COST-BENEFIT ANALYSIS OF THE POTATOES, ONIONS, AND TOMATOES VALUE CHAINS IN ETHIOPIA

GRADUATION WITH RESILIENCE TO ACHIEVE SUSTAINABLE DEVELOPMENT (GRAD) PROJECT

FINAL REPORT

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UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT
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FINAL REPORT

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ACRONYMS

ADSCR	Annual Debt Service Coverage Ratio
AGP	Agriculture Growth Program
CARE	Non-Governmental Organization, Implementing Organization
CBA	Cost-Benefit Analysis
CF	Conversion Factor
CRS	Catholic Relief Services
ENPV	Economic Net Present Value
ETB	Ethiopian Birr (Currency)
FEP	Foreign Exchange Premium
FNPV	Financial Net Present Value
FtF	Feed the Future
GRAD	Graduation With Resilience to Achieve Sustainable Development
Ha	Hectare
MFI	Microfinance Institution
MT	Metric Ton
NCF	Net Cash Flow
NGO	Non-Governmental Organization
NPV	Net Present Value
ORDA	Organization for Rehabilitation and Development in Amhara
PSNP	Product Safety Net Program
REST	Relief Society of Tigray
RUSACCO	Rural Savings and Credit Cooperative
SNNPR	Southern Nations, Nationalities, and People's Region
SNV	Netherlands Development Agency
US$	United States Dollar
USAID	United States Agency for International Development
WHO	World Health Organization

EXECUTIVE SUMMARY

The Graduation With Resilience to Achieve Sustainable Development (GRAD) project proposed by the United States Agency for International Development (USAID) started in 2012 and was implemented in 16 woredas around Ethiopia. The project spans 5 years. The selected woredas are located in Amhara; Oromia; Southern Nations, Nationalities, and People's Region (SNPPR); and Tigray. The GRAD project aims to graduate 50,000 chronically food-insecure households among the 65,000 that are targeted. Each of the selected households will need to achieve an increase in its yearly income of US$365 to successfully graduate from the program. Four commodity value chains have been chosen for this project's interventions: honey, pulses, meat, and vegetables.

The implementers of the project include CARE, the Relief Society of Tigray (REST), the Organization for Rehabilitation and Development in Amhara (ORDA), Catholic Relief Services (CRS), the Netherlands Development Agency (SNV), and Tufts University. These well-known organizations are engaged in food-security and value chain–development projects in Ethiopia and other developing countries throughout the world.

To facilitate the project's proper implementation and the flow of necessary financial resources for the targeted households, USAID/Ethiopia established a US$2-million loan-guarantee fund that will be available to the microfinance institutions (MFIs) and rural savings and credit cooperatives (RUSACCOs) that will be in charge of providing loans to the participating chronically food-insecure households. Such financial assurance will diminish the risk associated with microlending and help facilitate the flow of funds.

Project Description: The objective of the vegetables value chain analysis was to understand the situation concerning vegetable growing at the farm level and to analyze a number of proposed GRAD interventions designed to improve the targeted households' livelihoods. Field visits were used to collect primary data that were compared with information from credible publications and, when necessary, adjusted. Adjusted data were then compared with the business plans proposed by the local implementers of the GRAD project. In many cases, data obtained from the field visits were consistent with data proposed by the GRAD implementers; however, specifically on the benefits side, some inconsistencies emerged. The key findings are summarized as follows:

1. Farmers who already have access to irrigation usually do not plant three vegetable crop rotations during the year; the constraints are mainly weather conditions and limited water supply. The situation may differ according to the different regions and climatic conditions of Ethiopia. In some regions, perhaps, the number of rotation rounds (vegetables + crops) can reach three rounds per year, with two rounds allocated for vegetables. The maximum number of rotation rounds that was observed during the field visits was two.

2. Crops, specifically maize, are a very important part of Ethiopian households' nutritional diet. Despite the importance of such crops in the farmers' lives, they are reluctant to plant vegetables during both rotation rounds. Farmers typically plant vegetables during the short rainy season and supplement their production with irrigation water. Crops planted during the long rainy season are usually grown without the provision of supplementary water. Another reason for having only two cycles of production is the high fuel cost of irrigation, which could make having a third rotation round with vegetables unprofitable due to the volume of water needed; however, the team could not obtain exact data regarding incremental fuel consumption during a third rotation round, because they did not observe any farmers doing three cycles.

3. Taking into consideration the very small landholding of the potential GRAD beneficiaries (one-quarter of a hectare), the assumption that farmers will completely switch from the production of crops mainly used for home consumption toward a vegetables-only model seems to be unrealistic.[1] Interventions should instead result in the farmers' having one additional rotation round per year in which to cultivate vegetables. This change will be possible only by giving farmers access to irrigation, capital, and adequate training to start vegetable production. All financial and economic results presented in this report have been calculated under the assumption that farmers will complete one round of vegetable production in addition to their usual crop production rounds.

4. The loan structure proposed for the potential GRAD beneficiaries selected for the vegetable-production intervention needs to be redesigned. The current loan structure will allow the households to get up to 4,000 ETB, 10,000 ETB, and 15,000 ETB in years one, two, and three, respectively. This is a standard MFI policy in Ethiopia. The GRAD project also assumes that pumps required for irrigation will come from the government support program, which leaves the intervention's success entirely dependent on the implementation of this government support program. It is suggested that farmers be allowed to borrow 8,995 ETB, 10,730 ETB, or 10,115 ETB for potatoes, onions, and tomatoes production, respectively, in the first year. The repayment period should be increased to 3 years, with equal annual repayments tied to harvest periods. In this set-up, farmers will borrow only once and pay the total amount back over 3 years instead of borrowing once annually for 3 years. Such a loan structure will enable a group of four farmers to purchase a pump together and allow USAID be independent of other aid projects. It will also allow increased return on investment for the GRAD interventions in the vegetables value chain.

5. The availability of seeds requires close monitoring for the intervention to succeed. Currently, most farmers have no access to improved seed varieties for vegetable production and very limited knowledge of any required technologies. For example, potatoes are mainly produced by planting small potatoes from the previous harvest, which results in extremely low yields (around 8 metric tons per hectare [MT/ha]). With such yields, any interventions may bring negative results, so it is recommended that USAID initiate a system to ensure the adequate distribution of vegetable seeds. Commercial production of seeds is very weak in Ethiopia, which limits supply; additional interventions may be required to increase the supply of seeds for vegetable production.

6. The business plan for vegetable cultivation used a yield of 30 MT/ha for all the commodities selected for the vegetables value chain. Such yields may be attainable in some countries around the world, but they still extremely high for Ethiopia. The average yield for a potato crop using local seeds, for instance, is about 8 MT/ha. It increases to about 19 MT/ha using improved seeds, but this amount is still far below the GRAD project's promise of 30 MT/ha. The situation is similar for the onions and tomatoes value chains.

