USAID | ETHIOPIA
FROM THE AMERICAN PEOPLE

COST-BENEFIT ANALYSIS OF THE DAIRY VALUE CHAIN IN ETHIOPIA

AGRICULTURAL GROWTH PROGRAM (AGP) - LIVESTOCK MARKET DEVELOPMENT (LMD)

FINAL REPORT

This report was produced for review by the United States Agency for International Development (USAID). It was prepared by Optimal Solutions Group, LLC, and Cambridge Resources International, Inc., for USAID's *Learning, Evaluation, and Analysis Project* (LEAP). Contract Number: AID-OAA-C-11-00169

United States Agency for International Development

Learning, Evaluation, and Analysis Project

(AID-OAA-C-11-00169)

COST-BENEFIT ANALYSIS OF THE LMD DAIRY VALUE CHAIN

FINAL REPORT

Prepared for:

U.S. Agency for International Development/Ethiopia
Attn: Mark Carrato, USAID Ethiopia

Prepared by:

Optimal Solutions Group, LLC

University of Maryland
Research Park, M Square
5825 University Research Court, Suite 2800
College Park, MD 20740
USA
www.OptimalSolutionsGroup.com

Cambridge Resources International Inc.
60 Montgomery Street
Cambridge, MA, 02141
USA
www.cri-world.com

Project Analysts:
Glenn P. Jenkins, Cost-Benefit Manager
Richard Barichello, Senior Cost-Benefit Analyst
Mikhail Miklyaev, Cost-Benefit Analyst
Mergia Bekele, Local Consultant

April 2013

Disclaimer
The authors' views expressed in this publication do not necessarily reflect the views of the United States Agency for International Development or the United States government.

TABLE OF CONTENTS

ACKNOWLEDGMENTS

The LEAP team appreciates the assistance received from many people during the field visits to Tigray and Oromia in August 2012, including the representatives of USAID, SNV, and Holeta agricultural research center. Special thanks are also directed to many small-scale farmers and local traders unknown by name who were interviewed to allow the team to obtain a clear picture of the current situation in the commodities of interest. The assistance and willingness to cooperate of all aforementioned people are greatly appreciated.

ACRONYMS

AGP	Agriculture Growth Program
AI	Artificial Insemination
CBA	Cost-Benefit Analysis
CF	Conversion Factor
ENPV	Economic Net Present Value
EOCK	Economic Opportunity Cost of Capital
ETB	Ethiopian Birr (Currency)
FEP	Foreign Exchange Premium
FNPV	Financial Net Present Value
FtF	Feed the Future (Program)
GDP	Gross Domestic Product
GRAD	Graduation with Resilience to Achieve sustainable Development
Ha	Hectare
kg	Kilogram
LMD	Livestock Market Development
MFI	Microfinance Institution
NAIC	National Artificial Insemination Center
NCF	Net Cash Flow
NGO	Nongovernmental Organization
NPV	Net Present Value
ORDA	Organization for Rehabilitation and Development in Amhara
PLI – II	Pastoralist Livelihoods Initiative – Phase II
PLWHA	People Living With HIV/AIDS
PSNP	Productive Safety Net Program
SNV	Netherlands Development Agency
US$	United States Dollar
USAID	United States Agency for International Development

EXECUTIVE SUMMARY

USAID/Ethiopia was awarded a 5-year US$38.00-million contract under the U.S. government's Feed the Future (FtF) Initiative. The investment will serve as part of USAID's contribution to the government of Ethiopia's Agriculture Growth Program (AGP). The aim of the USAID Ethiopia Livestock Market Development (LMD) is to foster growth and reduce poverty through improving the competitiveness of selected livestock value chains in target woredas for the benefit of a large numbers of smallholders. LMD will also reduce hunger through income increases and job creation for rural households. The LMD budget of US$38.00 million includes US$25.30 million for Productivity and Competitiveness improvement, US$2.50 million earmarked for nutrition, US$7.70 million for Policy and Enabling Environment improvement, and US$2.50 million for people living with HIV/AIDS (PLWHA).

Project Description: The objective of the dairy value chain analysis was to understand the situation at the farm level and to analyze a number of possible LMD interventions designed to improve the livelihood of the targeted households. Field visits were used to collect primary data. The data were then used to construct cost-benefit analysis (CBA) models of the proposed interventions. The CBA models were designed to assess financial and economic outcomes of the interventions, such as the financial net present values (FNPVs) and the economic net present values (ENPVs). Taking into consideration the variety of climatic conditions and livestock production systems in Ethiopia, the CBA models were built to be easily adjusted to predict outcomes of interventions made in different regions of Ethiopia by changing the key parameters of the interventions in the model's Table of Parameters. The models can then automatically recalculate all corresponding figures.

The key observations from the field visits were as follows:

1. Milk production in the highlands of Ethiopia is usually done using cross-breed cows. The average milk yield of cross-breed dairy cows is much higher than the milk yield of the local breeds (4,000 liters per lactation period, compared to 507 liters). The cross-breed cows, however, consume more feed, are more vulnerable to local livestock diseases, and are less adaptive to the local climatic conditions.

2. The households frequently rent land for hay production. This allows them to minimize the cost of feeding and be more independent of the market availability of hay.

3. A large share of the milk is usually sold to cooperatives, which process milk into butter and cheese and then sell the skim milk and whey. The smallholder households do not have equipment to process large quantities of milk into butter or cheese. In 2012, milk was sold to cooperatives at ETB 5.00 (US$0.28) per liter.

4. The households also sell milk to neighbors and local cafeterias. This proportion of milk is sold at ETB7.00/liter (US$0.39), which is 40 percent above the price paid by the cooperatives.

5. The dairy households do not fatten male calves. The calves are usually sold at age 11–12 months.

6. The households prefer to use artificial insemination (AI) services from private-sector providers. These services, when available, are delivered in a timely manner and with a high conception rate. The price of AI services from the private providers ranges from ETB60.00 (US$3.33) to ETB180.00 (US$10.00), which is much higher than the cost of the AI service provided by government institutions (ETB4.00 [US$0.22]).

7. Female calves are usually raised until they join the milking herd. The households may sell cross-breed heifers or milking cows only if they are faced with a severe shortage of cash. The households may also expand their herd size by adding more milking cows or heifers when they have the financial resources.

8. The mortality rate of cattle is very low, because the households pay considerable attention to caring for the animals.

9. The households frequently exchange dung for the by-products of the local brewery and winery industries to minimize the cost of feeding.

10. The loss rate of milk was reported to be close to 0 percent. Households producing milk have an efficient marketing system, where most of the milk is sold immediately after collection. The 0 percent milk loss in this case represents complete milk loss/spoilage. Some part of milk, however, may be used in less productive ways. For instance, part of the milk may be fed to calves or processed into other dairy products, such as cheese and butter, thus reducing the benefits for the dairy farmers.

11. The average age of the first calving is reported to be 32 months. The average productive life of the cross-breed milking cattle is 5 to 6 years. The households directly profit from the milk production for a period of 3 to 4 years. The animals are then kept for another 2 or 3 years for the purpose of breeding as milk production is reduced over time.

12. The main assumption of this study is that the households will expand the herd size until it includes six milking cows per household. After that point, the households will continue to raise heifers to replace culled or dead animals. Any excess heifers after these replacements will be sold in the market.

13. The analysis also assumes that the LMD project will result in the general improvement of the dairy value chain through effecting positive changes in the key profitability factors of milk production at the household level. These changes, if they happen, would result in a shift from milk production using indigenous dairy cattle toward milk production using cross-breed cattle by the Ethiopian households. The analysis assumes that the households would sell an indigenous dairy cow to purchase a cross-breed one.

At the time this analysis was conducted, the selection of LMD implementers was in progress. The current analysis is based on the possible interventions that could be undertaken in the dairy value chain.

Strategic Context and Rationale: The USAID Ethiopia LMD is part of the wider strategy of the FtF programs, which support investments in profitable and relatively easy-to-implement interventions in agricultural value chains. The goal of FtF is to reduce poverty and hunger in a sustainable manner.

The milk yield of indigenous cattle is only about 1.5–2.0 liters per day. Currently, Ethiopia imports significant quantities of dairy products. Domestic milk processors complain about the limited raw milk supply. The increase in the popularity of milk consumption by young Ethiopians[1] together with the country's increasing population will increase the demand for milk. The increased demand under currently limited supply could lead to an increase in the market prices of milk. Taking into consideration the low purchasing power of Ethiopians, higher prices for milk will reduce the quantity of milk consumed by the population. A number of factors prevent many farmers from starting small-scale cross-breed dairy operations:

- The high price of the cross-breed heifers, around ETB30,000.00 (US$1,667)
- Poor level and frequent inaccessibility of AI services
- High feeding cost and poor or almost no access to low-cost feed concentrates (dairy feed concentrates are available only around Addis Ababa and some big cities)
- Poor veterinary services

Interventions: At the time the CBA was conducted, the local implementing partner of LMD project had no estimates of the exact cost of the LMD interventions. The results of the CBA presented in this report are measured assuming that the LMD project would reach the specific targets to improve the productivity and competitiveness of the selected livestock value chain. This assumption is consistent with the area for which the main part (US$25.3 million for productivity and competitiveness improvement) of the LMD budget would be allocated.

Seven interventions have been analyzed in this study:

1. **Shift from the indigenous breed toward cross-breed cattle** (due to increased productivity and competitiveness of the Ethiopian dairy value chain): The CBA attempts to estimate the benefits to the households if the status quo of the Ethiopian dairy sector were to change. The main assumption is that the Ethiopian households will shift toward milk production using cross-breed dairy cattle.
2. **Improved veterinary services**: The current mortality rate of milking cows is estimated at 3 percent on average. The assumed target of the LMD project is to reduce the mortality rate to 2 percent.
3. **Improved AI services:** The average current calving interval of the cross-breed milking cows is estimated at 425 days, while the optimal calving interval is 365 days. The target is to reduce the current calving interval to 380 days.
4. **Access to sexed semen:** The standard proportion of male/female calves' birth is 50/50 percent. The access to the sexed semen will allow targeted households to have **100 percent female** calves born.
5. **Provision of in-calf cross-breed heifers:** The milk production in Ethiopia is constrained by the low productivity of the indigenous cattle breeds. The LMD project is assumed to provide financial subsidy to the targeted households for the purchase of the 7-month in-calf cross-breed heifers.
6. **Improved access to low-cost feed concentrates:** The productivity of milking cattle is limited due to the poor nutrition status of the feed. Feed concentrates are very expensive

[1] One of the reasons is a recent advertising campaign, conducted by different NGOs, promoting healthy lifestyles and higher milk consumption.

and not readily available to the households in the rural areas. For instance, dairy feed concentrates are only available around Addis Ababa (the capital of Ethiopia). The target is to increase the milk yield/lactation period from 4,000 liters to 4,500 liters due to better nutrition for the animals.

7. **Fodder Production:** LMD may assist the households, who potentially have access to the land that can be rented, with obtaining the required inputs and capital to start fodder production.

Structure of the Analysis: The baseline scenario of the analysis assumes that each household currently has one indigenous cow/heifer that is used to produce milk. The households minimize the direct cost of keeping the animal to as much as possible to compensate for the low productivity of the cattle.

The goal of the LMD project is to improve the current situation in the dairy value chain. It is assumed that this will result in more households shifting toward low-scale dairy farming using cross-breed cattle. This shift in the status quo itself is analyzed as the LMD intervention (Intervention 1). The benefits of this intervention to the households that would start small-scale cross-breed dairy operations are discussed in more details in the following section. In addition, this shift also represents the baseline for further analysis.

The main parameters of the milk production process, if positively affected by the LMD project, would benefit both the households that already have cross-breed dairy cattle as well as those that would join the industry. The changes in the main parameters of the milk production also represent the potential LMD interventions (Interventions 2, 3, 4, and 6).

Two additional potential interventions have also been analyzed. The first intervention (Intervention 5) represents the direct subsidy from USAID to the Ethiopian households for the purchase of the in-calf heifers to enable the households to start the small-scale dairy farming. The second intervention (Intervention 7) is a fodder-production intervention.

Financial and Economic Analysis Results: The baseline scenario assumes that the households will expand the farm size until the herd size reaches 6 milking cows per household. The total investment cost per household is presented in table A, below.

Table A. Total investment cost per household (thousands ETB, real)

Line item	**ETB**
Cross-breed dairy cattle	30.00
Noug seed cake (2-month requirement)	0.43
Wheat bran (2-month requirement)	0.24
Other supplements (2-month requirement)	0.55
Salt (2-month requirement)	0.00
Cost of hay (2-month requirement)	0.63
Average veterinary expense	0.06
Total Investment Cost	**31.91**
Less value of indigenous cattle	10.00
Less additional equity contribution	0.00
Total USAID investment required/per household (case of heifers provision)	21.91
Total USAID investment required US$/household (case of heifers provision)	**1,217.1**

If the status quo of the dairy sector were to be positively affected by the LMD project, the households are assumed to purchase 7-month-old in-calf cross-breed heifers. The milk production

will start approximately 2 months later. The households have to ensure that they will have feed sufficient for the 2-month period.

The total amount of the USAID subsidy per household, if the in-calf heifers were to be provided, is calculated to be ETB21,910.00 (US$1,217.10). The calculation is based on the assumption that the households would use the funds obtained from the sale of the indigenous cow, with the rest of the total investment cost covered by the subsidy. The CBA model that accompanies this report can also show the impact of the increased equity contribution requirement by changing the model cell (in Excel file) "Less Additional Equity Contribution" to reflect the corresponding increase in the equity contribution requirements.

The analysis has been carried out for a 20-year period. The incremental FNPVs have been calculated using a 12 percent real discount rate, and the incremental ENPVs have been calculated using a 12 percent economic opportunity cost of capital (EOCK). The figures provided in table B, below, are estimated under the assumption that the specific targets presented in the "Interventions" section above would be achieved by LMD project. The outcomes of Interventions 2, 3, 4, and 6 described in the table would benefit the households that switch from the indigenous breed dairy cattle toward the cross-breed cattle as well as for those that are already using cross-breed dairy cattle.

Table B. Incremental FNPVs and ENPVs of the interventions (US$ mill/1,000 households)

Intervention	FNPV	ENPV
1. Shift from the indigenous breed toward cross-breeds	US$2.01	US$2.84
2. Improved veterinary services	US$0.49	US$0.56
3. Improved AI services	US$2.88	US$3.14
4. Access to sexed semen	US$3.85	US$4.36
5. Provision of in-calf cross-breed heifers	US$3.23	US$2.84
6. Improved access to low-cost feed concentrates	US$2.36	US$2.51
7. Fodder production	US$1.64	US$1.65

The ENPVs are also positive in the all scenarios, using a 12 percent EOCK. The difference between the financial and the economic outcomes of the project arises from the fact that the financial values do not include all the externalities presented in the project. In the case of the dairy farm operations, the difference would result because of three factors:

- Milk is an internationally tradable good. Ethiopia currently exports significant amounts of dairy products. Internationally tradable goods, when imported, use foreign exchange resources of the country. The foreign exchange premium (FEP) for Ethiopia was reported to be 6.5 percent (Kuo, 2011), so every incremental dollar spent on imports would have an economic cost of 1.065 times the market exchange rate.

- The other output of the intervention is meat. Meat is also an internationally tradable good. Meat, when exported, brings foreign exchange to the country. Every incremental dollar earned on exports would have a financial value of 1.065 times the market exchange rate. Transportation costs are also incurred when meat is exported from Ethiopia, and high tax rates are applied on fuel required for transportation. Although these taxes on fuel are a component of the financial cost of transportation, they are not included in the economic cost of the project. The resulting economic value of meat is 10 percent above the financial value.

- The financial cost of the inputs used in the dairy farm operations, such as feed and veterinary expenses, differ from their true economic cost due to taxes.

Beneficiary Analysis Results

The results of the analysis reveal that there would be two main stakeholders of the interventions. The first group of beneficiaries would be the targeted households. The net increase in the incomes of the households, including the opportunity cost of family labor over the 20-year evaluation period, would be US$3,587.98 per household for the "without fodder production" scenario and US$5,235.80 for the "with fodder production" scenario.

