Major Stakeholders (Without Intervention)**

| Stakeholders | Million UGX | Million USD |
|---|---|---|
| **Agricultural households** | 5,825,260 | 2,330.1 |
| **Small and medium traders** | 633,672 | 253.5 |
| **Warehouse operators** | 10,269 | 4.1 |
| **Volume buyers** | 379,988 | 152.0 |
| **Government** | 418,364 | 167.3 |
| **Economy** | 7,267,553 | 2,907.0 |

# ANNEX 2 — TECHNICAL NOTE

This technical note provides an overview of the structure of the Excel models, the purpose(s) of individual tables, and comments on formula links that may not be immediately transparent to reviewers. This note does not address any issues regarding data sources and derivation of parameter values; these are fully documented in a separate worksheet in the Excel file.

**Model Structure**

The model attempts to track the two types of flow in the maize value chain. The first is the flow of the physical good from farm gate to various final markets via different channels, and the second is the flow of value added during the maize trade. Combined, they capture the quantity and price dimensions of the value chain.

In the model, the two flows run parallel and do not intersect with one another. More specifically, changes in maize prices in one market do not induce changes in the quantity flowed to that market, or vice versa. This is a rather restrictive but necessary assumption, for it is an audacious undertaking to predict with reasonable precision changes in household behavior without adequate empirical research. If reviewers believe an intervention will lead to major departure from the existing pattern, they may change the distribution percentages or prices manually.

**List of Tables**

**Table 1A—Parameters for Agricultural Households.** The table contains all information pertinent to agricultural households, including implied crop yield, the percentages of maize produce disposed to various channels and their prices, the percentage of postharvest loss, farm budgets, and postharvest costs, such as milling and warehouse charges. Farm budgets consist of three scenarios: subsistence farming, which is the base case scenario; low-input farming; and high-input farming. Estimates of yield improvement in the two latter scenarios are also included.

**Tables 1B and 1C—Parameters for Small Traders and Volume Buyers.** Similarly, the tables contain information about the disposition percentages, procurement and other operating costs, and offered prices in different markets. The purpose of these tables is to determine the share of value added captured by actors operating at the marketing stage of the value chain.

**Table 1D—Parameters for World Food Programme (WFP).** This table displays the procurement price of maize from different sources.

**Table 1E—Economic and Demographic Parameters.** This table contains information about demographics and economic parameters, such as tax rates, inflation rates, and economic discount rates. It also contains estimates on the shares of area that are under maize cultivation and lie within USAID Feed the Future’s (FtF’s) targeted districts. This piece of information is used to gauge the number of households covered by the FtF program, under the hypothesis that the distribution of farmland is uniform across households. The number of households covered by FtF is then used to determine the incremental benefits accrued to them as a result of interventions. This is done by first computing the incremental benefits at the regional level. Dividing incremental regional benefits by the number of covered households yields the incremental benefit per covered household.

**Table 1W—Warehouse Parameters.** This table contains information about the warehouse construction and operating costs and the tariff structure of Agroway Ltd. in Jinja. Details of the tariff structure are displayed in the main model rather than in the footnote so reviewers can modify the structure manually by adjusting the percentage of maize that requires varying level of cleaning and drying services.

**Table 1P—Intervention Summary.** The information in this table is taken directly from the previous ones. Its purpose is to provide a summary of changes in a subset of parameters that different interventions are expected to induce.

**Table 2—Projections of Inflation Indices and Exchange Rate.** This table forecasts inflation rates and exchange rates between the Ugandan shilling (UGX) and the American dollar (USD).

**Tables 3A to 3D—Agricultural Households' Production and Disposition.** This set of tables, each representing a different region, forecasts the quantities of maize production and disposition by agricultural households. Some of the formula links in this table are explained below, because they are not as transparent as those in other tables.

**Yield Improvement Adjustment Factor (%):** Expected yield improvement in a *region* is determined by two factors: the specific intervention measure undertaken (subsistence, low-, or high-input farming) and the areas covered. For example, if an intervention is expected to increase yield by X percent, and if the intervention is implemented in all districts in a region, then yield is expected to improve by exactly X percent for that region. If not all districts are covered, as is currently the case, then only the areas in covered districts receive a boost in yield. If the covered areas account for Y percent of the total area under maize cultivation in the region, yield improvement in the region must be (X*Y) percent.

**Disposition Percentages (%):** Following the same line of argument, the disposition pattern remains constant in non-covered areas and is altered only in covered areas. Suppose that households in non-covered areas typically store X percent of maize in home storage, while the percentage is Y percent for covered areas. Further suppose that Z percent of areas in a region is covered. The average percentage of maize stored in the region is thus (Z*Y) percent + (1–Z)*X percent.

**Loss and Spoilage:** The spoilage quantity is higher in the first season, because the first harvest overlaps with the rainy reason.

**Per-unit Warehouse Storage Cost:** Tariff structure dictates a higher charge on maize with higher moisture content. The seasonal variation in per-unit storage cost reflects this difference.

**Per-unit Milling Cost:** By assumption, the nonproducing population consumes maize flour. Only the share of maize sold in local markets requires milling. This rule applies to agricultural households, small traders, and volume buyers uniformly, although milling costs may vary.

**Per-unit Farming Cost:** Recall the distinction between "profit" and "net cash flow" (NCF) as a financial impact indicator. By the profit indicator, agricultural households are treated as farming enterprises that hire labor and pay its cost. By the NCF indicator, agricultural households are treated as those providing their own labor without paying for it. The LEAD farm budget uses the former, whereas the notion exists that the latter is a better indicator of agricultural households' financial situation, because it measures disposable cash income rather than accounting profits. The model is linked such that, if the basis of analysis is profit, then per-farming costs are weighted averages of two modes of farming. If however the basis is NCF, then per-unit costs are set to zero.

Seed presents a slight complication. In the base case, the subsistence-farming scenario, farmers recycle seeds and as a result do not pay for them. With low- and high-input farming, improved varieties are acquired from inputs suppliers, which entails costs as well as VAT payments.

For low- and high-input items, the basis for financial analysis is immaterial, because they cannot be home produced. Also, for non-covered areas, the cost is simply zero. This explains why these formulas differ from substance farming inputs.

**Tables 4A to 4D—Small and Medium Traders' Procurement and Disposition.** This set of tables determines the quantities of maize procured from agricultural households by small traders as well as the costs paid and revenue received from sales to various channels. The tables should be straightforward and require no additional explanation.

**Table 5—Warehouse Storage System.** This table serves two purposes: determining warehouse operators' business profits and tallying the total quantity of maize that flow to warehouses. The latter is used to prepare the maize balance sheet in Table 8.

**Table 6—Volume Buyers' Procurement and Disposition.** This table determines the quantities of maize procured from agricultural households and small traders by volume buyers as well as the costs paid and revenue received from selling to various channels. The table should be straightforward and require no explanation.

**Table 7—WFP Aid and Relief.** This table determines the amount of maize that WFP acquires.

**Table 8—Reconciliation.** This maize balance sheet ensures that total inflows (maize production) match total outflows (disposition) at the national level. The last line in this table must be zero.

**Tables 9A to 9H—Stakeholders' Analysis Tables.** This set of tables summarizes the findings in the previous tables. Each stakeholder has a separate table, although small and medium traders and volume buyers are omitted to reduce space.

**Tables 10A to 10B—Economic Analysis Tables.** This set of tables further condenses Tables 9A to 9H into two tables.

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