7. Due to their perishable nature, vegetables are mainly sold immediately after being harvested. In addition, farmers usually do not consume a lot of vegetables themselves. In some cases, however, potatoes are seen as an important food commodity; these farmers select only poor-quality, partially damaged potatoes for home consumption, which results in a decreased post-harvest loss rate. Potatoes also can be stored for a longer period of

[1] GRAD investment proposal for vegetables cultivation assumes that whole land will be allocated for the vegetables cultivation.

time than other vegetables. It is suggested that training programs related to the interventions include discussion of the benefits of vegetable consumption and provide some recipes for cooking vegetables so that farmers can improve their nutrition levels.

Strategic Context and Rationale: The USAID/Ethiopia GRAD project is part of the wider Feed the Future (FtF) strategy, which supports investments in viable and potentially easy-to-engage-in agricultural value chains. The GRAD project also hopes to promote gender equality and the inclusion of women with the selected interventions.

In the case of the vegetables value chains, the GRAD project proposes interventions for growing potatoes, tomatoes, and onions.

Selected beneficiaries for the GRAD vegetables interventions are poor households that have potentially irrigable land (e.g., close location to rivers, lakes, or other water points) but very limited investment capital and knowledge about growing vegetables. This analysis reveals that such households may benefit from the GRAD vegetable interventions. It is recommended, however, that the GRAD interventions in the vegetables value chains be tweaked to become independent from other aid projects in the region. Access to irrigation due to the interventions will not only allow the households to add one vegetable production cycle per year but also decrease the risks associated with frequent drought in Ethiopia.

Financial and Economic Analysis Results: The main assumption of the pursued cost-benefit analysis of potatoes, tomatoes, and onions value chains states that each GRAD-targeted chronically food-insecure household engaged in the vegetables' production will receive a loan in the amount necessary for the initial purchase of required inputs for the vegetables' production.

The loan should be structured to allow targeted households to repay it within 3 years, with a grace period of 5 months. Such a loan will be offered at a subsidized interest rate of 15 percent. The financial analysis reveals that farmers will have an adequate cash flow to repay this loan in full by the end of the project. The Annual Debt Service Coverage Ratio (ADSCR) for the first year, however, is below the value of 1 for all three commodities, which indicates that farmers may not be able to repay the full amount of their debt burden for the first year (although the households may repay more than 80 percent in all three cases). The balance must be carried forward to year 2 and added to the principal and interest payment for the second year. The ADSCRs for year 2 in all three cases are greater than 1, indicating that farmers can repay all their debt obligations for years 1 and 2.

GRAD beneficiaries will need to be given some flexibility with loan repayments, taking into consideration different circumstances. During the first year of vegetable production, farmers need to have the flexibility to repay a fraction of the loan amount from year 1 in year 2 without incurring a penalty. The net cash flows (NCFs) used to calculate ADSCRs in this analysis have been calculated on incremental basis, excluding in-house consumption. Because the intervention results in an additional round of planting, farmers may save some money that they would have to otherwise spend on food by consuming some of these vegetables. Therefore, farmers may be willing to use the money they save as a result of this vegetable consumption to cover their debt obligations in full for year 1.

This analysis covers an 11-year period. Interventions in all three cases—potatoes, onions, and tomatoes—yield positive financial net present values (FNPVs) using a real discount rate of 12 percent. Table A shows the FNPVs for the interventions in the potatoes, tomatoes, and onions value chains.

Table A. Incremental FNPV from the equity's point of view, per intervention (US$ real)

FNPV @ 12% discount rate	US$
Intervention in potatoes value chain	**1,577.25**
Intervention in tomatoes value chain	**1,328.75**
Intervention in onions value chain	**1,669.89**

The economic net present value (ENPV) is also positive in all three cases. The differences between financial and economic outcomes of the projects are due to the fact that the financial values do not include all externalities presented in the interventions.

Table B. ENPVs, per intervention (US$ real)

ENPV @ 12% discount rate	US$
Intervention in potatoes value chain	**1,761.55**
Intervention in tomatoes value chain	**1,437.75**
Intervention in onions value chain	**1,801.71**

Beneficiary Analysis Results: Based on this analysis, it is expected that the GRAD project will increase the yearly income of targeted households. This net increase in income results from the financial NCF from the project plus the additional labor income accruing to the households. Table C, below, shows the present value over the 11-year period for the three value chains.[2]

Table C. Present value of the net increase in the income of the targeted households over the 11-year period (US$ real)

PV @ 12% discount rate	US$
Intervention in potatoes value chain	**1,720.10**
Intervention in tomatoes value chain	**1,592.22**
Intervention in onions value chain	**1,857.76**

Table D, below, presents the net annual increases in the net income of the households, as defined in table C.

Table D. Net annual increase in the income of the targeted households (US$ real)

	2013	2014	2015–2022
Intervention in potatoes value chain	78.15	153.51	284.13
Intervention in tomatoes value chain	46.34	120.21	267.10
Intervention in onions value chain	91.36	146.25	302.05

The Ethiopian government is the other primary beneficiary of the project:

- Although vegetables are exported from the border regions of Ethiopia, it is expected that the vegetables produced in the GRAD woredas will be consumed domestically. Because of their perishable nature, it would not be financially beneficial to transport them to the

[2] The net increase in the income of the targeted households over the 11-year period is the sum of the FNPV and the present value of the incremental labor cost at a 12% real discount rate.

point of export from Ethiopia. Hence, in this case, the analysis assumes the vegetables to be neither exportable nor importable goods and therefore internationally nontraded goods.

- The government will benefit directly from the taxes collected on the inputs of the intervention. High tax rates are assessed on the fuel required for running the irrigation pump, and a 10 percent duty rate and a 15 percent VAT are assessed for the pumps when they are imported. Although these taxes on the fuel and the pumps are components of the financial cost, they are not included in the project's economic cost, representing instead a transfer of tax revenue to the government of Ethiopia.

- The fertilizer used for vegetable cultivation is an importable good for Ethiopia. Such goods cost the country in foreign exchange when they are used in domestic production, which makes their economic cost greater than their financial cost by the amount of foreign exchange premium (FEP). In Ethiopia, no import duty is charged for the inputs required to produce vegetables.

- The present value of the amount that the Ethiopian government will benefit from the intervention over the 11-year period is estimated to be US$159.53 for the intervention in the potatoes value chain, US$134.69 for the intervention in the onions value chain, and US$90.96 for the intervention in the tomatoes value chain. These values are the difference between direct government benefits from the taxes collected on inputs for the intervention and economic cost of foreign exchange foregone when fertilizers are imported.