The other beneficiary of the intervention would be the government, for the following reasons:

- The government would benefit directly from the taxes collected on the inputs and outputs of the intervention. Vaccines, exotic bull's semen, salt, and fuel (used to transport meat for exports) are imported to Ethiopia. The total tax rate applied to salt and fuel is higher than the FEP. The inflow of taxes on salt would reduce the economic cost below its financial cost and generate net tax revenue for the government of Ethiopia. No taxes are applied to exotic bull's semen and vaccines when they are imported to Ethiopia. Instead, there is a high subsidy from the government for vaccines and the bull semen, so the intervention's economic cost of these items would be higher than the financial cost by the amount of the government subsidy and the FEP.

- The government would also benefit indirectly, because meat is exported from Ethiopia. Exports allow the country to earn foreign exchange, hence making the FEP an additional benefit.

- A significant quantity of dairy products is also imported to Ethiopia. Ethiopia pays foreign exchange when importing the products. The project would increase the local milk production, hence reducing the quantity of imports and saving the foreign exchange for the country.

The total amount of government benefits from the intervention over the 20-year period is estimated to be US$880 per household.

Conclusions and Recommendations: The CBA analysis of the proposed interventions in the dairy value chain shows positive FNPVs and ENPVs, suggesting that the benefits of implementing such interventions would outweigh the costs. The households would increase their annual income due to the interventions.

To enable the households to participate in some of the analyzed interventions (provision of in-calf heifers), USAID would need to provide a financial subsidy to the households. The recommended subsidy is the provision of cross-breed in-calf heifers and feed after the collection of the equity contribution from the households. In this case, it is also recommended that the local implementers of the project carefully select in-calf heifers and administer the initial vaccinations to reduce possible animal losses and ensure the success of the interventions. The proper animal conditions are extremely important, because such factors as the age at the first calving have a significant impact on the animal's productivity.

The adequate supply of exotic bull's semen in the intervention's implementation areas must also be ensured. The timing and quality of the AI services is an extremely important factor in the dairy industry. Unavailability of the AI services when a cow is in heat will result in a 1-month loss of milk production. The analysis reveals that the interventions designed to improve the AI services and to provide access to sexed semen are the most promising interventions that, if implemented

properly, would result in the significant improvement of the livelihoods of the targeted Ethiopian households.

The households should be advised to rent land for fodder production when such a possibility exists. The intervention is designed to provide access to inputs for fodder production and would result in a significant increase in the financial returns of dairy farming for the households. The analysis reveals that the cost of hay is a significant factor affecting returns of the intervention. The rental cost of land used in the analysis was reported to be ETB10,000.00/ha (US$555.55). In Ethiopia, it is possible to rent quite productive land for a price that would produce a good yield of a fodder. The households can rent a timad[2] of the land initially and expand the size of the rented land with the farm growth.

The analysis reveals that there is a trade-off between short-run returns and long-run returns of the intervention. The households that decide to expand the size of the farm would have lower annual net cash flows until the expansion limit were met but would have significantly higher cash flows after the expansion point were reached. On the other hand, households that choose to sell the cross-breed heifers would have a constant but somewhat higher annual net cash flow in the early years of the life of this program.

It is also recommended that the institutions operating in Ethiopia assist in addressing the feed issues. The cost of feed accounts for 60 percent to 70 percent of the total cost of livestock production. A feed shortage and high prices have a dramatic impact on the profitability of such a commercial livestock operation. The high cost of feeding contributes to the factors affecting low productivity of Ethiopian dairy cattle. A positive change in the current situation would not only lead to the improved health status of the animals but also would directly result in the increased production of milk per lactation period.

Drought-mitigating activities should be carefully examined before implementation. During the 2007–2008 droughts, a substantial amount of concentrate and roughage feeds were purchased by various governmental and nongovernmental organizations (NGOs) to address the critical feed shortages in the pastoralist areas. This drought-mitigation intervention, coupled with a general feed shortage, dramatically increased the price of feed and resulted in a crisis in the animal feed supply throughout Ethiopia. This crisis resulted in the closure of many dairy farms in the highlands of Ethiopia.

[2] A timad is equal to 0.25 hectare. In Ethiopia, land is usually rented by timads.

LMD DAIRY VALUE CHAIN: COST-BENEFIT ANALYSIS

METHODOLOGY

Project Background

The growth rate of Ethiopian real gross domestic product (GDP) in 2011 was 7.5 percent. Ethiopia, however, is still one of the poorest countries in the world. Currently about 8 million Ethiopians, out of the total population of 93 million,[3] live with chronic food insecurity (The World Fact Book, CIA). Each year between June and October, more than 60 percent of Ethiopian rural households experience significant food shortages (GRAD Technical Proposal, 2011). These figures show that for several months of the year, a large portion of Ethiopian families cannot obtain enough food to avoid hunger. This situation is one of the main reasons that USAID Ethiopia supports various initiatives to increase food security for Ethiopia's most vulnerable inhabitants.

The LMD is part of the broader USAID FtF agenda. The USAID Ethiopia LMD would foster growth and reduce poverty through improving the productivity and competitiveness of selected livestock value chains in the target woredas for the benefit of a large numbers of smallholders. These investments would, in turn, generate increased productivity and competitiveness of these value chains to benefit smallholders, both men and women. The LMD would also reduce hunger through increased income and job creation for rural households. The LMD budget is estimated at US$38 million, including US$25.30 million for productivity and competitiveness improvement, US$7.70 million for policy and enabling environment improvement, US$2.50 million for nutrition, and US$2.50 million for PLWHA.

The LMD will be implemented in the AGP's targeted 83 woredas within Ethiopia's four main regions (Oromia, SNNPR, Amhara, and Tigray). Meat and dairy rank among the top-priority commodities in each region. The LMD will focus on two key value chains: dairy and "live animals and meat," including hides, skins, and leather (a subset of the live animals and meat value chain).

To reduce poverty, the LMD will establish strong linkages with new USAID programs, such as the Productive Safety Net Program (PSNP), Graduation With Resilience to Achieve Sustainable Development (GRAD) and Pastoralist Livelihoods Initiative – Phase II (PLI – II) programs. The LMD will pilot a strategy to "pull" very poor graduates from GRAD and PLI – II into value chain–specific market opportunities. This pilot will test the efficacy of USAID Ethiopia's FtF "Push-Pull" strategy in creating a "pathway out of poverty" for the chronically poor. The "Push-Pull" hypothesis posits that asset-building "Push" efforts by PSNP – GRAD and PLI – II projects in vulnerable areas can help link those communities with more stable livelihoods through greater integration in stable value chains.

Commodity Background

Current Situation in Ethiopian Dairy Production

Ethiopian farmers have had a long tradition of animal husbandry. It is estimated that Ethiopia possesses the largest number of livestock in Africa, comprising about 59 million cattle, 35 million sheep, and 31 million goats (Negassa, Rashid and Gebremedhin, 2011). Given the total Ethiopian

[3] Per CIA estimation from July 2012.

population of 93 million people, the per-capita livestock holding is still very low (about 1.3 animals per capita). The livestock holding per capita in Kenya, for example, is 1.43 animals.

About 10 million dairy cows in Ethiopia produce 3.2 billion liters of milk per year. The average production per cow is estimated at approximately 1.54 liters per day for an average lactation period of 6 months. These figures, however, are more relative to the indigenous breeds of cattle. The milk production of the cross-breeds is much higher.

In the highlands of Ethiopia, the use of cattle for draft power is important in the crop-production systems. The commercial off-take rates are low, at 8 percent to 10 percent.

Market-oriented milk production is located in the highlands, where rainfall, temperature, and soil types are conducive for forage production. There are three main milk-producing areas in the highlands: Greater Addis, Lake Tana, and Mekele. The main milk supply comes from the Greater Addis milk shed. Nevertheless, the milk processors in Addis complain about the very limited milk supply. Some of the processors operate below 50 percent of their capacity.

Ethiopia's dairy production can be categorized into four systems:

1. Commercial
2. Peri-urban and urban
3. Rural dairy smallholder
4. Pastoral and agro-pastoral

The rural dairy smallholder system produces the largest share of milk production, contributing 98 percent of total milk supply. The current analysis is built on the Ethiopia highlands rural dairy smallholder system.

The population of cross-breed dairy cattle in Ethiopia is very small, an estimated 300,428 heads. Producers rely exclusively on AI for good semen and are willing to pay for more expensive imported genetics and breeding supplies.

Main Obstacles in the Ethiopian Dairy Production

The highlands of Ethiopia are characterized by mixed crop and livestock systems. Livestock feed supply depends mainly on crop residues, natural pastures, and other agricultural by-products, such as thinning and leaf stripping from such crops as maize and sorghum or the leaves of sweet-potato vines, depending upon the locality. The contribution of natural pastures, however, has declined over time, as most of the available land is cultivated for crop production. The use of animal-feed mixes (oilseed cakes, wheat bran, etc.) is still very low, mainly because of high prices and low availability. The use of agro-industrial by-products is also very limited due to the scattered settlement of the farmers.

Feed costs account for 60 to 70 percent of the total cost of livestock production. Feed shortages and the high price of feed ingredients negatively affect the productivity and profitability of commercial livestock operations.

The main source of improved breed genetics (bull semen) is the National Artificial Insemination Center (NAIC). The center currently produces only 300,000 units of bull semen per year, with a goal of increasing that level to 600,000 within the next 5 years.

Only about 1,700 AI technicians operate at the woreda level, a number much lower than the optimal level of AI technicians. The situation is even worse when their low mobility is taken into

consideration. No transportation, such as motorcycles, is available for the AI technicians, which limits the timely distribution of the service. NAIC estimates that 50 percent of the bull semen produced never gets used.

The government's AI services are highly subsidized, with the farmer bring charged only ETB4.00 (US$0.22) per unit for AI service and semen, while the actual cost is ETB22.00 (US$1.22) per unit.

The private AI sector also faces a number of constraints, including:

1. Shortage of foreign exchange, which makes import transactions difficult.
2. Lack of protocol to import animal genetics.
3. The expense of the equipment, all of which is imported; the cost of semen tanks is currently ETB18, 000/tank (US$1,000).
4. AI technicians' common status as government employees; the number of successful private AI technicians is very limited.

Project Description and Activities

LMD Interventions in the Dairy Value Chain

At the time the CBA was conducted, the local implementing partner of the LMD project had no estimates for the exact cost of the LMD interventions. In addition, an alternative option of the cross-breed in-calf heifer provision as the direct subsidy from USAID to the households has been evaluated. The results of the CBA presented in this report are measured assuming that the LMD project reaches the specific targets to improve the productivity and competitiveness of the selected livestock value chain. This assumption is consistent with the area for which the main part (US$25.3 million for productivity and competitiveness improvement) of the LMD budget would be allocated.

Seven interventions are analyzed in this study:

1. **Shift from the indigenous breed toward cross-breeds** (due to increased productivity and competitiveness of the Ethiopian dairy value chain): The CBA attempts to estimate the benefits to the households if the status quo of the Ethiopian dairy sector were to change. The main assumption is that the Ethiopian households would shift toward milk production using cross-breed dairy cattle in one of two ways:
    a. The first way is that the households would use equity to purchase a cross-breed heifer. The milk production in this case would start as soon as the calf will be born.
    b. The second way is for the households to breed indigenous cows using AI services to get cross-breed calves. The milk production from the cross-breed milking cow, in this case, would start in approximately 3 to 4 years.

    The current analysis considers the first option. Each household is assumed to purchase a 7-month in-calf heifer using equity funds.

2. **Improved veterinary services**: The current mortality rate of milking cows is estimated at 3 percent on average. The target is to reduce the mortality rate to 2 percent. This intervention would affect the households that already engage in the dairy farming as well as new entrants.
3. **Improved AI services:** The average current calving interval of the cross-breed milking cows is estimated at 425 days, while the optimal calving interval is 365 days. The target

is to reduce the current calving interval to 380 days. The target, if achieved, would result in a significant increase in the financial returns of milk production. The baseline scenario assumes a 425-day calving interval. The CBA reveals the positive FNPV of the baseline scenario. However, high investment costs and a range of risks associated with dairy farming in Ethiopia prevent many households from participating. The calving interval, if reduced, would attract more entrants to the industry. The difference between the FNPV of the baseline scenario and the FNPV of the 380-day calving interval scenario represents the increase in the financial returns to the households due to the intervention.

4. **Access to sexed semen:** The standard proportion of male/female calves' birth is 50/50. Access to the sexed semen would allow targeted households to have 100 percent female calves born. Female calves have a significantly greater financial value than male calves. In this case, again, the difference between the FNPV of the baseline scenario and the FNPV of the situation when the households would have access to sexed semen represents the increase in the financial returns to the households due to the intervention.
5. **Provision of in-calf cross-breed heifers:** Milk production in Ethiopia is constrained by the low productivity of the indigenous cattle breeds. The current average productivity of indigenous breed is 1.5 to 2.0 liters of milk per day. In contrast, the productivity of cross-breed cattle is about 12 liters/day. The population of the cross-breed animals, however, is very small. This specific LMD intervention that is proposed for the dairy value chain consists of the small-scale dairy farms' getting a financial subsidy from USAID to combine with an equity contribution equivalent to the value of the indigenous cow. The value of the indigenous cow is estimated at ETB10,000.00 (US$555.55). This intervention would be suitable for the households who already engage in milk production using local-breed milking cows as well as those that have the financial resources to make an equity contribution and want to participate in milk production. The total investment cost per household is presented in table 1, below.

Table 1. Total investment cost/household (thousands ETB, real)

Line Item	**ETB**
Cross-breed dairy cattle	30.00
Noug seed cake (2-month requirement)	0.43
Wheat bran (2-month requirement)	0.24
Other supplements (2-month requirement)	0.55
Salt (2-month requirement)	0.00
Cost of hay (2-month requirement)	0.63
Average veterinary expense	0.06
Total Investment Cost	31.91
Less value of indigenous cattle	10.00
Less additional equity contribution	0.00
Total USAID investment required/household	21.91
Total USAID investment required US$/household	**1,217.10**

6. **Improved access to low-cost feed concentrates:** The productivity of milking cattle is limited due to the poor nutrition status of the feed. Feed concentrates are very expensive and not readily available to the households in the rural areas. For instance, dairy feed concentrates are only available around Addis Ababa (the capital of Ethiopia). The target

is to increase the milk yield/lactation period from 4,000 liters to 4,500 liters due to the better nutrition of the animals.

7. **Fodder production:** LMD may assist the households that potentially have access to the land that can be rented with obtaining the required inputs and capital to start fodder production.

The baseline scenario assumes that the household would expand the farm size until the herd size reaches six milking cows. Two intervention scenarios are analyzed. Under the first scenario, the households purchase hay to feed the cattle. The second scenario assumes that the households would also receive support from the implementer of the LMD project to start fodder production. The initial investment cost for both scenarios is calculated using the cost of hay that would be sufficient to feed one cow for a 2-month period to minimize the required amount of the initial investment and hence minimize the required USAID subsidy.

Feeding Cost

The main operating cost of the dairy farm operation is the cost of feed. The feed ingredients, however, may be location specific, so some ingredients may be replaced with other types of feed suitable to provide the same nutritional value.

The main four ingredients of the nutritional ration (used in the analysis) to be provided to the cross-breed cows are as follows:

1. **Hay:** The households frequently rent land for forage production. The intensity of cropping is another factor that determines the area available for grazing and browsing. In the Ethiopian highlands, the better soils are used for cropping, while the steep slopes and the seasonally waterlogged foothills are allocated for grazing. Natural pastures are continuously decreasing due to the increasing human population and expansion of croplands.

   The cost of hay production in the "with hay production" scenario is calculated using the rental value of the better soils in the highlands of Ethiopia. The hay yield in this case is up to four harvests per year and much higher than what can be obtained on the steep slopes and seasonally waterlogged areas. The availability of the land may be problematic, taking into consideration Ethiopian conditions. Thus the "with hay production" scenario is a special case that should be recommended to the households when the possibility of renting the land exists.