Conclusions and Recommendations: The projected FNPVs and ENPVs show that the proposed interventions in the three value chains (onions, potatoes, and tomatoes) will yield positive results and will benefit the targeted households and the economy as a whole. The loan structure, however, should be redesigned so that households will be able to get sufficient funding to finance not only the variable inputs of production, but also the pumps and fuel required for irrigation. Each pump can be shared by a group of four farmers, hence decreasing the amount required to purchase it. None of the proposed interventions will be able to achieve the target increase in income of US$365 per year per household. Therefore, it is recommended that the interventions in the vegetables value chain be "packaged" with an intervention from another commodity value chain proposed by the GRAD project.

THE VEGETABLES GRAD VALUE CHAIN: COST-BENEFIT ANALYSIS

METHODOLOGY

Project Background

The United States Agency for International Development (USAID) started implementation of the Graduation With Resilience to Achieve Sustainable Development (GRAD) project in Ethiopia in 2012. The project is part of USAID's Feed the Future (FtF) agenda and aims to support improvements in the value chains of several commodities (honey, pulses, meat, and vegetables) to increase the food security of the targeted Ethiopian households.[3] The GRAD project will include a special emphasis on strengthening the livelihoods of chronically food-insecure households in the Highlands Areas, improving household and community resilience, and strengthening an enabling environment to promote scale-up and sustainability.

The project has a 5-year lifespan. During this period, the GRAD project will target 65,000 food-insecure Ethiopian households that can be categorized as either chronically food insecure (58,500 households) or "Ultra Poor"[4] (6,500 households). Of the participating 65,000 households, the GRAD project intends to graduate 50,000 households from chronic food insecurity by increasing each household's yearly income by US$365. The GRAD project will also include another group of 10,000 Ethiopian households that are either food-sufficient households (6,000) or food-secure households (4,000) to act as role models for the chronically food-insecure and "Ultra Poor" groups that are the project's main target.

Sixteen woredas located in four regions of Ethiopia—Southern Nations, Nationalities, and People's Region (SNNPR), Tigray, Amhara, and Oromia—will be included in the GRAD project. The project's woredas were selected on the basis of their proximity to the Agriculture Growth Program (AGP) and the presence of active local markets that bring opportunities for engagement in commodity trading. This geographical selection criterion is intended to guarantee that the households have the potential to market the commodities that they produce if the intervention goes as planned. The GRAD project also intends to facilitate market linkages to connect these households with commodity traders at the local level. This connection in turn will facilitate the sale of commodities and foster income inflows to the households. Additionally, the GRAD project is expected to correct shortcomings experienced in the Productive Safety Net Program (PSNP) Plus project to allow each targeted household to increase its yearly income by US$365 (or US$1 per day).

As the implementer of this project, CARE will cooperate with the following technical partners to ensure the project's proper implementation: the Relief Society of Tigray (REST), the Organization for Rehabilitation and Development in Amhara (ORDA), Catholic Relief Services (CRS), SNV (Netherlands Development Agency), and Tufts University. All these organizations are well-known nongovernmental organizations (NGOs) that are engaged in various projects in Ethiopia related to improving food security and developing commodity value chains.

USAID will establish a loan-guaranteed fund of US$2 million to ensure that microfinance institutions (MFIs) and rural savings and credit cooperatives (RUSACCOs) have sufficient access

[3] "Food security" is defined as access to sufficient food by all members of the household for an active and healthy lifestyle in a normal or moderately bad year (per GRAD Technical Proposal).
[4] Ultra Poor households include female-headed households and landless youth.

to lending capital to develop a flexible lending scheme for the GRAD households. This fund will also help reduce these institutions' risks associated with loan defaults among the targeted households.

The GRAD project plans to emphasize non-gender-biased participation and inclusion of women in its proposed interventions for the commodities value chains. Ethiopian women are typically disadvantaged in terms of access to agricultural inputs, so the GRAD project plans to correct these issues whenever possible.

The three commodity value chains selected for the GRAD project have been chosen because of their simplicity in terms of the knowledge required for their implementation and the rather low initial start-up costs necessary to engage in their production. These commodities also offer the potential for post-GRAD production increases and marketing. Demand for these commodities is growing in domestic and export markets, creating the possibility for future increases in commodities sales and income generation for the households participating in the GRAD project.

The proposed commodities in the vegetables value chain are potatoes, onions, and tomatoes. The objective of this vegetables value chain analysis was to understand the conditions of farming and analyze proposed GRAD interventions designed to improve the targeted households' livelihoods. Field visits were conducted to collect primary data that were compared with information from credible publications, analyzed, and adjusted as needed. Adjusted data were then compared with the business plans proposed by the GRAD project's local implementers.

Commodity Background

Vegetables Production in Ethiopia

Vegetables are not only a major source of vitamins and microelements necessary for human health but also a good source of cash income for small-scale farmers.

The total production of vegetables in Ethiopia during the long rainy season, Meher, in 2010–2011 was about 1.75 million tons (CSA, 2011). The average yield of potatoes in 2010–2011 was about 8.28 tons per hectare. The average yield of tomatoes was about 10.5 tons per hectare. The average yield of onions in 2010–2011 was about 10.8 tons per hectare (CSA, 2011). The population of Ethiopia is about 93 million people (CIA Factbook, 2012). Current levels of vegetable production are low and insufficient to satisfy the growing demand for vegetables caused by population growth.

It is estimated that an average Ethiopian consumes fewer than 100 grams of vegetables and fruits per day. This caloric intake is not enough to maintain a healthy lifestyle and falls far below the levels of per-capita daily consumption of vegetables and fruits suggested by the World Health Organization (WHO). Such low levels of vegetables production and consumption result in a society that is significantly vitamin-deprived (SNV, 2012).

Currently GRAD-targeted households do not produce vegetables for a variety of reasons. Vegetables' nutritional benefits are highly undervalued at the farm household level in Ethiopia, where farmers mainly emphasize the production of crops and haricot beans with a few other vegetables, particularly potatoes. Shifting current production toward vegetables seems to be unrealistic due to the fact that households with landholdings of 1 timad (0.25 hectare) will be very reluctant to substitute production of their main food crops with that of any other commodity.

Farmers in Ethiopia do not contribute all the land throughout the year for vegetable production. The better-off farmers, who are more commercially oriented in terms of vegetable production, also have land allocated for the cultivation of maize and other main food commodities.

Households with access to irrigation usually do not plant three rotation rounds of vegetables during the year—constraints include weather conditions and limited water supply. Taking into consideration the nutritional importance of crops in the lives of farmers, they are reluctant to plant only vegetables throughout the year. Typically, farmers plant vegetables during the short rainy season and supplement their production with water from irrigation; they plant crops during the long rainy season that do not require supplementary water.

Cultivating crops under normal circumstances[5] during the long rainy season usually does not necessitate supplementary water.[6] Vegetables, however, may require additional water, which will incur additional expenses in terms of the cost of a pump and fuel requirements. Additional labor time will also be necessary to drain excess water when rains are too intensive.

Current Problems Observed in the Vegetables Sector in Ethiopia

1. Low productivity rates for vegetables

The amount of vegetables produced in Ethiopia is low for several reasons, including

- poor land preparation and management (use of suboptimal traditional farming methods, lack of training on modern production techniques);
- low input use (lack of improved seeds and pesticides);
- low use of irrigation;
- erratic climate (shortages of water during droughts);
- poor or nonexistent extension services specialized in vegetable production; and
- diseases, insects, and pests.

The local implementing partners should carefully address all the issues mentioned above due to the resulting yields' impact on the interventions' financial and economic outcomes. A sensitivity analysis showed that in the case of potatoes, a decrease in the baseline yield for the intervention from 19 metric tons per hectare (MT/ha) to 15 MT/ha would cut the financial net present value (FNPV) by two-thirds and reduce the amount of additional income at the household level by half. In turn, an increase to 23 MT/ha would increase the FNPV by US$1,000 and cause the intervention to bring in additional yearly income of US$391 per year (above the annual target of US$365). The break-even potato yield to reach the targeted amount of US$365 is 22.2 MT/ha.

Having access to improved seed varieties will be critical for the overall achievement of project targets. The current seed supply at the farm level is very limited. Households usually use traditional methods of planting, such as cultivating potatoes by seeding small fruits from their previous harvest.

[5] During the drought season, supplementary water is mandatory for cultivation.
[6] During field interviews in SNNPR in July 2012, the LEAP team obtained information that irrigation pumps provided under a government umbrella were distributed inefficiently, with time lags and suboptimal allocation of pump use between farmers.

2. **Transportation problems**

   The majority of vegetables are perishable goods, so after being harvested they need to be quickly sold to the final consumer or processed. The poor transportation infrastructure in Ethiopia (due to the lack of roads in rural areas) sets a barrier for such quick linkage between vegetables producers and consumers, particularly the export markets.

3. **Seasonal price variations**

   Prices for vegetables depend on seasonal variations that change due to the different climatic conditions in each year. In good years with sufficient rainfall, vegetable production increases, which in turn lowers the prices (due to excess supply). The reverse happens during droughts.

   In the case of vegetables, it is also important to distinguish between the causes of the price fluctuations. In some years, farmers may benefit from higher yields due to climatic conditions, yet prices for vegetables will drop because of excess supply. Such scenarios can be understood via the two-dimensional sensitivity analysis by looking at corresponding net present values (NPVs) when yields increase but prices drop. The other possible scenarios occur if either prices or yields change without a corresponding change in the second variable. In such scenarios, one should look at a one-dimensional sensitivity analysis to understand the individual impact of the changes in a single value chain item. For instance, vegetable prices may increase throughout Ethiopia because of limited supply coming from the main vegetable-producing regions; however, yields in other regions may remain unchanged, thus allowing farmers to increase their incomes.

4. **Weak market linkages**

   Poor market linkages leave producers dependent on traders who can exercise their market power and demand prices for vegetables that are lower than the market would suggest. Vegetable producers have low bargaining power because there are few processors that would be able to compete for their products against the vegetable traders.

   Households currently try to line up potential purchasers of their harvests just before the harvesting period to avoid storing and/or transporting easily perishable vegetables and thus reduce their post-harvest losses. Even farmers around Addis-Ababa with knowledge of prices in town and who could potentially deliver vegetables to the city prefer selling to traders, indicating that the traders add real value at a lower cost than if the farmers carried out these services themselves.

5. **Lack of credit**

   Small-scale farmers do not have access to credit that would allow them to purchase the inputs for modern vegetable-production techniques. Generally they lack the required collateral and are not seen as desirable borrowers by financial institutions. Financial institutions usually perceive high credit risks for agricultural producers due to the final harvest outcome's high climatic dependency.

6. **Lack of proper storage facilities**

   Because of their perishable nature, vegetables require either quick selling to the final consumer, processing, or being properly stored. Ethiopia has very few processors of vegetables, and vegetable storage facilities are either nonexistent or poorly developed. This situation forces producers to sell vegetables only in the local domestic market for immediate consumption.

Project Description and Activities

In recognition of the potential that vegetables present in terms of increasing food security among these chronically food-insecure Ethiopian households, the GRAD project has included in its plan interventions in the potatoes, tomatoes, and onions value chains, to be introduced in the following woredas: Shebedino, Hawassa Zuria, Hawale Tula, Mareko, Meskan (all in the SNNPR region); Enda Mehoni (Tigray region); Lay Gayint, Libokemken (Amhara region); and Zeway Dugda, Shalla (Oromia region).

The GRAD Interventions in the Vegetables Value Chains

The suggested GRAD interventions for the potatoes, onions and tomatoes value chains are to provide access to the financing required to purchase inputs for vegetable cultivation, such as improved seeds, fertilizers, and a pump and fuel for irrigation. The financing will be provided in the form of a loan at an interest rate below the market rate.

Details of the investment expenditures necessary for the planned interventions in the vegetables value chains are presented in tables 1, 2, and 3, below.

Table 1. Total investment expenditures for the potatoes value chain in Timad (ETB/0.25 Ha)

Inputs	**ETB/timad**
Potato seeds	2,000.00
DAP	777.50
UREA	285.00
Mancozeb	280.00
Redomil Gold	450.00
Pump	2,125.00
Fuel	2,100.00
Total	**8,017.50**

Table 2. Total investment expenditures for the onions value chain in Timad (ETB/0.25 Ha)

Inputs	ETB/timad
Onion seeds	40.00
DAP	583.13
UREA	190.00
Mancozeb	560.00
Redomil Gold	1,800.00
Selecron	500.00
Endosulfan	700.00
Karate	380.00
Pump	2,125.00
Fuel	2,688.00
Total	**9,566.13**

Table 3. Total investment expenditures for the tomatoes value chain in Timad (ETB/0.25 Ha)

Inputs	ETB/timad
Tomato seeds	38.00
DAP	583.13
UREA	190.00
Mancozeb	560.00
Redomil Gold	1,800.00
Selecron	500.00
Endosulfan	700.00
Karate	380.00
Pump	2,125.00
Fuel	2,142.00
Total	**9,018.13**

Assumptions for the Selected GRAD Interventions in Potatoes, Tomatoes, and Onions Value Chains:

1. Each GRAD-targeted household engaged in vegetable cultivation will receive a loan necessary for the purchase of improved seeds and other inputs of production. The size of the loan will vary according to the type of vegetables being grown (potatoes, onions, tomatoes). The total amount of loan includes a service charge of 1 percent of the total investment, an insurance fee of 1 percent, a pass book fee of ETB 15, and upfront savings of 10 percent, which will be returned to the household upon repayment of the loan, with no interest accrued. The total loan amount for cultivating potatoes is ETB 8,994.60, ETB 10,729.06 for onions, and ETB 10,115.30 for tomatoes.