   The protein content and digestibility of most grass species declines rapidly with advancing physiological maturity. The productivity of natural pastures in Ethiopia is very low and usually does not exceed 0.5 to 2 tons per hectare of dry matter per year. The knowledge of silage production is also limited. The field visits revealed that the hay yield using better soils could reach 12MT/ha/year. The analysis is built using the yield of 8MT/ha/year. The rental cost of the land is reported to be 10,000ETB/ha/year (US$555.55).

2. **Wheat bran:** Wheat bran is the most common milling by-product used for livestock feeding in Ethiopia. It can be used as a source of energy and protein. Wheat bran is easily digestible. It contains 15 to 18 percent crude protein and has a digestibility level of 75 percent. It is also a good source of water-soluble vitamins, except niacin. Wheat bran can improve the feed intake, digestibility, and growth performance of animals when added to protein-source feeds.

3. **Oilseed cakes:** Oilseed cakes are the residues or cakes produced as by-products during the extraction of oil from the oilseeds. They include noug cake, cottonseed cake, groundnut cake, linseed cake, and sesame cake. The analysis has been conducted using noug cake as an ingredient in the daily dairy cattle nutrition ration.

The two methods of extracting oil from the oilseeds are the mechanical press or the solvent extraction process. Mechanical extraction leaves a substantial amount of oil in the residue. In Ethiopia, most of the oil-extracting factories use the mechanical method of extraction.

The protein content of noug cakes is between 28 and 35 percent. Most oilseed cakes are low in the essential amino acids cysteine and methionine and usually have low lysine content.

4. **Other feed supplements:** This group of feed represents location-specific inexpensive feed components that can be used as roughage or as a component of the feed mix. Here are the main potential candidates to this group:

    a. Crop residues are very important as a source of roughage feed for livestock in the highlands of Ethiopia. These include cereal straws, such as tef, wheat, barley, maize, sorghum, field peas, chickpeas, and haricot beans. The principal crop residues used for animal feeding are the straws of cereals and pulses. Haricot beans residues are also a good source of protein for livestock.

        Cereal straws and stovers generally have low nutrient content, high fiber content, low digestibility, and low voluntary intake by animals. The nutritional value of many cereal straws is close to medium-quality native grass hay.

    b. Brewery and winery by-products: This ingredient of feed ration is commonly used, but farmers often exchange manure for these brewery and winery by-products, so the cost of the by-products in some cases can be measured by the value of the manure.

        The brewery and winery by-products are important sources of supplementary feed in commercial livestock operations, particularly for households located close to commercial breweries, distilleries, and wineries. These by-products have moderately high levels of crude protein, energy, and digestibility content.

Technical Coefficients

The nature of the analysis in the dairy value chain requires understanding the technical coefficients. This section provides an explanation of the most important coefficients used in the analysis.

- **Lactation period**: The analysis assumes that the lactation period of the cross-breed dairy cattle is 305 days. The lactation period for the indigenous cattle is 240 days.

- **Calving interval**: The calving interval is reported to be 425 days. This is much higher than the optimal calving interval level. Taking into consideration the general situation in Ethiopia, such as frequent unavailability of the AI services and other factors, the calving interval of 425 days is more appropriate. The calving interval for the “without case” scenario is reported to be 447 days.

- **Dry period**: The remaining 120 days are assumed to be the dry period. The optimal dry period is 60 days. Some farmers during the field visits also reported dry periods of 60

days, but it is more appropriate to use the 120-day period to analyze the general situation in Ethiopia. The dry period of the local breeds is assumed to be 207 days.

- **Lactation milk yield**: The lactation milk yield is reported to be 4,000 liters per lactation period. This translates into 13.11 liters per day. This is above the average lactation milk yield reported in most studies of dairy sector in Ethiopia. The milk yield is calculated as a factor of the cow parturition number, feed provision, and exotic blood level. During the field visits, farmers report on average a 10 percent increase in the milk yield as the exotic blood level of the cross-breed cow increases. The yield of approximately 13 liters per day was also frequently reported by the households. The indigenous cattle lactation milk yield is 507 liters per lactation period on average.

- **Annual milk yield**: Annual milk yield is calculated using the formula lactation milk yield/calving intervals*365 days. The calving interval is reported to be 425 days; hence the annual milk yield is less than the lactation milk yield and is equal to 3,435 liters per year. Using the same formula, the annual milk yield of the local breeds is estimated to be 414 liters per year.

- **Calf mortality rate**: The dairy households claimed that the calves' mortality rate increased as the exotic blood level increased. This, perhaps, can be explained by the decreased immunity to the local conditions as the exotic blood level increased. The calf mortality rates are reported to be 10, 11, and 12 percent for the F1, F2, and F3 generations, respectively. The actual calf mortality rate in each generation can be a bit higher, but it is assumed that the households would decrease the rate due to better management as they gain experience. For the "without case" scenario, the calf mortality rate is assumed to be constant at 10 percent.

- **Adult mortality rate**: The adult mortality rate of the cross-breed cattle is reported to be 3 percent compared to 2 percent with the indigenous cattle.

- **Calving rate**: The calving rate for the first year of the intervention is assumed to be 100 percent, because the households will start production with a 7-month in-calf heifer. For Year 2 and until the end of the project, the calving rate is calculated using the formula 365 days/the calving interval of 425 days and reported to be 85.9 percent. Using the same formula, the calving rate for indigenous cattle is estimated to be 81.7 percent.

- **Culling rate cows**: The culling rate of cows removed from the herd because they don't meet performance standards is proportional to the size of the herd and the age of the cows. For Year 1 of the intervention, the culling rate of cows is assumed to be 0 percent. The implementers of the intervention should ensure that the households get quality cross-breed in-calf heifers. The culling rate of cows for Year 2 of the intervention is estimated to be 5 percent, and then it reaches 10 percent for Year 3 and until the end of the project.
  The culling rate of indigenous cattle is a factor of the average productive life. The average productive life of cattle can be determined using the formula 1/(adult mortality rate + culling rate). The average productive life of the local breeds is usually about 10 years. The culling rate is equal to 8 percent and assumed to be constant for the evaluation period of 20 years.
- **Culling rate heifers:** The culling rate of the heifers is assumed to be 8 percent and 4 percent for the cross-breed heifers and indigenous heifers, respectively. The higher culling rate of the cross-breed heifers is due to tighter performance standards.

- **Female versus male calves birth:** The proportion of female versus male calves' birth is assumed to be 50 percent by 50 percent for both the "without intervention" and "with intervention" scenarios.

- **Animal feeding units as proportion of adult animal's requirements:** The feed consumption is a factor of the body weight. To calculate the feed consumption of the herd, the assumption has been made that calves up to 1 year old will consume 30 percent of the adult animal feed consumption. The heifers 1 to 2 years old will consume 60 percent, and heifers 2 to 3 years old will consume 80 percent of the adult feed consumption.

Assumptions for the Selected LMD Interventions in the Dairy Value Chain:

1. There are substantial domestic price fluctuations for milk due to the long fasting periods in Ethiopia. The price of milk is higher during the holiday periods and lower during the nonholiday periods. The households sell milk to cooperatives, milk-processing industries, and cafeterias (or neighbors). The milk sold to cooperatives fetches the price of ETB5.00 per liter (US$0.28). The share of milk sold to cafeterias/neighbors is sold at ETB7.00 (US$0.39), which is 40 percent above the price paid by the cooperatives.

2. The baseline scenario of the analysis assumes that the households will sell 70 percent of milk to cooperatives and 30 percent to cafeterias/neighbors.

3. The by-products of brewery and winery industries are frequently used as a part of the feed ration, but they are also often exchanged for manure. The households will try to minimize feed cost by providing location-specific cheap feed, such as by-products of winery and brewery industries.

4. The cost of feed required for the weight gain is calculated based on the current market prices of the feed ingredients and adequate feed requirements.

5. The cost of hay used for the analysis represents the current market price of hay. Some farmers, however, rent their land for hay production, thus allowing them to minimize the cost of hay.

6. Culled animals are assumed to be sold for slaughtering. Culled milking cows are assumed to be sold at ETB10,000 (US$555.55). Heifers that are 2 to 3 years old would be sold at ETB7,000 (US$388.89).

7. The households are not assumed to engage in any fattening operation and hence would sell 12-month-old male calves at ETB5,000 (US$277.78).

8. The households are assumed to expand the size of their herds until they reach six milking cross-breed cows per households. Under the "without intervention" scenario, the households will not expand the farm size and will be limited to one milking cow.

9. After the expansion limit is met, the households will continue to keep the heifers to replace the culled cows or any milking cows that die. After these replacements, it is assumed that the households will sell the rest of the heifers. The price of 2- to 3-year-old heifers sold due to overstocking is reported to be ETB30,000 (US$1,666.67).

10. The households are assumed to use AI services from the private sector. The cost of AI service is assumed to be ETB120.00 (US$6.67). This is much higher than the cost of AI services from the government institutions.

11. For the purpose of this analysis, the following macro-level assumptions are made: The rate of domestic inflation is 20 percent, the US inflation rate is 2.5 percent, the real financial discount rate is 12 percent, the economic real discount rate is 12 percent, the FEP is 6.5 percent, and the exchange rate in 2012 is US$1 = 18.00 ETB.

The table of parameters used in the analysis is presented below.

Table 1. Table of parameters of the CBA model

	With intervention	Without intervention
General Information		
Total number of farms	1,000	1,000
Maximum heads of cattle per farm	6.00	1.00
Number of days in the year	365.00	365.00
Initial heads of dairy cattle per farm	1.00	1.00
Reproductive and milk performance		
Dry period (days)	120.0	207.00
Lactation period (days)	305.0	240.00
Calving interval (days)	425.0	447.00
Age at first calving (months)	32.0	42.80
Number of services per conception	1.0	2.44
Lactation milk yield	4,000.0	507.00
Annual milk yield	3,435.3	413.99
Milk loss	0.00%	0.00%
Input Cost ETB/animal		
Cost of cattle	30,000.0	10,000.00
Feeding Cost ETB/kg		
Noug seed cake	7.00	7.00
Wheat bran	4.00	4.00
Other supplements	1.50	1.50
Salt	5.00	5.00
Cost of hay production ETB/ha		
Land rent ETB/ha/year	10,000.00	10,000.00
Cutting labor cost	2,300.00	2,300.00
Transportation cost (labor intensive)	2,300.00	2,300.00
Additional labor cost	300.00	300.00
Hay yield kg/ha/year	8,000.00	8,000.00
Hay requirement kg/cattle/year	1,500.00	550.00
Hay production cost ETB/20 kg	37.25	37.25
Feeding Requirements kg/animal unit/year		
Noug seed cake	365.00	0.00
Wheat bran	365.00	302.00
Other supplements	1,820.00	0.00
Salt	5.00	0.00
Animal Shelter		
Construction cost of shelter ETB	400.00	100.00
Maintenance cost of shelter per year	10.00%	10.00%
Labor requirements		
Time required for milking hours/day/head	0.5	0.20
Average time required for other dairy farm activities	1.0	0.25
Working day hours	8.0	8.00
Labor cost ETB/day	25.0	15.00
Veterinary Services ETB/animal/year		
Average veterinary expense	60.0	20.0
AI cost	120.0	4.0
Coefficient Rates		
Calf Mortality Rate		
F1 generation	10.00%	10.00%
F2 generation	11.0%	10.00%

	With intervention	Without intervention
F3 generation	12.0%	10.00%
Adult mortality rate	3.00%	2.00%
Calving Rate		
Year 1	100.00%	81.7%
Year 2 - 2031	85.9%	81.7%
Culling rate – cows (year 1)	0.00%	8.00%
Culling rate – cows (year 2)	5.00%	8.00%
Culling rate – cows (year 3 and after)	10.00%	8.00%
Culling rate – heifers	8.00%	4.00%
Female calves' birth	50.00%	50.00%
Male calves' birth	50.00%	50.00%
Animal Feeding units as proportion of adult animal		
Calves (0 to 1 year)	0.3	0.3
Heifers (1 to 2 years)	0.6	0.6
Heifers (2 to 3 years)	0.8	0.8
Cattle (over 3 years)	1.0	1.0
Selling Price ETB		
Price of milk sold to cooperatives (ETB/liter)	5.0	5.0
Price of milk sold to neighbors and cafeterias	7.0	7.0
Percentage of milk sold to neighbors and cafeterias	30.0%	30.0%
Percentage of milk sold to cooperatives	70.0%	70.0%
Price of culled cattle	10,000.00	9,000.00
Price of cow (for residual values calculation)	32,000.00	9,000.00
Price of heifers 2–3 years (due to culling)	7,000.00	5,000.00
Price of heifers 2–3 years (due to overstocking)	30,000.00	8,000.00
Price of male calves (12 months old)	5,000.00	4,000.00
Price of female calves (12 months old)	14,000.00	4,000.00

PROJECT MODELING

The purpose of this CBA was to determine whether these proposed interventions would yield benefits that would outweigh their costs and to measure (when applicable) the resulting increase in the incomes of the LMD households in the target woredas.

The financial and economic feasibility of the LMD dairy value chain interventions has been estimated using a cost-benefit model in which all revenues or resource inflows have been treated as inflows and all expenditures or resource outflows have been treated as outflows (Jenkins, Kuo and Harberger, 2012). The analysis was carried out for a 20-year time period.

The cash-flow statements in the financial analysis have been constructed from the total investment/project and equity's/household's points of view.

The total investment point of view determines the overall strength of the project. This point of view sees a project as an activity that generates tangible financial benefits and absorbs tangible financial resources. It disregards any distinction in the sources of finance but asks whether the financial receipts generated from the operations of the project are sufficient to cover the investment and operating expenditures and whether they provide a sufficient return.

The total investment point of view of the "with intervention" scenario also acts as a baseline scenario of the current CBA. It derives the financial and economic returns of the "shift from the indigenous breed toward cross-breeds" intervention as a result of improved productivity and competitiveness of the dairy value chain due to the LMD project. The total investment point of view calculates the financial and economic returns of the activity without any direct subsidy from USAID at the household level.

The owner of a project examines the incremental net cash flow from the investment relative to what could have been earned in the absence of the project. Unlike the total investment point of view, the owner adds the financial subsidy from USAID as a cash receipt. Therefore the difference between FNPV from the total investment point of view and equity/owner point of view of the "in-calf heifers provision" intervention in this case represents an increase in the wealth of the households due to the financial subsidy from the USAID.

The economic resource-flow statements have been constructed by adjusting each of the line items in the cash-flow statements of the total investment point of view by the corresponding economic conversion factors.

BASELINE INTERVENTION ANALYSIS (SHIFT FROM INDIGINEOUS BREED TOWARD CROSS-BREEDS)

It is necessary to estimate the benefits of the intervention on an incremental basis. One needs to distinguish between what would be earned by the household in its existing practice as opposed to what would be earned due to the intervention.

(a) "Without Intervention" Scenario (Case of traditional husbandry practice)

The smallholders of Ethiopia highlands usually do not keep more than one milking indigenous cow. The limited land holding does not allow the households to produce sufficient quantities of hay to feed more than one animal. The cow is usually fed by the grass available around the house, the crop residues, and very limited feed supplements, particularly wheat bran. The milk yield is usually not more than 1.5 liter per day. Such a small milk yield does not provide incentive for the

households to purchase concentrates. The households generally keep the cow as a draft power and for the calves' production.

The "without intervention" scenario assumes that the households will keep only one milking cow. They will raise heifers to 2 to 3 years of age to replace the culled cows and any milking cows that die in the herd. Any excess heifers after these replacements will be sold for slaughtering, as will the culled cattle. The male calves will be sold at age 12 months.

Revenue: The revenue for the households is the value of milk produced, whether it is sold or consumed at home. The annual milk yield per household is 414 liters/milking cow. The "without intervention" scenario assumes that there is 0 percent milk loss, which is very consistent with the field observations. Any excess milk is usually used to feed the calves. The households assume they will sell 70 percent of the milk to cooperatives at the price of ETB5.00 (US$0.28) and 30 percent to neighbors/cafeterias at ETB7.00 (US$0.39). This translates into ETB2,320 (US$128.89) per household per milking cow.

The other revenue items include sales of culled cattle, sales of male calves, and sales of heifers. The culling rate of cows for the "without intervention" scenario is reported to be 8 percent, which translates into 80 culled cows sold per 1,000 households. When sold at ETB9,000/head, this translates into ETB720.00 (US$40.00) per household. The sale of the 2- to 3-year-old heifers will generate revenues of ETB1,690.00 (US$93.89) per household starting in Year 3 of the evaluation period, when the newly born female calves in the first year will reach the age of heifers. The value of male calves sold is ETB1,470 (US$81.67) per household starting in Year 2 of the evaluation period, when the first male calves will be 12 months old.

The last revenue for the households would be the residual value of the herd and the animal shelter. The residual value is reported to be ETB15,610.00 (US$867.22) per household.

Expenditures: The expenditures are divided into two groups: input costs and operating costs. Input costs are the cost of the indigenous cows and the construction cost of the animal shelter. Operating costs include the feeding cost, the veterinary expenses, the cost of AI, the maintenance cost of the animal shelter, and the opportunity cost of the family labor.

The cost of an indigenous cow is reported to be ETB10,000.00 (US$555.55) per household in Year 1 of the evaluation period. In Year 2 of the evaluation period, 8 percent of the herd will be culled and 2 percent will die. The heifers, however, will not be ready to be transferred to the milking herd; hence the households will have to repurchase 10 percent of the herd, thus incurring an expense of ETB1,000 (US$55.55) per household. The construction cost per animal shelter is reported to be ETB100.00 (US$5.55) per household. This value represents the opportunity cost of family labor foregone due to the construction activity.

The main operating expense is the cost of feed. The households are assumed to purchase only 550 kg of hay to feed one milking cow. The cost of hay is reported to be ETB50.00 per 20 kg. This translates into ETB2,290.00 (US$127.22) per household per year starting in 2015, when the herd size will be stable. The hay that will be eaten by the animals around the house does not represent a cost to the households, because the opportunity cost of labor to collect and sell the hay will be above the market price.

The households will also provide wheat bran to improve the animals' nutrition and digestion. The quantity of wheat bran is reported to be 302 kg/animal/year. The current market price of wheat bran is ETB4.00/kg (US$0.22). This translates into ETB2,010.00/year (US$111.67), starting in 2015, when the herd size will be stable.

The maintenance cost of the animal shelter is assumed to be 10 percent of the construction cost per year, so it is equal to ETB10.00 (US$0.55) per household. The average veterinary expense is reported to be ETB20.00 (US$1.11)/animal/year. The households are assumed to use AI services and veterinary services from the government institutions. The government provides a large subsidy on the services, so households are assumed to minimize the operating cost. The cost of AI services is ETB4.00 (US$0.22). The average number of services per successful conception is reported to be 2.44 services/conception, which translates into ETB9.76 (US$0.54)/animal/year.

Table 2. Annual cash-flow statement from total investment point of view "without intervention" (real ETB mill/1,000 households)

Line Items	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Receipts																				
Market sales of milk to cooperatives	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45
Market sales of milk to neighbors/cafeterias	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87
Market sales of culled cows for slaughtering	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
Market sales of heifers 2-3 years culled for slaughtering	0.00	0.00	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Market sales of heifers 2-3 years for slaughtering	0.00	0.00	1.69	1.69	1.69	1.69	1.69	1.69	1.69	1.69	1.69	1.69	1.69	1.69	1.69	1.69	1.69	1.69	1.69	1.69
Market sales of male calves	0.00	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47
Residual value of herd																				15.61
Total inflows	3.04	4.51	6.26	6.26	6.26	6.26	6.26	6.26	6.26	6.26	6.26	6.26	6.26	6.26	6.26	6.26	6.26	6.26	6.26	21.87
Expenditures																				
Repurchase of Boran cattle	10.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feed Concentrates cost																				
Noug Seed Cake	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wheat bran	1.35	1.59	1.81	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.01
Other supplements	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Salt	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cost of hay	1.54	1.81	2.06	2.29	2.29	2.29	2.29	2.29	2.29	2.29	2.29	2.29	2.29	2.29	2.29	2.29	2.29	2.29	2.29	2.29
Veterinary Expenses																				
Average Veterinary Expense	0.03	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
AI cost	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Cost of Animal shelter																				
Construction cost of shelter	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maintenance cost of shelter per year	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Labor cost to milk cattle	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Labor cost - other activities	0.19	0.23	0.26	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
Total Outflows	13.38	4.83	4.33	4.80	4.80	4.80	4.80	4.80	4.80	4.80	4.80	4.80	4.80	4.80	4.80	4.80	4.80	4.80	4.80	4.80
Net Cash Flows	-10.34	-0.32	1.93	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	1.46	17.07
Net Cash Flows $US	-0.57	-0.02	0.11	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.95

NPV @12% discount rate ETB mill	**1.04 ETB**
NPV @12% discount rate $US mill	**0.06 USD**

The positive FNPV value of US$0.06 million/1,000 households or US$60.00/household suggests that currently the households are getting a normal return of 12 percent and a small amount above it.

(b) "With Intervention" Scenario (Case without fodder production)

The intervention in the dairy value chain will change the traditional animal husbandry practice. The households will start building a herd and producing a significant amount of milk. The annual milk production per 1,000 households is reported to be 3,435,294.12 liters starting in Year 1 of the intervention and constantly increasing along with the herd expansion. The households will purchase hay and concentrates to feed the animals. They also will spend more time taking care of the animals. The veterinary and AI expenses will increase, because the households will acquire timely services from the private providers. At some point in time, when the herd size will expand, the households will spend a full working day on the farm, so the intervention will eventually result in an increase in the full-time employment of the participating households. The details of the expenditures and revenues for the dairy farm establishment intervention with the hay production scenario are as follows:

Revenue: The revenue for the households is the value of milk produced, whether it is sold or consumed at home. The annual milk yield per household is 3,435.30 liters/cross-breed milking cow. The baseline scenario assumes that there is a 2.5 percent milk loss. The milk loss, in this case, is assumed to represent a complete loss of milk due to spoilage. In many cases, however, the milk spoilage may account for approximately 0 percent of the total crop yield. The households may only lose part of the value of milk produced due to the less-efficient milk-utilization methods. This assumption again is very consistent with the field observations. The dairy households sell milk to cooperatives, which produce butter and cheese and resell the skim milk and whey. Any excess of milk is usually either consumed at home or fed to calves. The households are assumed to sell 70 percent of the milk to cooperatives at a price of ETB5.00 (US$0.28) and 30 percent to neighbors/cafeterias at a price of ETB7.00 (US$0.39). The revenues from the sale of milk constantly increase along with increases in milk production due to the herd growth.

The other revenue items include the sales of culled cattle, sales of male calves, sales of culled 2- to 3-year-old heifers, and sales of 2- to 3-year-old heifers due to overstocking when the farm expansion limit of six milking cows[4] per household is reached. The annual production of milk, meat, and cross-breed heifers (due to overstocking) is reported in table 3, below.

The last revenue for the households will be the residual value of the herd and the animal shelter. The households will build a herd, so the residual value in this case will be very significant and reported to be ETB261,540.00 (US$14,530.00) per household in real terms.

Expenditures: The expenditures are divided into two groups: input costs and operating costs. Input costs are the cost of the cross-breed 7-month in-calf heifer and construction costs of the animal shelter. Operating costs include the feeding cost, the veterinary expenses, the cost of AI, the maintenance cost of the animal shelter, and the opportunity cost of family labor.

The cost of a 7-month in-calf heifer is reported to be ETB30,000.00 (US$1,666.67) per household in Year 1 of the evaluation period. The analysis assumes that 3 percent of the cows may die in Year 1 of the evaluation period, so the households will need to repurchase the cows. It is suggested, however, that the local implementers of the project take responsibility for the careful selection of the animals to minimize the risk associated with the death rate in Year 1 of the intervention. In Year 2 of the evaluation period, 5 percent of the herd will be culled. The adult death rate is reported to be 3 percent, so 3 percent of the animals will die. The heifers, however,

[4] Milking cows is a general category including currently milking cows as well as those that are on dry.

will not be ready yet to be transferred to the milking herd, so the households will have to repurchase 8 percent of the herd, thus occurring an expense of ETB2,400.00 (US$133.33) per household. The construction cost of an animal shelter is reported to be ETB400.00 (US$22.22)per household. This value represents the opportunity cost of the family labor foregone due to the construction activity.

The main operating expense is the cost of feed. The households will purchase 1,500 kg of hay/year to feed one milking cow. The cost of hay is reported to be ETB50.00 per 20 kg. This translates into ETB3,750.00 per household/year/milking cow (US$208.33).

The households will also feed wheat bran, noug seed cake, other feed supplements, and salt to the animals. The quantity of wheat bran is reported to be 365 kg/animal/year. The current market price of wheat bran is ETB4.00/kg (US$0.22). This translates into ETB1,460.00 (US$81.11)/year/milking cow. The quantity of noug seed cake is also reported to be 365 kg/year/milking cow. At the current market price of ETB7.00 (US$0.39), this translates into ETB2,555.00 (US$141.95)/year/milking cow. The annual cost of other feed supplements and salt is estimated at ETB2,730.00 (US$151.67)/milking cow and ETB25.00 (US$1.38)/milking cow, respectively. The maintenance cost of the animal shelter is assumed to be 10 percent of the construction cost per year. This is equal to ETB40.00 (US$2.22) per household. The average veterinary expense is reported to be ETB60.00 (US$3.33)/animal/year. The households are assumed to use AI services and veterinary services from the private providers. The cost of AI services is ETB120.00 (US$6.66)/service.

(c) "With Intervention" Scenario (Case with fodder production)

The revenues and expenditures of the scenario are the same as in the case of "without hay production" scenario, except for the cost of hay. It is suggested that the households produce fodder when it is possible to rent land for fodder production. The rental value of the land is reported to be ETB10,000 (US$555.55)/year/ha. The households would also need to hire labor to cut the grass. The cost of labor to cut the grass is reported to be ETB2,300.00 (US$ 127.78). The labor-based transportation cost of getting the hay from the field to the farm is also reported to be ETB2,300.00 (US$127.78). The additional labor expense of hay production activity is reported to be ETB300.00 (US$16.67). These additional labor activities include any other small activities to preserve grass for feeding. The interviews with the dairy farmers in the highlands of Ethiopia revealed that the households incurring the expenses may be able to harvest up to 12MT of hay/year because they could rent good quality land for the amount of ETB10,000.00 (US$555.55) per year and reap several harvests annually. The current analysis is built under the assumption that the households would be able to harvest 8MT/ha/year. The calculated cost of 20 kg of hay is reported to be ETB37.25 (US$2.07), compared to the market price of ETB50.00 (US$2.78). The analysis reveals that when the option is available, the households will be significantly better off by producing hay then by purchasing it from the market.

Table 3. Annual milk, meat, and cross-breed heifer production (due to overstocking)

Line Items	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Total milk production (mill liters)	3.35	3.35	3.35	4.22	4.78	5.28	6.00	6.80	7.66	8.64	9.76	10.99	12.38	13.96	15.73	17.72	19.97	20.10	20.10	20.10
Breeding cows culled (heads)	0.00	50.00	100.00	125.85	142.85	157.65	179.14	202.98	228.61	257.99	291.42	328.12	369.63	416.64	469.52	529.06	596.21	600.00	600.00	600.00
Heifers 2-3 years culled (heads)	0.00	0.00	34.92	29.99	29.99	37.74	42.37	46.75	53.13	60.20	67.04	75.65	85.46	96.22	108.39	122.18	137.68	155.14	174.83	175.94
Heifers 2-3 years sold (heads due to overstocking)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	718.70	945.95	1,164.98	1,177.36
Male Calves (heads)	0.00	450.00	386.47	386.47	486.37	545.95	602.48	684.63	775.75	863.87	974.91	1,101.24	1,239.90	1,396.75	1,574.43	1,774.24	1,999.24	2,252.96	2,267.29	2,267.29

PREPARATORY TABLES IN THE CBA EXCEL MODEL

In the CBA Excel model that accompanies this report, tables 2 to 8 display preparatory information about the LMD interventions, including the required loans and projected incomes and expenditures related to the project analysis.

Table 2 of the CBA model presents domestic inflation per production period. The analysis has been carried out on an annual basis. The annual inflation rate in Ethiopia is reported to be 20 percent. The domestic price index is used to adjust current prices to reflect the impact of inflation over the evaluation period. The expected exchange rate of the ETB to the US$ was derived by multiplying the current exchange rate by the relative price index. The relative price index, in turn, is the ratio of the price index of Ethiopia to that of United States.

Tables 3 through 10 are built to assess the “without intervention” scenario. One can refer to the CBA model (Excel file) for the details of the tables. The assessment of the “without intervention” scenario is required to calculate the incremental impact of the interventions.

Table 11 is the basis of the “with intervention” analysis. It presents the projected herd growth and quantity of animals under each category. The table is the basis for the annual production of milk, meat, calves, and heifers. The households are assumed to expand farm size until it reaches six milking cows/household. Table 11 shows a baseline of 1,000 households. The herd projection reveals that, without any additional purchase of cross-breed heifers, the farm expansion limit will be met by the year 2029. After this point, the households will sell the heifers that remain after the replacement of dead and culled milking cows. The production of milk, meat, calves, and heifers also stabilizes after the farm expansion limit is reached. Table 11 of the CBA model is presented below as table 4.

Table 4. Dairy farm herd projection ("With Intervention" Scenario)