2. The loan required for financing the inputs will be provided at an interest rate of 15 percent. It is proposed that this loan be structured differently than initially outlined by the GRAD project. Instead of receiving one loan per year for each of the 3 years of the intervention, with the loan amount increasing each year, the farmer will receive only one big loan and have a repayment period of 3 years. This structure will allow farmers and the GRAD project to operate independently of government programs offering irrigation pumps; farmers will have sufficient money to buy their own irrigation pumps. Each pump can be shared between four farmers, which will further ensure the successful outcome of the intervention in the vegetables value chain.

It is proposed that this loan have a repayment period of 3 years, with a grace period of 5 months.[7] It is also assumed that the farmers will make one (post-harvest) repayment per year. The rest of the loan structure—the up-front savings, insurance fees and so forth—is assumed to be the same as described by the GRAD project.

3. Farmers should be instructed to buy inputs for the next round of vegetable production immediately after they obtain resources from the sale of the current year's production. The farmers will repay the first debt service amount after 6 months. Accrued interest for the first debt service obligation is only for a 6-month period, because the households will receive the loan at the beginning of the cultivation period and make their first payment after the harvest.

4. It is assumed that farmers will pay all production-related costs at the beginning of the 6-month cultivation period, while harvested vegetables will be sold at the end of the period.

5. During the drought years, if the financing required for the pump and fuel purchase is provided, the proposed GRAD interventions will also help the households deal with insufficient rainfall levels for other crops, such as maize. This equipment will then result in increased financial returns for the interventions during the drought years, although the benefits will be partially offset by the cost of fuel required for irrigation.

6. For the purpose of this analysis, the following macrolevel assumptions have been established: Domestic inflation is 20 percent, the U.S. inflation rate is 2.5 percent, the real financial discount rate is 12 percent, the real economic discount rate is 12 percent, the foreign exchange premium (FEP) is 6.5 percent, the exchange rate in 2012 is US$1 = ETB 17.50, the land-tax rate is ETB 85 per year, and the MFI (nominal) interest rate is 18 percent.

[7] Such a loan structure will allow farmers to borrow money before planting and repay the loan after the harvest.

Table 4. Parameters for analysis of the intervention in the potatoes value chain

Parameters	Without Intervention	With Intervention
Household size	5 people	5 people
Area under maize	0.25 Ha	0.25 Ha
Rental value of land	800.00 ETB/Ha/year	800.00 ETB/Ha/year
Land tax	85.00 ETB/year	85.00 ETB/year
Average family consumption		
Potatoes	0	400.00 kg
Maize	250.00 kg	250.00 kg
Monocropping annual productivity and prices		
Maize yield	2,400.00 kg/Ha	2,400.00 kg/Ha
Potato yield	0	19,000.00 kg/Ha
Maize price	4.00 ETB/kg	4.00 ETB/kg
Potato price	2.50 ETB/kg	2.50 ETB/kg
Drought factor		
Number of droughts in 5-year period (max. 3	0	0
Maize yield during drought	500.00 kg/Ha	2,400.00 kg/Ha
Fuel requirements for irrigation (gasoline)	0	25.00 L/0.25 Ha
Input costs		
Maize seeds	30.40 ETB/kg	30.40 ETB/kg
Potato seeds	400.00 ETB/kg	400.00 ETB/kg
UREA	7.60 ETB/kg	7.60 ETB/kg
DAP	15.55 ETB/kg	15.55 ETB/kg
Mancozeb	140.00 ETB/kg	140.00 ETB/kg
Redomil Gold	450.00 ETB/kg	450.00 ETB/kg
Pump	8,500.00 ETB/pc	8,500.00 ETB/pc
Fuel	21.00 ETB/L	21.00 ETB/L
Input requirements in kg/0.25 Ha		
Maize seeds	12.50	12.50
Potato seeds	0	5.00
UREA for maize	25.00	25.00
DAP for maize	25.00	25.00
UREA for potatoes	0	37.50
DAP for potatoes	0	50.00
Mancozeb	0	2.00
Redomil Gold	0	1.00
Pump unit	0	0.25
Pump repair and maintenance cost	0	10%
Pump lifespan	11 years	11 years
Fuel	0	100.00 L
Losses		
Maize	8%	8%
Potatoes	6%	6%
Opportunity cost of family labor		
Plowing	15.00 ETB	15.00 ETB
Planting	15.00 ETB	15.00 ETB
Fertilizer application	30.00 ETB	30.00 ETB

Weeding	15.00 ETB	15.00 ETB
Hilling	15.00 ETB	15.00 ETB
Harvesting	20.00 ETB	20.00 ETB
Pesticide application	25.00 ETB	25.00 ETB
Activities time allocation (Person/Days/0.25		
Maize		
Plowing	4	4
Planting	2	2
Fertilizer application	1	1
Weeding	8	8
Harvesting	3	3
Potatoes		
Plowing	0	4
Planting	0	3
Fertilizer application	0	1
Hilling	0	10
Weeding	0	5
Pesticide application	0	2
Harvesting	0	2

Table 5. Parameters for analysis of the intervention in the tomatoes value chain

Parameters	Without Intervention	With Intervention
Household size	5 people	5 people
Area under maize	0.25 Ha	0.25 Ha
Rental value of land	800.00 ETB/Ha/year	800.00 ETB/Ha/year
Land tax	85.00 ETB/year	85.00 ETB/year
Average family consumption		
Tomatoes	0	50.00 kg
Maize	250.00 kg	250.00 kg
Monocropping annual productivity and prices		
Maize yield	2,400.00 kg/Ha	2,400.00 kg/Ha
Tomato yield	0	12,000.00 kg/Ha
Maize price	4.00 ETB/kg	4.00 ETB/kg
Tomato price	5.00 ETB/kg	5.00 ETB/kg
Drought factor		
Number of droughts in 5-year period (max. 3 droughts)	0	0
Maize yield during drought	500.00 kg/Ha	2,400.00 kg/Ha
Fuel requirements for irrigation	0	25.00 L/timad
Input costs		
Maize seeds	30.40 ETB/kg	30.40 ETB/kg
Tomato seeds	380.00 ETB/kg	380.00 ETB/kg
UREA	7.60 ETB/kg	7.60 ETB/kg
DAP	15.55 ETB/kg	15.55 ETB/kg
Mancozeb	140.00 ETB/kg	140.00 ETB/kg
Redomil Gold	450.00 ETB/kg	450.00 ETB/kg
Selecron	500.00 ETB/kg	500.00 ETB/kg
Endosulfan	280.00 ETB/kg	280.00 ETB/kg
Karate	380.00 ETB/kg	380.00 ETB/kg
Tackling	4.00 ETB	4.00 ETB
Jute string	10.00 ETB	10.00 ETB
Pump	8,500.00 ETB/pc	8,500.00 ETB/pc
Fuel	21.00 ETB/L	21.00 ETB/L
Input requirements in kg/0.25Ha		
Maize seeds	12.50	12.50
Tomato seeds	0	0.10
UREA for maize	25.00	25.00
DAP for maize	25.00	25.00
UREA for tomatoes	0	25.00
DAP for tomatoes	0	37.50
Tackling	0	25.00
Jute string	0	10.00
Mancozeb	0	4.00
Redomil Gold	0	4.00
Selecron	0	1.00
Endosulfan	0	2.50
Karate	0	1.00
Pump unit	0	0.25
Pump repair and maintenance cost	0	10%
Pump lifespan	11 years	11 years
Fuel	0	102.00 L
Losses		
Maize	8%	8%
Tomatoes	19.40%	19.40%
Opportunity cost of family labor		
Raising seedlings	15.00 ETB	15.00 ETB
Plowing	15.00 ETB	15.00 ETB
Planting	15.00 ETB	15.00 ETB