Line Items	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Breeding cows																				
Opening Stock	1000.00	1000.00	1000.00	1258.49	1428.52	1576.45	1791.40	2029.83	2286.08	2579.93	2914.25	3281.17	3696.26	4166.45	4695.21	5290.65	5962.07	6000.00	6000.00	6000.00
- Death	30.00	30.00	30.00	37.75	42.86	47.29	53.74	60.89	68.58	77.40	87.43	98.44	110.89	124.99	140.86	158.72	178.86	180.00	180.00	180.00
- Culls	0.00	50.00	100.00	125.85	142.85	157.65	179.14	202.98	228.61	257.99	291.42	328.12	369.63	416.64	469.52	529.06	596.21	600.00	600.00	600.00
Subtotal	970.00	920.00	870.00	1094.88	1242.81	1371.52	1558.51	1765.95	1988.89	2244.54	2535.39	2854.62	3215.74	3624.81	4084.83	4602.86	5187.00	5220.00	5220.00	5220.00
+ Purchases for existing herd (End of the year)	30.00	80.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subtotal	1000.00	1000.00	870.00	1094.88	1242.81	1371.52	1558.51	1765.95	1988.89	2244.54	2535.39	2854.62	3215.74	3624.81	4084.83	4602.86	5187.00	5220.00	5220.00	5220.00
+ Heifer transfers	0.00	0.00	388.49	333.64	333.64	419.88	471.32	520.12	591.04	669.71	745.78	841.64	950.70	1070.40	1205.81	1359.20	1531.70	1725.95	1944.98	1957.36
Closing Stock	1000.00	1000.00	1258.49	1428.52	1576.45	1791.40	2029.83	2286.08	2579.93	2914.25	3281.17	3696.26	4166.45	4695.21	5290.65	5962.07	6718.70	6945.95	7164.98	7177.36
Female calves																				
Births	500.00	429.41	429.41	540.41	613.42	676.95	769.25	871.63	981.67	1107.85	1251.41	1408.97	1587.22	1789.12	2016.18	2271.87	2560.18	2576.47	2576.47	2576.47
- Deaths	50.00	42.94	42.94	54.04	67.48	74.46	84.62	95.88	117.80	132.94	150.17	169.08	190.47	214.69	241.94	272.62	307.22	309.18	309.18	309.18
Closing Stock	450.00	386.47	386.47	486.37	545.95	602.48	684.63	775.75	863.87	974.91	1101.24	1239.90	1396.75	1574.43	1774.24	1999.24	2252.96	2267.29	2267.29	2267.29
Heifers 1 -2 years																				
Opening Stock	0.00	450.00	386.47	386.47	486.37	545.95	602.48	684.63	775.75	863.87	974.91	1101.24	1239.90	1396.75	1574.43	1774.24	1999.24	2252.96	2267.29	2267.29
- Deaths	0.00	13.50	11.59	11.59	14.59	16.38	18.07	20.54	23.27	25.92	29.25	33.04	37.20	41.90	47.23	53.23	59.98	67.59	68.02	68.02
Closing Stock	0.00	436.50	374.88	374.88	471.78	529.57	584.41	664.09	752.48	837.95	945.66	1068.20	1202.70	1354.85	1527.19	1721.01	1939.27	2185.37	2199.28	2199.28
Heifers 2-3 years																				
Opening stock	0.00	0.00	436.50	374.88	374.88	471.78	529.57	584.41	664.09	752.48	837.95	945.66	1068.20	1202.70	1354.85	1527.19	1721.01	1939.27	2185.37	2199.28
- Deaths	0.00	0.00	13.10	11.25	11.25	14.15	15.89	17.53	19.92	22.57	25.14	28.37	32.05	36.08	40.65	45.82	51.63	58.18	65.56	65.98
- Culls	0.00	0.00	34.92	29.99	29.99	37.74	42.37	46.75	53.13	60.20	67.04	75.65	85.46	96.22	108.39	122.18	137.68	155.14	174.83	175.94
Subtotal	0.00	0.00	388.49	333.64	333.64	419.88	471.32	520.12	591.04	669.71	745.78	841.64	950.70	1070.40	1205.81	1359.20	1531.70	1725.95	1944.98	1957.36
Transfer to cows	0.00	0.00	388.49	333.64	333.64	419.88	471.32	520.12	591.04	669.71	745.78	841.64	950.70	1070.40	1205.81	1359.20	1531.70	1725.95	1944.98	1957.36
Male calves																				
Births	500.00	429.41	429.41	540.41	613.42	676.95	769.25	871.63	981.67	1107.85	1251.41	1408.97	1587.22	1789.12	2016.18	2271.87	2560.18	2576.47	2576.47	2576.47
- Deaths	50.00	42.94	42.94	54.04	67.48	74.46	84.62	95.88	117.80	132.94	150.17	169.08	190.47	214.69	241.94	272.62	307.22	309.18	309.18	309.18
Closing Stock	450.00	386.47	386.47	486.37	545.95	602.48	684.63	775.75	863.87	974.91	1101.24	1239.90	1396.75	1574.43	1774.24	1999.24	2252.96	2267.29	2267.29	2267.29
Male calves sold	0.00	450.00	386.47	386.47	486.37	545.95	602.48	684.63	775.75	863.87	974.91	1101.24	1239.90	1396.75	1574.43	1774.24	1999.24	2252.96	2267.29	2267.29
Total herd stock																				
Opening Stock	1000.00	1000.00	1000.00	1258.49	1428.52	1576.45	1791.40	2029.83	2286.08	2579.93	2914.25	3281.17	3696.26	4166.45	4695.21	5290.65	5962.07	6000.00	6000.00	6000.00
Closing Stock	1000.00	1000.00	1258.49	1428.52	1576.45	1791.40	2029.83	2286.08	2579.93	2914.25	3281.17	3696.26	4166.45	4695.21	5290.65	5962.07	6718.70	6945.95	7164.98	7177.36
Over - stocking	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	718.70	945.95	1164.98	1177.36
Balancing sales Heifers 2-3 years	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	718.70	945.95	1164.98	1177.36
Actual Closing	1000.00	1000.00	1258.49	1428.52	1576.45	1791.40	2029.83	2286.08	2579.93	2914.25	3281.17	3696.26	4166.45	4695.21	5290.65	5962.07	6000.00	6000.00	6000.00	6000.00
Herd composition																				
Breeding cows	1000.00	1000.00	1258.49	1428.52	1576.45	1791.40	2029.83	2286.08	2579.93	2914.25	3281.17	3696.26	4166.45	4695.21	5290.65	5962.07	6000.00	6000.00	6000.00	6000.00
Female calves	450.00	386.47	386.47	486.37	545.95	602.48	684.63	775.75	863.87	974.91	1101.24	1239.90	1396.75	1574.43	1774.24	1999.24	2252.96	2267.29	2267.29	2267.29
Heifers 1-2 years	0.00	436.50	374.88	374.88	471.78	529.57	584.41	664.09	752.48	837.95	945.66	1068.20	1202.70	1354.85	1527.19	1721.01	1939.27	2185.37	2199.28	2199.28
Heifers 2-3 years	0.00	0.00	388.49	333.64	333.64	419.88	471.32	520.12	591.04	669.71	745.78	841.64	950.70	1070.40	1205.81	1359.20	1531.70	1725.95	1944.98	1957.36
Male calves	450.00	386.47	386.47	486.37	545.95	602.48	684.63	775.75	863.87	974.91	1101.24	1239.90	1396.75	1574.43	1774.24	1999.24	2252.96	2267.29	2267.29	2267.29
Total animal	1900.00	2209.44	2794.79	3109.77	3473.77	3945.81	4454.82	5021.80	5651.19	6371.72	7175.09	8085.89	9113.35	10269.32	11572.13	13040.76	13976.88	14445.91	14678.84	14691.22
Herd composition (unit based)																				
Breeding cows	1000.00	1000.00	1258.49	1428.52	1576.45	1791.40	2029.83	2286.08	2579.93	2914.25	3281.17	3696.26	4166.45	4695.21	5290.65	5962.07	6000.00	6000.00	6000.00	6000.00
Female calves	135.00	115.94	115.94	145.91	163.78	180.75	205.39	232.73	259.16	292.47	330.37	371.97	419.03	472.33	532.27	599.77	675.89	680.19	680.19	680.19
Heifers 1-2 years	0.00	261.90	224.93	224.93	283.07	317.74	350.65	398.45	451.49	502.77	567.40	640.92	721.62	812.91	916.32	1032.61	1163.56	1311.22	1319.57	1319.57
Heifers 2-3 years	0.00	0.00	310.79	266.91	266.91	335.90	377.05	416.10	472.83	535.77	596.62	673.31	760.56	856.32	964.65	1087.36	1225.36	1380.76	1555.98	1565.88
Male calves	135.00	115.94	115.94	145.91	163.78	180.75	205.39	232.73	259.16	292.47	330.37	371.97	419.03	472.33	532.27	599.77	675.89	680.19	680.19	680.19
Total animal units	1270.00	1493.78	2026.08	2212.18	2454.00	2806.53	3168.31	3566.08	4022.57	4537.73	5105.94	5754.43	6486.68	7309.10	8236.16	9281.58	9740.69	10052.36	10235.93	10245.83

Table 12 of the CBA model presents the residual value of the herd in nominal terms at the end of the evaluation period. The residual value of the herd is derived by multiplying herd composition (see table 4, above) at the end of the evaluation period by the corresponding prices of the animals.

Table 13 depicts the total annual production of milk, meat, male calves, and cross-breed heifers.[5] The analysis assumes that the male calves will be sold at the age of 1 year. Table 14 presents the nominal value of production. The value is derived by multiplying the total quantity produced by the corresponding price.

Table 15 depicts the projected inputs and operating costs. The households will purchase cross-breed heifers at Year 1 of the project as part of the investment and again in Year 2 of the project to replace culled or dead animals. The feed cost is a function of the herd size. The coefficients to represent different groups of the animals are presented in the section "Technical Coefficients," above. The cost of labor is calculated on the daily basis. At some point, due to the increased number of the animals, the households may need to hire additional labor to perform certain activities.

FINANCIAL ANALYSIS

The modeling exercise has been constructed for the 20-year evaluation period. The incremental FNPVs are calculated using a 12 percent real discount rate.

The "without intervention" scenario yields a positive FNPV of ETB1.04 million/1,000 households (US$0.06 million) using 12 percent real financial discount rate. The positive FNPV suggest that the households will get returns above the financial discount rate of 12 percent. The FNPV per household is equal to ETB1,041.66 (US$57.87).

The figures provided in table 5, below, are estimated under the assumption that the specific targets presented in the "Interventions" section above would be achieved by LMD project. The outcomes of Interventions 2, 3, 4, and 6 described in table 6, below, would benefit the households that switch from the indigenous breed dairy cattle to the cross-breed cattle as well as those that are already using cross-breed dairy cattle.

Table 5. Incremental FNPVs and ENPVs of the interventions (US$ million/1,000 households)

Intervention	FNPV
1. Shift from the indigenous breed toward cross-breeds	US$2.01
2. Improved veterinary services	US$0.49
3. Improved AI services	US$2.88
4. Access to sexed semen	US$3.85
5. Provision of in-calf cross-breed heifers	US$3.23
6. Improved access to the low-cost feed concentrates	US$2.36
7. Fodder production	US$1.64

Tables 21 and 24 of the CBA model are constructed to assess the incremental impact of the baseline intervention. Table 21 presents the incremental cash-flow statement for the "shift from the indigenous breed toward cross-breeds" intervention. Table 24 presents the incremental cash-flow statement for the "shift from the indigenous breed toward cross-breeds" intervention, including fodder production. The difference between FNPVs of these two scenarios represents the FNPV of the "fodder production" intervention itself and is equal to US$1.64 million/1,000 households.

[5] Cross-breed heifers ages 2–3 years will be sold in the market only after the farm expansion limit is reached.

Table 6. Incremental annual cash-flow statement "without fodder production" case (total investment point of view, real ETB/1,000 households)

Line Items		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
	Receipts																				
Market sales of milk to cooperatives		10.27	10.27	10.27	13.30	15.30	17.03	19.55	22.35	25.35	28.80	32.71	37.02	41.88	47.39	53.59	60.57	68.44	68.89	68.89	68.89
Market sales of milk to neighbors/cafeterias		6.16	6.16	6.16	7.98	9.18	10.22	11.73	13.41	15.21	17.28	19.63	22.21	25.13	28.44	32.16	36.34	41.07	41.33	41.33	41.33
Market sales of culled cows for slaughtering		-0.72	-0.22	0.28	0.54	0.71	0.86	1.07	1.31	1.57	1.86	2.19	2.56	2.98	3.45	3.98	4.57	5.24	5.28	5.28	5.28
Market sales of heifers 2-3 years culled for slaughtering		0.00	0.00	0.18	0.14	0.14	0.20	0.23	0.26	0.31	0.36	0.40	0.46	0.53	0.61	0.69	0.79	0.90	1.02	1.16	1.17
Market sales of heifers 2-3 years (due to overstocking)		0.00	0.00	-1.69	-1.69	-1.69	-1.69	-1.69	-1.69	-1.69	-1.69	-1.69	-1.69	-1.69	-1.69	-1.69	-1.69	19.87	26.69	33.26	33.63
Market sales of male calves		0.00	0.78	0.46	0.46	0.96	1.26	1.54	1.95	2.41	2.85	3.40	4.04	4.73	5.51	6.40	7.40	8.53	9.80	9.87	9.87
Residual value of herd		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	245.93
Total inflows		15.72	17.00	15.67	20.74	24.60	27.88	32.44	37.59	43.15	49.45	56.66	64.60	73.56	83.71	95.13	107.99	144.05	153.01	159.79	406.10
	Expenditures																				
Repurchase of Cross-breed cattle		20.90	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feed Concentrates cost																					
Noug Seed Cake		3.24	3.82	5.18	5.65	6.27	7.17	8.10	9.11	10.28	11.59	13.05	14.70	16.57	18.67	21.04	23.71	24.89	25.68	26.15	26.18
Wheat bran		0.50	0.59	1.15	1.22	1.57	2.08	2.61	3.19	3.86	4.61	5.44	6.39	7.46	8.66	10.01	11.54	12.21	12.66	12.93	12.94
Other supplements		3.47	4.08	5.53	6.04	6.70	7.66	8.65	9.74	10.98	12.39	13.94	15.71	17.71	19.95	22.48	25.34	26.59	27.44	27.94	27.97
Salt		0.03	0.04	0.05	0.06	0.06	0.07	0.08	0.09	0.10	0.11	0.13	0.14	0.16	0.18	0.21	0.23	0.24	0.25	0.26	0.26
Cost of hay		3.22	3.79	5.54	6.00	6.91	8.23	9.59	11.08	12.79	14.72	16.85	19.29	22.03	25.12	28.59	32.51	34.23	35.40	36.09	36.13
Veterinary Expenses																					
Average Veterinary Expense		0.08	0.09	0.12	0.14	0.16	0.19	0.22	0.25	0.29	0.33	0.38	0.44	0.50	0.57	0.65	0.73	0.79	0.82	0.83	0.83
AI cost		0.23	0.23	0.23	0.29	0.33	0.37	0.42	0.48	0.54	0.61	0.69	0.78	0.88	0.99	1.12	1.26	1.42	1.43	1.43	1.43
Cost of Animal shelter																					
Construction cost of shelter		0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maintenance cost of shelter per year		0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Labor cost to milk cattle		0.59	0.43	0.43	0.58	0.68	0.76	0.88	1.02	1.17	1.33	1.53	1.73	1.97	2.24	2.54	2.88	3.26	3.29	3.29	3.29
Labor cost - other activities		0.95	0.91	0.88	1.15	1.34	1.51	1.76	2.03	2.32	2.66	3.04	3.46	3.93	4.47	5.07	5.75	6.52	6.56	6.56	6.56
Total Outflows		33.54	15.41	19.14	21.16	24.05	28.08	32.34	37.02	42.36	48.40	55.07	62.67	71.24	80.88	91.74	103.99	110.19	113.57	115.51	115.62
Net Cash Flows		-17.83	1.59	-3.47	-0.41	0.55	-0.20	0.10	0.57	0.80	1.05	1.58	1.93	2.32	2.83	3.39	4.00	33.86	39.44	44.28	290.48
Net Cash Flows $US		-0.99	0.09	-0.19	-0.02	0.03	-0.01	0.01	0.03	0.04	0.06	0.09	0.11	0.13	0.16	0.19	0.22	1.88	2.19	2.46	16.14
NPV @12% discount rate EIB mill	**36.27 EIB**																				
NPV @12% discount rate $US mill	**2.01 USD**																				

Table 7. Incremental annual cash-flow statement "with fodder production" case (total investment point of view, real ETB/1,000 households)

Line Items		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
	Receipts																				
Market sales of milk to cooperatives		10.27	10.27	10.27	13.30	15.30	17.03	19.55	22.35	25.35	28.80	32.71	37.02	41.88	47.39	53.59	60.57	68.44	68.89	68.89	68.89
Market sales of milk to neighbors/cafeterias		6.16	6.16	6.16	7.98	9.18	10.22	11.73	13.41	15.21	17.28	19.63	22.21	25.13	28.44	32.16	36.34	41.07	41.33	41.33	41.33
Market sales of culled cows for slaughtering		-0.72	-0.22	0.28	0.54	0.71	0.86	1.07	1.31	1.57	1.86	2.19	2.56	2.98	3.45	3.98	4.57	5.24	5.28	5.28	5.28
Market sales of heifers 2-3 years culled for slaughtering		0.00	0.00	0.18	0.14	0.14	0.20	0.23	0.26	0.31	0.36	0.40	0.46	0.53	0.61	0.69	0.79	0.90	1.02	1.16	1.17
Market sales of heifers 2-3 years (due to overstocking)		0.00	0.00	-1.69	-1.69	-1.69	-1.69	-1.69	-1.69	-1.69	-1.69	-1.69	-1.69	-1.69	-1.69	-1.69	-1.69	19.87	26.69	33.26	33.63
Market sales of male calves		0.00	0.78	0.46	0.46	0.96	1.26	1.54	1.95	2.41	2.85	3.40	4.04	4.73	5.51	6.40	7.40	8.53	9.80	9.87	9.87
Residual value of herd																					245.93
Total inflows		**15.72**	**17.00**	**15.67**	**20.74**	**24.60**	**27.88**	**32.44**	**37.59**	**43.15**	**49.45**	**56.66**	**64.60**	**73.56**	**83.71**	**95.13**	**107.99**	**144.05**	**153.01**	**159.79**	**406.10**
	Expenditures																				
Repurchase of Cross-breed cattle		20.90	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feed Concentrates cost																					
Noug Seed Cake		3.24	3.82	5.18	5.65	6.27	7.17	8.10	9.11	10.28	11.59	13.05	14.70	16.57	18.67	21.04	23.71	24.89	25.68	26.15	26.18
Wheat bran		0.50	0.59	1.15	1.22	1.57	2.08	2.61	3.19	3.86	4.61	5.44	6.39	7.46	8.66	10.01	11.54	12.21	12.66	12.93	12.94
Other supplements		3.47	4.08	5.53	6.04	6.70	7.66	8.65	9.74	10.98	12.39	13.94	15.71	17.71	19.95	22.48	25.34	26.59	27.44	27.94	27.97
Salt		0.03	0.04	0.05	0.06	0.06	0.07	0.08	0.09	0.10	0.11	0.13	0.14	0.16	0.18	0.21	0.23	0.24	0.25	0.26	0.26
Cost of hay		2.01	2.36	3.60	3.89	4.56	5.55	6.56	7.67	8.95	10.38	11.97	13.78	15.83	18.13	20.72	23.64	24.92	25.79	26.30	26.33
Veterinary Expenses																					
Average Veterinary Expense		0.08	0.09	0.12	0.14	0.16	0.19	0.22	0.25	0.29	0.33	0.38	0.44	0.50	0.57	0.65	0.73	0.79	0.82	0.83	0.83
AI cost		0.23	0.23	0.23	0.29	0.33	0.37	0.42	0.48	0.54	0.61	0.69	0.78	0.88	0.99	1.12	1.26	1.42	1.43	1.43	1.43
Cost of Animal shelter																					
Construction cost of shelter		0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maintenance cost of shelter per year		0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Labor cost to milk cattle		0.59	0.43	0.43	0.58	0.68	0.76	0.88	1.02	1.17	1.33	1.53	1.73	1.97	2.24	2.54	2.88	3.26	3.29	3.29	3.29
Labor cost - other activities		0.95	0.91	0.88	1.15	1.34	1.51	1.76	2.03	2.32	2.66	3.04	3.46	3.93	4.47	5.07	5.75	6.52	6.56	6.56	6.56
Total Outflows		32.33	13.98	17.21	19.04	21.71	25.40	29.31	33.61	38.51	44.06	50.19	57.16	65.04	73.89	83.87	95.11	100.87	103.95	105.72	105.82
Net Cash Flows		-16.61	3.02	-1.54	1.70	2.90	2.48	3.13	3.98	4.64	5.39	6.47	7.44	8.52	9.82	11.27	12.88	43.18	49.05	54.07	300.28
Net Cash Flows $US		-0.92	0.17	-0.09	0.09	0.16	0.14	0.17	0.22	0.26	0.30	0.36	0.41	0.47	0.55	0.63	0.72	2.40	2.73	3.00	16.68
NPV @12% discount rate EIB mill	**65.93 EIB**																				
NPV @12% discount rate $US mill	**3.66 USD**																				

The FNPVs of the “provision of in-calf cross-breed heifers” intervention and “provision of in-calf cross-breed heifers” together with fodder production are presented in tables 27 and 28 of the CBA model, respectively.

The FNPVs of the “improved veterinary services,” “improved AI service,” “access to sexed semen,” and “improved access to low-cost feed concentrates” interventions are calculated on the incremental basis if the current situation of the dairy sector would improve due to the LMD project. The FNPVs are calculated as a difference between the FNPVs of the improved situation and the baseline analysis.

FINDINGS

Financial Analysis

The financial analysis performed for the baseline ("shift from the indigenous breed toward cross-breeds" intervention) LMD intervention in the dairy value chain yields a positive FNPV of ETB36.27 million (US$2.01 million)/1,000 households for the "without fodder production" and FNPV of ETB65.93 million (US$3.66 million)/1,000 households for the "with fodder production" case using a real discount rate of 12 percent. These positive FNPVs suggest that the production would be sustainable, because over the life of the project, the financial benefits would outweigh the financial costs for the targeted households.

The incremental FNPV of the "fodder production" intervention of US$1.64 million suggests that the households should be instructed to rent land and produce hay/fodder. The annual net cash flows are significantly higher when households produce hay rather than buy it. The households producing hay will also be more independent of the market availability of hay. The required land, however, will not be available for rent in every case.

The positive FNPV of the "in-calf cross-breed heifers provision" intervention suggests that the households would benefit from the intervention. To enable the households, USAID will need to provide a financial subsidy, thus minimizing the initial investment cost for the households.

A loan-based enabling mechanism is not recommended for two reasons:

- The financial analysis reveals that the households will not have sufficient cash flow during the first years of the intervention to be able to repay the loan.
- The required financial subsidy is reported to be ETB21,814.00 (US$1,211.90) per household. This amount is above the maximum amount available for the new clients of the Microfinance Institutions (MFIs) operating in Ethiopia. The maximum amount of a MFI-sourced loan is ETB4,000 (US$222.22), which is much below the required financial subsidy.

The annual increase in the income of the targeted households is defined by the sum of the net annual cash flow and the opportunity cost of the labor. The projected annual increase in income is presented in table 8, below.

Table 8. Annual increase in the income of the households, including opportunity cost of family labor (in US$)

Year	(A) "Shift from the indigenous breed toward cross-breeds" intervention	(B) "Shift from the indigenous breed toward cross-breeds" intervention + fodder production	(C) Fodder production (incremental B-A)
2012	–886.63	–819.17	67.47
2013	164.84	244.20	79.36
2014	–118.06	–10.42	107.64
2015	74.92	192.44	117.52
2016	144.49	274.86	130.37
2017	116.84	265.94	149.10
2018	154.26	322.58	168.32
2019	202.94	392.39	189.45
2020	239.68	453.38	213.70
2021	282.04	523.10	241.07
2022	343.27	614.52	271.25
2023	397.51	703.21	305.70
2024	458.51	803.12	344.60
2025	531.56	919.86	388.30
2026	612.81	1,050.36	437.55
2027	703.40	1,196.49	493.08
2028	2,426.31	2,943.78	517.47
2029	2,739.74	3,273.77	534.03
2030	3,008.37	3,552.16	543.78
2031	16,686.45	17,230.76	544.31

The incremental annual family income cash flows are positive for all years except 2014. The positive values suggest that when treating opportunity cost of family labor as a part of the family income, the households are significantly better off with this type of intervention. In 2028, when the farm expansion limit is met, the households' net cash flows will increase significantly as the households start selling the cross-breed heifers. This is an important finding of the analysis, because it shows that the interventions will result in the households' having significantly higher annual incomes in the long run. The negative incremental net family income in 2014 arises because at this point in time, the number of calves and heifers in the farm will increase and they will need to be fed, yet the milk production will still be limited to one milking cow.

Column C of table 8 presents the increase in the households' income, including opportunity cost of labor, for the "fodder production" intervention. If the LMD project would enable the households that previously could not participate in fodder production to start production, the annual income of the dairy farmers would be higher by the amount presented in column C. The fodder in this analysis is assumed to be any kind of fodder that is nutritionally similar to hay, or hay itself. Producing improved varieties of fodder may result in a significantly higher increase in the annual income of the targeted households.

One of the main assumptions of this analysis is that the households will expand the dairy farm's size until it reaches six cross-breed milking cows per household. This means that the households will be making a long-term investment. Table 9, below, presents the FNPV that results if this assumption is changed.

Table 9. Incremental FNPVs of the baseline intervention under different dairy farm expansion limits (US$ million/1,000 households)

Expansion limit (milking cross-breed cows)	FNPV (without fodder production)	FNPV (with fodder production)
1	1.55	2.28
2	1.83	2.98
3	1.96	3.33
4	2.01	3.51
5	2.03	3.62
6	2.01	3.66

The FNPV increases along with the farm expansion limit, suggesting that financial returns to the households would be higher if the households do not sell cross-breed heifers before the maximum herd size of six is reached. This finding is again consistent with the field observations. In Ethiopia, sale of a milking cross-breed cow is a cultural taboo. The households will sell cross-breed cows only if they are faced with serious cash shortages or when the cows are no longer productive. This finding reveals a financial rationale behind this cultural taboo.

However, the financial analysis reveals that the net annual cash flows increase as farm expansion limit decreases, until the expansion limit is reached[6]. This finding shows that there is a trade-off between lower short-term returns and higher long-term returns. This important conclusion suggests that the intervention is suitable for achieving different goals, such as improving the annual income of the households and increasing competitiveness and efficiency of the value chain in the long run. The households probably will choose a mix of interventions, selling the animals when they are short of cash but keeping the animals otherwise. The annual net cash-flow statements under each expansion limit are presented in tables 10 and 11, below.

[6] For instance the net annual cash flows of the farm with the expansion limit of one dairy cow are significantly higher than the net cash flows of a farm with expansion limit of 6 cows, due to the sale of heifers, until the expansion limit of the farm with 6 dairy cows will be reached. After that point the net cash flows of the farm with expansion limit of 6 cows would be significantly above the other farm.

Table 10. Incremental net annual cash flows of the baseline intervention under different dairy farm expansion limits without fodder production, excluding opportunity cost of family labor (US$ million/1,000 households)

Farm Expansion Limit	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*2025*	*2026*	*2027*	*2028*	*2029*	*2030*	*2031*
1	0.22	0.09	0.39	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	1.92
2	0.22	0.09	-0.19	-0.02	0.03	-0.01	0.07	0.61	0.69	0.78	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	4.76
3	0.22	0.09	-0.19	-0.02	0.03	-0.01	0.01	0.03	0.04	0.06	0.72	1.03	1.16	1.20	1.20	1.20	1.20	1.20	1.20	7.60
4	0.22	0.09	-0.19	-0.02	0.03	-0.01	0.01	0.03	0.04	0.06	0.09	0.11	0.50	1.34	1.50	1.62	1.62	1.62	1.62	10.45
5	0.22	0.09	-0.19	-0.02	0.03	-0.01	0.01	0.03	0.04	0.06	0.09	0.11	0.13	0.16	0.84	1.72	1.93	2.05	2.05	13.29
6	0.22	0.09	-0.19	-0.02	0.03	-0.01	0.01	0.03	0.04	0.06	0.09	0.11	0.13	0.16	0.19	0.22	1.88	2.19	2.46	16.14

Table 11. Incremental net annual cash flows of the baseline intervention under different dairy farm expansion limits with fodder production, excluding opportunity cost of family labor (US$ million/1,000 households)

Farm Expansion Limit	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*	*2024*	*2025*	*2026*	*2027*	*2028*	*2029*	*2030*	*2031*
1	0.29	0.17	0.48	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	2.01
2	0.29	0.17	-0.09	0.09	0.16	0.14	0.24	0.78	0.87	0.96	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	4.94
3	0.29	0.17	-0.09	0.09	0.16	0.14	0.17	0.22	0.26	0.30	0.98	1.29	1.43	1.47	1.47	1.47	1.47	1.47	1.47	7.88
4	0.29	0.17	-0.09	0.09	0.16	0.14	0.17	0.22	0.26	0.30	0.36	0.41	0.84	1.69	1.86	1.99	1.99	1.99	1.99	10.81
5	0.29	0.17	-0.09	0.09	0.16	0.14	0.17	0.22	0.26	0.30	0.36	0.41	0.47	0.55	1.27	2.16	2.38	2.50	2.50	13.75
6	0.29	0.17	-0.09	0.09	0.16	0.14	0.17	0.22	0.26	0.30	0.36	0.41	0.47	0.55	0.63	0.72	2.40	2.73	3.00	16.68

To properly explain the information provided in tables 10 and 11, several important points need to be made:

- The analysis has been done under the assumption that the households will keep female calves until they are 2–3 years old, when they are ready to be transferred to the milking herd. This will allow the households to replace the culled and dead milking cross-breed cows without purchasing additional animals. Once the farm expansion limit is reached and necessary replacements of the culled and dead animals have been made, the households will sell the rest of the heifers.
- The "without" scenario limit is built under the assumption that the households will sell both male and female calves, so the farm expansion is limited to one indigenous milking cow. This assumption is consistent with the field observations in the highlands of Ethiopia. The households do not expand the number of cattle they keep, because the primary purpose of keeping the animals is not for milk production. Cows are usually kept for calf production and as draft power. Expanding the farm size will require the purchase of feed, which is not financially sustainable when taking into consideration the very low milk production of the indigenous breeds.
- The net cash flows are calculated on the incremental basis. The negative net cash flows in tables 10 and 11 (in 2014) do not represent a real decrease in the income of the households, but a difference of what could be earned under the "without" scenario. At this point in time, in the "without intervention" scenario, the households will sell heifers and hence derive income from the sale. Under the "with intervention" scenario, the households will keep the heifers, so they will not realize any income from the sale of the animals. The total wealth of the households in the "with intervention" scenario, however, will increase, because the cross-breed heifers will fetch a market price much above that of the local breeds.
- Raising the cross-breed heifers will take 2–3 years, so increasing the farm expansion limit by one milking cow would result in a decrease in the net cash flows for 3 years, because the heifers will consume feed but would not produce milk. Keeping the heifers, however, will increase the total wealth of the households, as demonstrated by the higher FNPVs presented in table 9, above.
- The significant increase in the net cash flow in the last year of the project (2031) represents the residual value of the herd.

Economic Analysis

Differences emerge between the financial and economic outcomes due to the fact that the financial values do not include all the externalities that are present in the economy. In this case, the only externality would come from increased tax revenues. These taxes come either directly from the taxation of inputs or indirectly via the FEP. Dairy products are importable to Ethiopia. The intervention will increase the local supply of milk, thereby replacing part of the dairy imports. The intervention will also increase meat production (via culled animals and male calves). Meat is an exportable commodity in Ethiopia. The FEP for Ethiopia is estimated to be 6.5 percent (Kuo, 2011). Hence, every incremental unit of foreign exchange (dollars) earned from increased exports, or saved from reduced imports, would have an economic value to the country of 1.065 times the value of the revenues by the exporters when exchanging the foreign exchange for local currency at the market exchange rate.

To show the true economic impact of the proposed interventions on the Ethiopian economy, the economic values have been derived by adjusting the financial values by the appropriate economic conversion factors. If no distortions were present in the market, then the financial value of an item has been used to measure its economic value.[7]

The difference between the financial and economic outcomes of the project developed because of several factors. In the case of milk, for instance, the only externality it presents is the FEP. In the case of meat, however, a substantial transportation cost is incurred to export it from the country to the market. Ethiopia applies a high tariff rate and other taxes on the imports of fuel that increase its financial cost. Taxes, in turn, are just a transfer of resources from consumers to the government. At the same time, fuel is internationally traded and requires foreign exchange that has an economic cost to the economy that is 6.5 percent greater than its financial cost. Overall, the economic cost of fuel is below its financial cost. Every incremental dollar spent on the fuel required to transport meat for export has an economic cost of 79 percent of its financial cost. These figures also added to the difference between the financial and economic outcomes of the intervention.

The USAID subsidy in the case of the "in-calf heifers provision intervention" is a transfer of financial resources from USAID to the targeted households. The transfer of resources does not represent an economic resource flow. The conversion factor is 0 for the subsidy.

The ENPVs of the analyzed interventions are presented in table 12, below.

Table 12. Incremental ENPVs of the interventions (US$ million/1,000 households)

Intervention	ENPV
1. Shift from the indigenous breed toward cross-breeds	US$2.84
2. Improved veterinary services	US$0.56
3. Improved AI services	US$3.14
4. Access to sexed semen	US$4.36
5. Provision of in-calf cross-breed heifers	US$2.84
6. Improved access to the low-cost feed concentrates	US$2.51
7. Fodder production	US$1.65

[7] The list of CFs used for the purpose of this analysis is presented in table A in the appendix.

Tables 12 and 13 depict a resource-flow statement from the economy's point of view of the baseline intervention for the "without fodder production" case and "with fodder production" case, respectively.