Fertilizer application	30.00 ETB	30.00 ETB
Weeding	15.00 ETB	15.00 ETB
Stacking	15.00 ETB	15.00 ETB
Harvesting	20.00 ETB	20.00 ETB
Pesticide application	25.00 ETB	25.00 ETB
Activities time allocation (Person/Days/0.25 Ha)		
Maize		
Plowing	4	4
Planting	2	2
Fertilizer application	1	1
Weeding	8	8
Harvesting	3	3
Tomatoes		
Raising seedlings	0	2
Plowing	0	4
Planting	0	6
Fertilizer application	0	1
Tackling	0	5
Weeding	0	10
Pesticide application	0	5
Harvesting	0	15

Table 6. Parameters for analysis of the intervention in the onions value chain

Parameters	Without Intervention	With Intervention
Household size	5 people	5 people
Area under maize	0.25 Ha	0.25 Ha
Rental value of land	800.00 ETB/Ha/year	800.00 ETB/Ha/year
Land tax	85.00 ETB/year	85.00 ETB/year
Average family consumption		
Onion	0	50.00 kg
Maize	250.00 kg	250.00 kg
Monocropping annual productivity and prices		
Maize yield	2400.00 kg/Ha	2400.00 kg/Ha
Onion yield	0	13,000.00 kg/Ha
Maize price	4.00 ETB/kg	4.00 ETB/kg
Onion price	4.50 ETB/kg	4.50 ETB/kg
Drought factor		
Number of droughts in 5-year period (max. 3 droughts)	0	0
Maize yield during drought	500.00 kg/Ha	2400.00 kg/ha
Fuel requirements for irrigation	0	25.00 L
Input costs		
Maize seeds	30.40 ETB/kg	30.40 ETB/kg
Onion seeds	4000.00 ETB/kg	400.00 ETB/kg
UREA	7.60 ETB/kg	7.60 ETB/kg
DAP	15.55 ETB/kg	15.55 ETB/kg
Mancozeb	140.00 ETB/kg	140.00 ETB/kg
Redomil Gold	450.00 ETB/kg	450.00 ETB/kg
Selecron	500.00 ETB/kg	500.00 ETB/kg
Endosulfan	280.00 ETB/kg	280.00 ETB/kg
Karate	380.00 ETB/kg	380.00 ETB/kg
Pump	8500.00 ETB/pc	8500.00 ETB/pc
Fuel	21.00 ETB/L	21.00 ETB/L
Inputs requirements in kg/0.25 Ha		
Maize seeds	12.50	12.50
Onion seeds	0	0.10
UREA for maize	25.00	25.00
DAP for maize	25.00	25.00
UREA for onion	0	25.00
DAP for onion	0	37.50
Mancozeb	0	4.00
Redomil Gold	0	4.00
Selecron	0	1.00
Endosulfan	0	2.50
Karate	0	1.00
Pump unit	0	0.25
Pump repair and maintenance cost	0	10%
Pump lifespan	11 years	11 years
Fuel	0	128.00 L/timad
Losses		
Maize	8%	8%
Onion	10.70%	10.70%
Opportunity cost of family labor		
Raising seedlings	15.00 ETB	15.00 ETB
Plowing	15.00 ETB	15.00 ETB
Planting	15.00 ETB	15.00 ETB
Fertilizer application	30.00 ETB	30.00 ETB

Weeding	15.00 ETB	15.00 ETB
Harvesting	20.00 ETB	20.00 ETB
Pesticide application	25.00 ETB	25.00 ETB
Activities time allocation (Person/Days/0.25 Ha)		
Maize		
Plowing	4	4
Planting	2	2
Fertilizer application	1	1
Weeding	8	8
Harvesting	3	3
Onion		
Seedlings raising	0	2
Plowing	0	4
Planting	0	8
Fertilizer application	0	2
Weeding	0	10
Pesticide application	0	5
Harvesting	0	4

PROJECT MODELING

The GRAD vegetable chain interventions' financial and economic feasibility have been estimated beginning with a financial cash-flow model for each interventions. All revenues or potential revenues have been treated as cash inflows, and all expenditures or potential expenditures as cash outflows. (Jenkins, Kuo, and Harberger, 2012) The analysis reviews a period of 11 years.

To estimate the financial sustainability of the interventions in the vegetables value chain, the annual debt service coverage ratios (ADSCRs) of the project over the life of the loans used to finance them have been calculated together with the project's FNPV of the project.

The economy resource-flow statements have been constructed by adjusting each of the line items in the cash-flow statements for the total investment point of view by proper economic conversion factors (CFs). These conversion factors have been derived by dividing the separately calculated economic value of a unit of an item by its financial price.

INTERVENTION

The purpose of the project model is to estimate the net benefit of USAID interventions and to estimate the net impact of these interventions on the income of the participating families. It is necessary to first understand the revenues and expenditures of the existing cultivation practices adopted by the households. Next, these values must be compared with revenues and expenditures under GRAD's suggested practices to determine whether the incremental benefits of the GRAD interventions are worth the cost. This has been carried out by examining "with" and "without" scenarios with respect to revenues and expenditure profiles and then constructing an incremental cash-flow statement for the entire 11-year evaluation period.

(a) "Without" Intervention Scenario (Case of Intervention in Potatoes, Onions, and Tomatoes Value Chain)

Ethiopian farmers who have no access to irrigation currently intercrop and rotate different crops. Their main landholdings are usually allocated for the production of maize, wheat, barley, and other cereals. This baseline (or "without" scenario) analysis assumes that households are cultivating only maize and each household's landholding is limited to 1 timad (0.25 Ha). The expenditures and incomes for the "without" intervention scenario are as follows:

Revenue: The revenue for the households is the value of maize, whether it is sold or consumed at home. The maize yield is 600 kg/timad. An allowance is made for a post-harvest loss of 8 percent, which reduces the total quantity harvested to 552 kg/timad. At the current price of 4 ETB/kg, this translates into 2,208 ETB of potential revenues per year. Approximately 250 kg of maize is consumed at home, however, allowing a farmer to sell 302 kg of maize per harvest.