Table 12. Economy resource-flow statement "without fodder production" (economy point of view, real ETB million/1,000 households)

Line Items		CF	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
	Receipts																					
Market sales of milk to cooperatives		**1.07**	10.94	10.94	10.94	14.17	16.29	18.14	20.82	23.80	27.00	30.67	34.84	39.42	44.60	50.47	57.08	64.51	72.89	73.37	73.37	73.37
Market sales of milk to neighbors/cafeterias		**1.07**	6.57	6.57	6.57	8.50	9.78	10.88	12.49	14.28	16.20	18.40	20.90	23.65	26.76	30.28	34.25	38.71	43.74	44.02	44.02	44.02
Market sales of culled cows for slaughtering		**1.10**	-0.79	-0.24	0.31	0.59	0.78	0.94	1.18	1.44	1.72	2.05	2.41	2.82	3.27	3.79	4.37	5.03	5.76	5.81	5.81	5.81
Market sales of heifers 2-3 years culled for slaughtering		**1.10**	0.00	0.00	0.20	0.16	0.16	0.22	0.25	0.29	0.34	0.39	0.44	0.51	0.59	0.67	0.76	0.87	0.99	1.12	1.27	1.28
Market sales of heifers 2-3 years (due to overstocking)		**1.04**	0.00	0.00	-1.76	-1.76	-1.76	-1.76	-1.76	-1.76	-1.76	-1.76	-1.76	-1.76	-1.76	-1.76	-1.76	-1.76	20.70	27.80	34.64	35.02
Market sales of male calves		**1.10**	0.00	0.86	0.51	0.51	1.06	1.39	1.70	2.15	2.65	3.13	3.74	4.44	5.20	6.06	7.04	8.14	9.38	10.77	10.85	10.85
Residual value of herd		**1.05**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	257.05
USAID Subsidy for initial investment		**0**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total inflows			16.72	18.12	16.76	22.17	26.31	29.81	34.69	40.20	46.15	52.88	60.59	69.08	78.67	89.52	101.74	115.49	153.45	162.88	169.95	427.40
	Expenditures																					
Purchase of Cross-breed cattle		**1.04**	21.76	1.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feed Concentrates cost																						
Noug Seed Cake		**1.08**	3.49	4.11	5.57	6.09	6.75	7.72	8.72	9.81	11.07	12.48	14.05	15.83	17.85	20.11	22.66	25.53	26.80	27.65	28.16	28.19
Wheat bran		**1.08**	0.54	0.64	1.24	1.32	1.70	2.26	2.83	3.46	4.18	4.99	5.89	6.92	8.07	9.37	10.84	12.49	13.22	13.71	14.00	14.02
Other supplements		**1.00**	3.47	4.08	5.53	6.04	6.70	7.66	8.65	9.74	10.98	12.39	13.94	15.71	17.71	19.95	22.48	25.34	26.59	27.44	27.94	27.97
Salt		**0.76**	0.02	0.03	0.04	0.04	0.05	0.05	0.06	0.07	0.08	0.09	0.10	0.11	0.12	0.14	0.16	0.18	0.19	0.19	0.20	0.20
Cost of hay		**1.00**	3.22	3.79	5.54	6.00	6.91	8.23	9.59	11.08	12.79	14.72	16.85	19.29	22.03	25.12	28.59	32.51	34.23	35.40	36.09	36.13
Veterinary Expenses																						
Average Veterinary Expense		**1.32**	0.11	0.12	0.16	0.18	0.21	0.25	0.29	0.34	0.38	0.44	0.51	0.58	0.66	0.75	0.85	0.97	1.04	1.08	1.10	1.10
AI cost		**1.14**	0.26	0.26	0.26	0.33	0.38	0.42	0.48	0.55	0.62	0.70	0.79	0.89	1.00	1.13	1.28	1.44	1.63	1.64	1.64	1.64
Cost of Animal shelter																						
Construction cost of shelter		**1.00**	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maintenance cost of shelter per year		**1.00**	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Labor cost to milk cattle		**1.00**	0.59	0.43	0.43	0.58	0.68	0.76	0.88	1.02	1.17	1.33	1.53	1.73	1.97	2.24	2.54	2.88	3.26	3.29	3.29	3.29
Labor cost - other activities		**1.00**	0.95	0.91	0.88	1.15	1.34	1.51	1.76	2.03	2.32	2.66	3.04	3.46	3.93	4.47	5.07	5.75	6.52	6.56	6.56	6.56
Total Outflows			34.75	15.86	19.70	21.76	24.75	28.90	33.29	38.11	43.61	49.83	56.72	64.54	73.38	83.31	94.50	107.13	113.51	116.99	119.00	119.11
Net Cash Flows			-18.04	2.26	-2.94	0.41	1.55	0.91	1.40	2.09	2.53	3.05	3.87	4.54	5.29	6.21	7.23	8.37	39.95	45.89	50.95	308.29
Net Cash Flows $US			-1.00	0.13	-0.16	0.02	0.09	0.05	0.08	0.12	0.14	0.17	0.22	0.25	0.29	0.35	0.40	0.46	2.22	2.55	2.83	17.13
NPV @12% discount rate EIB mill	**51.17 EIB**																					
NPV @12% discount rate $US mill	**2.84 USD**																					

Table 13. Economy resource-flow statement "with fodder production" (economy point of view, real ETB million/1,000 households)

Line Items		CF	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
	Receipts																					
Market sales of milk to cooperatives		**1.07**	10.94	10.94	10.94	14.17	16.29	18.14	20.82	23.80	27.00	30.67	34.84	39.42	44.60	50.47	57.08	64.51	72.89	73.37	73.37	73.37
Market sales of milk to neighbors/cafeterias		**1.07**	6.57	6.57	6.57	8.50	9.78	10.88	12.49	14.28	16.20	18.40	20.90	23.65	26.76	30.28	34.25	38.71	43.74	44.02	44.02	44.02
Market sales of culled cows for slaughtering		**1.10**	-0.79	-0.24	0.31	0.59	0.78	0.94	1.18	1.44	1.72	2.05	2.41	2.82	3.27	3.79	4.37	5.03	5.76	5.81	5.81	5.81
Market sales of heifers 2-3 years culled for slaughtering		**1.10**	0.00	0.00	0.20	0.16	0.16	0.22	0.25	0.29	0.34	0.39	0.44	0.51	0.59	0.67	0.76	0.87	0.99	1.12	1.27	1.28
Market sales of heifers 2-3 years (due to overstocking)		**1.04**	0.00	0.00	-1.76	-1.76	-1.76	-1.76	-1.76	-1.76	-1.76	-1.76	-1.76	-1.76	-1.76	-1.76	-1.76	-1.76	20.70	27.80	34.64	35.02
Market sales of male calves		**1.10**	0.00	0.86	0.51	0.51	1.06	1.39	1.70	2.15	2.65	3.13	3.74	4.44	5.20	6.06	7.04	8.14	9.38	10.77	10.85	10.85
Residual value of herd		**1.05**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	257.05
USAID Subsidy for initial investment		**0.00**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total inflows			**16.72**	**18.12**	**16.76**	**22.17**	**26.31**	**29.81**	**34.69**	**40.20**	**46.15**	**52.88**	**60.59**	**69.08**	**78.67**	**89.52**	**101.74**	**115.49**	**153.45**	**162.88**	**169.95**	**427.40**
	Expenditures																					
Purchase of Cross-breed cattle		**1.04**	21.76	1.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feed Concentrates cost																						
Noug Seed Cake		**1.08**	3.49	4.11	5.57	6.09	6.75	7.72	8.72	9.81	11.07	12.48	14.05	15.83	17.85	20.11	22.66	25.53	26.80	27.65	28.16	28.19
Wheat bran		**1.08**	0.54	0.64	1.24	1.32	1.70	2.26	2.83	3.46	4.18	4.99	5.89	6.92	8.07	9.37	10.84	12.49	13.22	13.71	14.00	14.02
Other supplements		**1.00**	3.47	4.08	5.53	6.04	6.70	7.66	8.65	9.74	10.98	12.39	13.94	15.71	17.71	19.95	22.48	25.34	26.59	27.44	27.94	27.97
Salt		**0.76**	0.02	0.03	0.04	0.04	0.05	0.05	0.06	0.07	0.08	0.09	0.10	0.11	0.12	0.14	0.16	0.18	0.19	0.19	0.20	0.20
Cost of hay		**1.00**	2.01	2.36	3.60	3.89	4.56	5.55	6.56	7.67	8.95	10.38	11.97	13.78	15.83	18.13	20.72	23.64	24.92	25.79	26.30	26.33
Veterinary Expenses																						
Average Veterinary Expense		**1.32**	0.11	0.12	0.16	0.18	0.21	0.25	0.29	0.34	0.38	0.44	0.51	0.58	0.66	0.75	0.85	0.97	1.04	1.08	1.10	1.10
AI cost		**1.14**	0.26	0.26	0.26	0.33	0.38	0.42	0.48	0.55	0.62	0.70	0.79	0.89	1.00	1.13	1.28	1.44	1.63	1.64	1.64	1.64
Cost of Animal shelter																						
Construction cost of shelter		**1.00**	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maintenance cost of shelter per year		**1.00**	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Labor cost to milk cattle		**1.00**	0.59	0.43	0.43	0.58	0.68	0.76	0.88	1.02	1.17	1.33	1.53	1.73	1.97	2.24	2.54	2.88	3.26	3.29	3.29	3.29
Labor cost - other activities		**1.00**	0.95	0.91	0.88	1.15	1.34	1.51	1.76	2.03	2.32	2.66	3.04	3.46	3.93	4.47	5.07	5.75	6.52	6.56	6.56	6.56
Total Outflows			33.54	14.43	17.76	19.65	22.40	26.22	30.26	34.70	39.77	45.50	51.83	59.04	67.17	76.32	86.63	98.25	104.19	107.38	109.21	109.31
Net Cash Flows			-16.82	3.69	-1.00	2.52	3.90	3.59	4.43	5.50	6.38	7.38	8.76	10.04	11.49	13.20	15.11	17.24	49.26	55.50	60.74	318.09
Net Cash Flows $US			**-0.93**	**0.20**	**-0.06**	**0.14**	**0.22**	**0.20**	**0.25**	**0.31**	**0.35**	**0.41**	**0.49**	**0.56**	**0.64**	**0.73**	**0.84**	**0.96**	**2.74**	**3.08**	**3.37**	**17.67**
NPV @12% discount rate EIB mill	**80.84 EIB**																					
NPV @12% discount rate $US mill	**4.49 USD**																					

STAKEHOLDER AND BENEFICIARY ANALYSIS

An economic surplus in the economy is created by producing an output that has an economic value greater than the economic cost of the inputs, such as capital, land, and labor that are used to produce the item. The analyzed baseline LMD intervention in the dairy value chain would yield two main stakeholders: the households engaged in the intervention and the government of Ethiopia.

The government of Ethiopia would benefit from an additional inflow of taxes coming from the tradable inputs used in the milk-production operation. The production inputs can be divided into three groups:

1. **Nontradable inputs:** Hay, straw, and by-products of brewery industries are internationally nontradable commodities. In this case, no economic externality is associated with nontradable commodities. The conversion factor used to adjust the financial cost of the inputs equals 1.

2. **Importable inputs:** Salt and fuel (used to transport meat for exports) are importable to Ethiopia. The total tax rate applied on salt and fuel is higher than the FEP. The inflow of taxes on salt and fuel reduces the economic cost below the financial cost and generates net tax revenue for the government of Ethiopia. The exotic bull's semen and vaccine are also importable to Ethiopia. No import tax is applied to the items. The government of Ethiopia applies a large import subsidy on these two inputs of the intervention. The subsidy reduces the financial cost below the economic cost, and the government pays the difference.
3. **Exportable inputs:** Wheat bran and noug seed cakes are exportable from Ethiopia. No taxes or subsidies are applied on exports by the government of Ethiopia. The economic cost of the items is higher than the financial cost by the amount of FEP lost times the market exchange rate.

The indirect benefits to the government of Ethiopia, in this case, would be substantially determined by the taxes generated as a consequence of dairy products' being an import substitute commodity for Ethiopia. The decrease in imports and the existence of a substantial FEP in Ethiopia would result in an increase of foreign exchange accruing to the government.

The present value of the taxes accruing to the government over the 20-year period would be US$0.83 million/1,000 households. Table 14, below, presents the value of the stakeholder's gains.

Table 14. Stakeholder and beneficiary impacts of the project (in US$ million/1,000 households)

	Without hay production	**With hay production**
Economic NPV (FNPV + externalities)	2.84	4.49
• **Financial NPV (households)**	2.01	3.66
• **Externalities**	0.83	0.83
o **Government**	0.83	0.83

The income accruing to household labor to compensate them for their opportunity cost is not included as an additional net benefit from the project in the beneficiary analysis (table 14). In the measurement of the value added created by the project, however, one would add the FNPV of the project plus the present value of the additional compensation for family labor. In this case, the value added of the project would have a present value of ETB 64,583.58 (US$3,587.98) for the "without fodder production" case and ETB94,244.32 (US$5,235.80) for the "with fodder production" case over the 20-year evaluation period.

SENSITIVITY ANALYSIS

A sensitivity analysis for the LMD dairy value chain baseline "shift from indigenous breed toward cross-breed" intervention has been performed using the key variables that are prone to changes and likely to influence the situation of the households engaged in the project, including the lactation milk yield, the purchase price of cross-breed in-calf heifers, the cross-breed calf mortality rate, the adult animals' mortality rate, the calving rate, the market price of culled cattle, the market price of cross-breed dairy cows, the market price of the culled 2- to 3-year-old heifers, the market price of the cross-breed heifers (due to overstocking), the market price of male calves, the market price of 12-month-old female calves, the joint impact of the market price and annual requirements of the feed ingredients, the joint impact of the share of milk production sold to cooperatives and the price of milk, the joint impact of rental cost of the land and the yield of fodder ("with fodder production" case), the impact of milk losses, and the impact of the calving interval. Details related to the sensitivity analysis are outlined in the following tables.

Table 15. Impact of the lactation milk yield on the FNPV (US$/1,000 households)

Yield (lit)	NPV ($US)
3,250.00	-0.11
3,500.00	0.60
3,800.00	1.07
4,000.00	2.01
4,200.00	2.96
4,500.00	4.37

The lactation milk yield is a significant variable that determines financial returns to the households. The baseline scenario of the analysis assumes the lactation milk yield of 4,000 liters/305 days of the lactation period. The resulted FNPV of the baseline scenario is US$2.01 million. The drop of the crop yield of 500 liters/lactation period results in a decrease in the FNPV to US$0.60 million, indicating the significance of the variable.

Table 16. Impact of the purchase price of the cross-breed heifers on the FNPV (US$/1,000 households)

PRICE (ETB)	NPV ($US)
25,000.00	2.32
26,000.00	2.26
28,000.00	2.14
30,000.00	2.01
32,000.00	1.89
33,000.00	1.83
35,000.00	1.71

The sensitivity analysis reveals that the purchase price of the cross-breed heifers does not significantly affect the returns to the households, because although the cost of the cross-breed heifers contributes to 94 percent of the total investment cost, the cross-breed heifers are also the output of the intervention. It is assumed that the farmers will sell the heifers when the farm expansion limit is reached. The value of the heifers in the herd at the end of the 20-year evaluation period is included in the household's cash flows as a residual value.

Table 17. Impact of the calves' mortality rate on the FNPV (US$/1,000 households)

F1 GENERATION		F2 GENERATION		F3 GENERATION	
MORTALITY (%)	NPV ($US)	MORTALITY (%)	NPV ($US)	MORTALITY (%)	NPV ($US)
8.00%	2.024	**9.00%**	2.037	**10.00%**	2.060
9.00%	2.020	**10.00%**	2.026	**11.00%**	2.038
10.00%	2.015	**11.00%**	2.015	**12.00%**	2.015
11.00%	2.010	**12.00%**	2.003	**13.00%**	1.992
12.00%	2.005	**13.00%**	1.992	**14.00%**	1.969

The field visits to the highlands of Ethiopia revealed that the cross-breed calves' mortality rate increases along with their exotic blood level due to the decreased resistance to the local conditions. On the other hand, the dairy farmers will reduce the mortality rate as they gain experience in the animals' management. The baseline scenario assumes the 10 percent, 11 percent, and 12 percent of the mortality rate for the F1, F2, and F3 generations, respectively. The small increase/decrease in the calf mortality rate does not significantly affect the FNPV of the intervention. The 2 percent increase in the mortality rate of the F1 generation, for instance, results in only a 0.50 percent drop of the FNPV.