Expenditures: A full list of expenditures is presented in tables 4, 5, and 6, above, for potatoes, onions, and tomatoes, respectively. The expenditures for maize cultivation are divided into two groups: input costs and activity costs. Input costs are maize seeds, UREA, and DAP. This group of expenditures represents the household's monetary cash outflows. Activity costs are the opportunity cost of labor and land. This group of expenditures is not a monetary cash outflow for

the household but the value of the group's opportunity cost. There is also an annual land tax of 85 ETB/Ha.[8]

(b) "With" Intervention Scenario (Case of Intervention in Potatoes Value Chain)

The intervention in the potatoes value chain will allow targeted households to have an additional rotation round per year allocated to the cultivation of vegetables, made possible because of access to irrigation. The intervention will not change the pattern of land allocation during the long rainy season; instead, it will allow farmers to minimize risks associated with frequent drought occurrences in Ethiopia, because the households will be able to provide supplementary water from irrigation in the case of drought. The expenditures and revenues for potato cultivation are as follows:

Revenue: The annual revenue for the household is the value of maize and potatoes, whether they are sold or consumed at home. The maize yield is 600 kg/timad. An 8 percent post-harvest loss reduces yields to 552 kg of maize per timad. If it were sold at the current market price of 4 ETB, the value of the harvested maize is 2,208 ETB. A quarter of a metric ton of maize is consumed at home, allowing the household to sell 302 kg of maize.

The yield of potatoes using improved seeds is assumed to be 19,000 kg/Ha, or 4,750 kg/timad. The post-harvest potato loss is reported to be 6 percent, so the total quantity available for sale is 4,465 kg. It is assumed that the price of potatoes does not increase due to the quality increase because of the improved seeds, but the price of potatoes fluctuates wildly in Ethiopia. The baseline scenario assumes a price of ETB 2.50/kg for potatoes. At such a price level, the total value of potatoes produced amounts to ETB 11,162.50. Family consumption of potatoes is reported to be 400 kg from each harvest, allowing the household to sell the remaining 4,065 kg.

Expenditures:

The full list of expenditures is presented in table 4, above. The annual expenditures for maize are the same as in the "without" intervention scenario. The expenditures for potato cultivation are divided into three groups: input costs, investment costs, and activity costs. Input costs are the cost of potato seeds, fertilizers, amortization of the pump, and the fuel required for the pump irrigation. There is also a one-time investment cost to purchase the pump, shared by group of four farmers. The annual amortization cost of the pump is assumed to be 10 percent of the investment cost, and the pump is assumed to last for 11 years. These two groups of expenditures represent real monetary outflows from the household. The last group is activity costs, which are the opportunity costs of labor and land. The opportunity cost of land, represented by the rental value, is shared between the two rotation rounds.

(c) "With" Intervention Scenario (Case of Intervention in Onions Value Chain)

Revenue: The annual revenue for the household is the value of maize and onions, whether they are sold or consumed at home. The maize yield is 600 kg/timad. An 8 percent post-harvest loss reduces the net yield to 552 kg/timad of maize. If it were sold at the current market price of 4 ETB, the value of the maize harvested is 2,208 ETB. A quarter of a metric ton of maize is consumed at home, allowing the household to sell 302 kg of maize.

[8] The land tax in Ethiopia is calculated based on a number of factors, such as soil fertility. The rate used in the analysis was the most frequent one mentioned by the households during interviews.

The yield of onions using improved seeds is 13,000 kg/Ha, or 3,250 kg/timad. The post-harvest loss is reported to be 10.7 percent, so the total quantity available for sale is 2,902.25 kg. It is assumed that the price of onions does not increase due to the quality increase because of the improved seeds. The price of vegetables fluctuates seasonally in Ethiopia, and onions are no exception. The baseline scenario of the analysis uses the price of ETB 4.50/kg for onions. At this price level, the total value of onions produced is ETB 13,060.13. Annual family consumption of onions is reported to be 50 kg, allowing the household to sell the remaining 2,852.25 kg.

Expenditures:

The lists of expenditures are presented in table 5, above. The annual expenditures for maize are the same as in the "without" intervention scenario. The expenditures for onion cultivation are divided into three groups: input costs, investment costs, and activity costs. Input costs are the cost of onion seeds, fertilizers, the amortization cost of the pump, and the fuel required for irrigation. A one-time investment cost covers the purchase of the pump for irrigation and is shared by a group of four farmers. The annual amortization cost of the pump is assumed to be 10 percent of the investment cost, and it is assumed to last for 11 years. These two groups of expenditures represent real monetary outflows for the household. The last group is the activity costs, which are the opportunity costs of labor and land. The opportunity cost of land, represented by the rental value, is now shared between the two rotation rounds.

(d) "With" Intervention Scenario (Case of Intervention in Tomatoes Value Chain)

Revenue: The annual revenue for the family is the value of maize and tomatoes, whether they are sold or consumed at home. The maize yield is 600 kg/timad. An 8 percent post-harvest loss reduces net yields to 552 kg/timad of maize. If it were sold at the current market price of 4 ETB, the value of the maize harvested is 2,208 ETB. A quarter of a metric ton of maize is consumed at home, allowing the household to sell 302 kg of maize.

The yield of tomatoes using improved seeds is equal to 12,000 kg/Ha, or 3,000 kg/timad. The post-harvest loss for tomatoes is reported to be 19.4 percent (due to the commodity's highly perishable nature), so the total quantity available for sale is 2,418 kg. The price of vegetables fluctuates seasonally in Ethiopia, and tomatoes are no exception. The post-harvest price is usually also very low due to high post-harvest loss rates associated with larger storage of the commodity. The baseline scenario of the analysis uses a price of 5 ETB/kg of tomatoes. At this price level, the total value of tomatoes produced amounts to 12,090 ETB. Annual family consumption of tomatoes is reported to be 50 kg, allowing the household to sell the remaining 2,368 kg.

Expenditures:

The full list of expenditures is presented in table 6, above. The annual expenditures for maize are the same as in the "without" intervention scenario. The expenditures for tomato cultivation are divided into three groups: input costs, investment costs, and activity costs. Input costs are the cost of tomato seeds and fertilizers, the amortization cost of the pump, and the fuel required for the irrigation. There is also a one-time investment cost to purchase the pump for irrigation, which is shared by a group of four farmers. The annual amortization cost of the pump is assumed to be 10 percent of the investment cost, and the pump is assumed to last for 11 years. These two groups of expenditures represent real monetary outflows for the household. The last group is activity costs, which are the opportunity costs of labor and land. The opportunity cost of land, represented by the rental value, is now shared between the two rotation rounds.

PREPARATORY TABLES

In the cost-benefit analysis (CBA) models of the interventions in the vegetables value chains, tables 2 to 10 present preparatory information about potatoes, onions, and tomatoes cultivation; projected expenditures; and the value of production for "with" and "without" intervention scenarios.