Table 18. Impact of the adult animals' mortality rate on the FNPV (US$/1,000 households)

MORTALITY (%)	NPV ($US)
2.00%	2.51
2.50%	2.26
3.00%	2.01
3.50%	1.78
4.00%	1.55
5.00%	1.11

During the field visits, the Ethiopian dairy households did not reveal any significant losses of the cross-breed dairy cattle. The farmers usually keep the animals under good conditions and put a lot of effort into minimizing the mortality rates. The baseline scenario of the analysis is built under the assumption of 3 percent adult animals' mortality rate. An increase of 2 percent to the mortality rate results in a reduction of the FNPV from US$2.01 million/1,000 households to US$1.11 million/1,000 households. Such a big decrease in the FNPV indicates the significant impact of the adult mortality rate.

Table 19. Impact of the calving rate, Year 2 until the end of the evaluation period of the intervention, on the FNPV (US$/1,000 households)

Calving rate (%)	NPV (US$)
80.00%	1.75
81.00%	1.80
83.00%	1.89
85.90%	2.01
87.00%	2.06
89.00%	2.15
90.00%	2.20

The calving rate for the first year of the intervention is assumed to be 100 percent, because the households will purchase in-calf cross-breed heifers. The calving rate for the second year and until the end of the evaluation period is a factor of the calving interval. The calving interval is reported to be 425 days, which suggests, for the baseline scenario, that on the average, 85.9 percent of the herd will calf every year. The 6 percent decrease in the calving rate will decrease the FNPV from US$2.01 million to US$1.75 million. The overall impact of the calving rate is moderate.

Table 20. Impact of the calving interval, Year 2 until the end of the evaluation period of the intervention, on the FNPV (US$/1,000 households)

DAYS	NPV (US$)
365	6.10
380	4.89
400	3.49
425	2.01
430	1.75
440	1.26
450	0.80
470	-0.03

The calving interval is one of the most significant variables affecting the financial returns of the intervention, because it affects annual milk production as well as the production of heifers. The baseline scenario assumes a calving interval of 425 days. During the field visits, the successful dairy smallholders reported calving intervals of 365–380 days, which is the goal of every dairy farm. It is, however, not practical to assume that the perfect calving interval can be achieved by relatively inexperienced households. The 425-day calving interval yields the FNPV of US$2.01 million/1,000 households. The best-case scenario, a calving interval of 365 days, yields a FNPV of US$6.10 million/1,000 households, which is 203.48 percent above the baseline scenario. The break-even calving interval is reported to be 469 days.

Table 21. Joint impact of the noug seed cake price and annual requirements on the FNPV (US$/1,000 households)

	NOUG CAKE REQUIREMENT (kg/year/animal unit)					
Price ETB/kg	**250**	**300**	**365**	**400**	**450**	**500**
5.00	**4.26**	3.83	3.27	2.97	2.54	2.11
6.00	3.83	3.32	2.64	2.28	1.76	1.25
7.00	3.40	2.80	**2.01**	1.59	0.99	0.39
8.00	2.97	2.28	1.39	0.90	0.21	-0.48
8.50	2.76	2.02	1.07	0.56	-0.17	**-0.91**

The baseline scenario of the analysis is built on the current price of ETB7.00/kg and the annual noug seed cake requirement of 365 kg/animal. Increasing the annual requirements to 500 kg/animal yields a FNPV of US$0.39 million/1,000 households, compared to the US$2.01 million/1,000 households. The worst-case scenario with the price of ETB8.50/kg and annual requirements of 500 kg/animal yields a negative FNPV of –US$0.91 million/1,000 households.

Table 22. Joint impact of the "other feed supplements" price and annual requirements on the FNPV (US$/1,000households)

	OTHER FEED SUPPLEMENTS REQUIREMENT (kg/year/animal unit)					
Price ETB/kg	**1,600**	**1,700**	**1,820**	**1,900**	**2,000**	**2,500**
1.00	**3.96**	3.79	3.58	3.45	3.27	2.41
1.25	3.27	3.06	2.80	2.63	2.41	1.33
1.50	2.58	2.33	**2.01**	1.81	1.55	0.26
2.00	1.20	0.86	0.45	0.17	-0.17	-1.90
2.25	0.52	0.13	-0.34	-0.65	-1.04	-2.97
2.50	-0.17	-0.60	-1.12	-1.47	-1.90	**-4.05**

This category of the feed ingredients represents location-specific cheap feed substitutes, such as by-products of brewery and winery industries or crop residues. The availability of the substitutes is a significant factor determining the financial returns to the households. The financial returns in this case are determined by the nutritional value, represented by the annual quantity required, and the cost of the particular feed ingredient, represented by the price. The worst-case scenario, an annual requirement of 2,500 kg/animal and price of ETB2.50/kg, yields a negative FNPV of –US$4.05 million/1,000 households. If the annual requirements of cheap feed supplements were to increase to 2.5MT/year/animal and the price were to remain at the same level, the FNPV is still positive, at US$0.26 million.

Table 23. Joint impact of hay price and annual feed requirements on the FNPV (US$/1,000 households)

	HAY REQUIREMENT (kg/year/head)					
Price ETB/20 kg	**1350**	**1400**	**1500**	**1600**	**1800**	**2000**
35.00	**4.41**	4.26	3.95	3.65	3.05	2.45
40.00	3.82	3.65	3.31	2.96	2.27	1.58
45.00	3.24	3.05	2.66	2.27	1.50	0.72
50.00	2.66	2.45	**2.01**	1.58	0.72	-0.14
55.00	2.08	1.84	1.37	0.89	-0.05	-1.00
67.50	0.63	0.33	-0.25	-0.83	-1.99	-3.15
70.00	0.33	0.03	-0.57	-1.17	-2.38	**-3.59**

The cost of hay along with annual feed requirements per animal unit has a dramatic impact on the results of the intervention. The cost of hay in Ethiopia experiences big seasonal fluctuations. The baseline scenario assumes a cost of ETB50.00/20 kg. Such a price is more relevant for the seasons when hay supplies are limited; however, taking into consideration recent climatic conditions in Ethiopia, such as frequent droughts, it is more appropriate to use this higher price for the baseline scenario and then test the different scenarios using sensitivity analysis. Holding the annual requirements constant at 1,500kg/animal unit, a decrease in the average price of hay throughout the year to ETB35.00/20 kg yields a FNPV of US$3.95 million/1,000 households. In turn, an increase in price to ETB70.00/20 kg yields a negative FNPV of US$0.57 million/1,000 households.

Table 24. Joint impact of the milk price and share of milk sold to cooperatives on the FNPV (US$/1,000households)

	SHARE OF MILK SOLD TO COOPERATIVES (%)							
Price ETB/liter	**60.00%**	**65.00%**	**67.50%**	**70.00%**	**75.00%**	**80.00%**	**85.00%**	**90.00%**
4.25	1.17	0.71	0.48	**0.25**	-0.22	-0.68	-1.14	**-1.61**
4.50	1.68	1.26	1.05	**0.84**	0.41	-0.01	-0.43	-0.85
4.75	2.18	1.80	1.61	**1.43**	1.05	0.67	0.29	-0.09
5.00	**2.69**	**2.35**	**2.18**	**2.01**	**1.68**	**1.34**	**1.00**	**0.67**
5.25	3.19	2.90	2.75	**2.60**	2.31	2.01	1.72	1.43
5.50	3.70	3.45	3.32	**3.19**	2.94	2.69	2.44	2.18
5.75	4.20	3.99	3.89	**3.78**	3.57	3.36	3.15	2.94
6.00	**4.71**	4.54	4.46	**4.37**	4.20	4.04	3.87	3.70

Ethiopian households mainly sell the milk produced to cooperatives or to milk-processing industries. A small fraction of milk is sold to the neighbors and cafeterias. The baseline scenario assumes that the households will sell 30 percent of milk to neighbors and cafeterias and 70 percent to cooperatives. The sensitivity analysis reveals that if the households were to reduce the proportion sold to cooperatives to 60 percent, the FNPV increases to US$2.69 million. The reason is that neighbors and cafeterias pay 40 percent more than the price paid by the cooperatives.

Table 25. Impact of the milk losses on the FNPV (US$/1,000 households)

LOSS (%)	NPV ($US)
0.00%	2.50
1.00%	2.31
2.00%	2.11
2.50%	2.01
3.00%	1.92
4.00%	1.72
5.00%	1.53
10.00%	0.56
11.00%	0.37
12.00%	0.18

The households did not report any significant losses or spoilage of milk. The households sell the main yield to the cooperatives, which produce butter and cheese and resell creamless milk. The rest of the milk is either sold to neighbors, consumed at home, or fed to the heifers. The baseline scenario assumes that the households experience a complete loss or spoilage of 2.5 percent of the total quantity produced. The sensitivity analysis reveals that even a dramatic increase in the milk loss rate of 12 percent still yields a positive FNPV of US$0.18 million/1,000 households.

RECOMMENDATIONS

The CBA of the proposed interventions in the dairy value chain shows positive FNPVs and ENPVs, suggesting that the benefits of implementing such interventions would outweigh the costs. The households would increase their annual incomes due to the interventions.

To enable the households to participate in some of the analyzed interventions (provision of in-calf heifers), USAID will need to provide a financial subsidy to the households. It is recommended that the subsidy be provided in the form of cross-breed in-calf heifers and feed after the collection of the equity contribution from the households. The loan-based enabling mechanism is not recommended for two reasons:

- The financial analysis reveals that the households will not have cash flows during the first years of the intervention sufficient to repay the loan.
- The required financial subsidy is reported to be ETB21,814.00 (US$1,211.90). This amount is above the maximum amount available for the new clients of the MFIs operating in Ethiopia. The maximum amount of a MFI-sourced loan is ETB4,000 (US$222.22), which is much below the required financial subsidy.

It is also recommended that the local implementers of the project carefully select in-calf heifers and administer the initial vaccinations to reduce possible animal losses and ensure the success of the intervention. The proper animal conditions are extremely important, because such factors as the age at the first calving have a significant impact on an animal's productivity. The mortality rate in the first year of intervention would have a dramatic impact on the overall success of the intervention. At the household level, death of the animal in the first year of the intervention would result in the total intervention failure for the particular household.

An adequate supply of the exotic bull's semen in the intervention's implementation areas must also be ensured. The timing and quality of the AI services are extremely important factors in the dairy industry. Unavailability of the AI services when cow are in heat will result in a 1-month milk production loss. The analysis reveals that the interventions designed to improve the AI services and to provide access to sexed semen are the most promising interventions that, if implemented properly, would result in the most significant improvement in the livelihood of the Ethiopian small-scale dairy farmers.

The FNPV increases along with the farm expansion limit, suggesting that financial returns to the households will be higher if the households do not sell cross-breed heifers. This finding is again consistent with the field observations. In Ethiopia, selling a milking cross-breed cow is a cultural taboo. The households will sell the cross-breed cows only if they are faced with a severe cash shortage or the cows are not productive anymore. This finding proves that there is a financial rationale behind this cultural taboo.

There is, however, a trade-off between short-term returns and long-term returns of the intervention. The households that decide to expand the size of their farms will have lower annual net cash flows initially, unless the expansion limit is met, but very high cash flows after the expansion limit is reached. On the other hand, households may choose to sell the cross-breed heifers and have constant relatively high annual net cash flows.

At some point in time, when the herd size expands, the households will spend a full working day on the farm, so the intervention will eventually result in an increase in full-time employment for the participating households.

The FNPV of the "with fodder production" case is significantly higher than the FNPV of the "without fodder production" case, suggesting that the households should be instructed to rent land and produce fodder. The annual net cash flows are also significantly higher when households produce fodder compared to when they buy it. The rental cost of land used in the analysis is reported to be ETB10,000.00 (US$555.55). In Ethiopia, it is possible to rent quite productive land for such a price. The households can rent a timad of land and expand the size of the rented land over time as the farms grow.

It is also recommended that the institutions operating in Ethiopia assist in addressing the feed issues. The cost of feed accounts for 60 percent to 70 percent of the total cost of livestock production. A feed shortage and high prices have a dramatic impact on the profitability of such a commercial livestock operation. The high cost of feeding contributes to the factors affecting low productivity of Ethiopian dairy cattle. A positive change in the current situation not only would lead to the improved health status of the animals but also would directly result in the increased production of milk per lactation period.

Drought-mitigating activities should be carefully examined before implementation. During the 2007–2008 drought, a substantial amount of concentrate and roughage feeds were purchased by different governmental and nongovernmental organizations to address the critical feed shortages in pastoralist areas. This drought-mitigation intervention, coupled with a general feed shortage, dramatically increased the price of feed and resulted in a crisis in the animal feed supply throughout Ethiopia, causing the closure of many dairy farms in the highlands of Ethiopia.

REFERENCES

Adugna T., Alemu Y., and Dawit A. (2012). *Livestock feed resources in Ethiopia.*

Assefa, H., and Tamir, S. *Challenges, Opportunities, and the Need for Transformation.* Ethiopian Animal Feeds Industry Association.

Mekuriaw, S. and Tsega, W. (2012). Agriculture and Consumer protection. *Case study 1. Haymaking in Ethiopia.*

Hopkins, B. A., Whiltlow, L. W. *Feeding dairy heifers from weaning to calving.*

Demonstration of maize and noug cake mixture supplementation for women focused small scale fattening in Yilmana Denssa District. *Journal of Agricultural Extension and Rural Development, 4*(1): 19–22.

Desta, Z., and Oba, G. (2004). Feed scarcity and livestock mortality in enset farming systems in the highlands of Southern Ethiopia. *Outlook on Agriculture, 33*(4): 277–280.

Debre Zeit Agricultural Research Center. (2003). *Milk production performance of Zebu, Holstein Friesian and their crosses in Ethiopia.*

Kiwuwa, G. H., Trail, J.C.M., Kurtu, M. Y., Worku, G., Anderson, F. M., and Durkin, J. (September 1983). *Crossbred dairy cattle productivity in Arsi Region, Ethiopia.*

Gebremedhin, B., Hirpa, A., and Berhe, K. (2009). *Feed Marketing in Ethiopia: Results of Rapid Market appraisal.* Improving Productivity and Market Success (IPMS) of Ethiopian farmers project Working Paper 15. ILRI (International Livestock Research Institute), Nairobi, Kenya:1–64.

Jenkins, G. P., Kuo, C. Y., and Harberger, A. C. (August 2011). *Cost-benefit analysis for investment decision.*

Kuo, C. Y. (2011). *Estimates of the foreign exchange premium and the premium for non-tradable outlays for countries in Africa.* John Deutsch International, Department of Economics, Queen's University, Canada.

The Sphere Project. (2011). *Humanitarian charter and minimum standards in humanitarian response.*

Land O'Lakes, Inc. (November 2010). *The next stage in the dairy development for Ethiopia. Dairy value chains, end markets and food security.*

Mburu, L. M., Gitu, K. W., and Wakhungu, J. W. (2007). *A cost-benefit analysis of smallholder dairy cattle enterprises in different agro-ecological zones in Kenya highlands.*

Negassa, A., Rashid, S., and Gebremedhin, B. (2011). *Livestock production and marketing.* ESSP II Working Paper: 1–40.

Staal, S. J., Pratt, A. N., and Jabbar, M. (2008). *Dairy development for the resource poor part 2: Kenya and Ethiopia dairy development case studies.*

APPENDIX

Table A. Summary of conversion factors used for the economic analysis of the interventions in the LMD dairy value chain

Summary of Conversion Factors	
Animals sold for slaughtering	1.10
Milk	1.07
Salt	0.76
Wheat bran	1.08
Noug seed cake	1.08
Hay	1.00
Veterinary expense	1.32
AI services	1.14
Cross-breed heifers	1.04
Rental value of tent	1.00
Labor cost ETB/round	1.00
Residual value of the herd	1.05
Other feed supplements	1.00