Table 2 shows the total investment cost required for vegetable cultivation, which is estimated to be 8,017.50 ETB (US$458.14) for potatoes, 9,556.13 ETB (US$546.06) for onions, and 9,018.13 ETB (US$515.32) for tomatoes. Table 2 forms the basis of table 3, which shows how the loan's total amount is derived. In addition to the investment cost, the total loan amount includes a service charge of 1 percent, an insurance fee of 1 percent, a pass book fee of 15 ETB, and up-front savings of 10 percent of the total investment required. These up-front savings are returned to the household upon repayment of the loan, with no interest accrued on the amount. The loan amounts are 8,994.60 ETB (US$513.98) for potatoes, 10,729.06 ETB (US$613.09) for onions, and 10,115.30 ETB (US$578.02) for tomatoes.

Table 4 presents domestic inflation per production period (6 months), which is estimated to be 9.54 percent, and the resulting domestic price index. The vegetables are cultivated in the period between January and June, during the short rainy season. The maize is cultivated in the period between June and January, during the long rainy season. 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 Ethiopian Birr to the U.S. Dollar is derived by multiplying the current exchange rate and the relative price index. The relative price index, in turn, is the factor of inflation in Ethiopia and the United States.

Table 5 depicts the projected loan schedule. It is designed to determine the household's ability to repay the suggested loan over a 1-year period to avoid increasing the loan life to 3 years; a 5-month grace period is included. The annual interest rate is 15 percent, which is below the current market interest rate in Ethiopia. The compounded monthly interest rate is estimated to be 1.17 percent. It is assumed that a household will take a loan before the beginning of the production cycle in January and repay any principal and interest accrued after it harvests and sells its vegetables in June.

Table 6 presents production round–based nominal input and operating costs for "with" and "without" intervention scenarios. The nominal values are derived by adjusting current values over the corresponding price index. It is assumed that each household bears all production-related costs at the beginning of the 6-month period, but the resulting yield is then sold at the beginning of the next period.

Table 7 presents the annual production in kilograms for the "with" and "without" intervention scenarios. This table forms the base for table 8, which shows the total value of production in nominal terms. Table 9, in turns, presents nominal inputs and operating costs for "without" and "with" intervention scenarios.

Table 15 of the CBA model shows the schedule for the proposed loan structure. The loan's life period is proposed to be extended to 3 years with annual repayments, plus a grace period of 5 months. The interest rate is 15 percent. Farmers, however, will pay only 7.24 percent interest for the first year of the loan, because interest accrues only for 6 months preceding the first principal repayment.

FINANCIAL ANALYSIS

The modeling exercise has been constructed for an 11-year evaluation period. Tables 11 and 12 in the model present the cash-flow statements from the total investment or project points of view in nominal and real values for "with" and "without" intervention scenarios.

The "without" intervention scenario (maize cultivation) yields an FNPV of 4,841 ETB (US$272), with a real discount rate of 12 percent. Table 7, below, shows the FNPV of the "with" intervention case, when the household is able to plant an additional rotation allocated for vegetable cultivation.

Table 7. FNPV of the interventions—"with" scenario

FNPV	ETB	US$
Intervention in potatoes value chain	**33,357.26**	**1,874.00**
Intervention in tomatoes value chain	**28,814.33**	**1,618.78**
Intervention in onions value chain	**34,514.40**	**1,939.01**

Table 12C of the CBA model has been constructed to run a sensitivity analysis on the effects of drought. No incremental benefits from the intervention emerge for the first rotation round (maize cultivation) under normal climatic conditions. During the drought year, however, the presence of irrigation may help farmers overcome an insufficient level of rain. During these years, the intervention also has a positive impact on the maize cultivation round. The sensitivity analysis shows that the FNPV increases if drought occurs, indicating incremental benefits of the intervention at the household level.

Examining the differences between the "with" and "without" intervention scenarios helps estimate the benefits of the intervention for family welfare. Tables 11 and 12 of the CBA model inform the consequent construction of the incremental cash-flow statements from the total investment or project points of view, as presented in table 13 of the CBA model. The results of the incremental analysis are presented in table 8, below.

Table 8. Incremental FNPV of the interventions

FNPV @ 12% discount rate	ETB	US$
Intervention in potatoes value chain	**28,516.90**	**1,602.02**
Intervention in tomatoes value chain	**23,972.97**	**1,346.80**
Intervention in onions value chain	**29,673.04**	**1,667.02**

Tables 9, 10, and 11 present incremental cash flows for interventions in the potatoes, onions, and tomatoes chains.

Table 9. Incremental cash-flow statement—total investment point of view (ETB, real), potatoes

Line Items	Year <<<	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Receipts												
Marketed maize		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
In-house maize consumption		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Marketed potato		10,162.50	10,162.50	10,162.50	10,162.50	10,162.50	10,162.50	10,162.50	10,162.50	10,162.50	10,162.50	10,162.50
In-house potato consumption		1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00
Total inflows		**11,162.50**	**11,162.50**	**11,162.50**	**11,162.50**	**11,162.50**	**11,162.50**	**11,162.50**	**11,162.50**	**11,162.50**	**11,162.50**	**11,162.50**
Expenditures												
Investment cost												
Pump		2,125.00										
Input costs												
Maize seeds		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Potato seeds		2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00
UREA (for maize production)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DAP (for maize production)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UREA (for potato production)		285.00	285.00	285.00	285.00	285.00	285.00	285.00	285.00	285.00	285.00	285.00
DAP (for potato production)		777.50	777.50	777.50	777.50	777.50	777.50	777.50	777.50	777.50	777.50	777.50
Mancozeb		280.00	280.00	280.00	280.00	280.00	280.00	280.00	280.00	280.00	280.00	280.00
Redomil Gold		450.00	450.00	450.00	450.00	450.00	450.00	450.00	450.00	450.00	450.00	450.00
Pump repair and maintenance cost		212.50	212.50	212.50	212.50	212.50	212.50	212.50	212.50	212.50	212.50	212.50
Fuel (gasoline)		2,100.00	2,100.00	2,100.00	2,100.00	2,100.00	2,100.00	2,100.00	2,100.00	2,100.00	2,100.00	2,100.00
Activity costs												
Maize												
-Plowing		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

-Planting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-Fertilizer application	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-Weeding	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-Harvesting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Potatoes											
-Plowing	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
-Planting	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00
-Hilling	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00
-Fertilizer application	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
-Weeding	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00
-Harvesting	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00
-Pesticides application	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Land Tax	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total outflows	8680.00	6555.00	6555.00	6555.00	6555.00	6555.00	6555.00	6555.00	6555.00	6555.00	6555.00
Net cash inflows	2482.50	4607.50	4607.50	4607.50	4607.50	4607.50	4607.50	4607.50	4607.50	4607.50	4607.50
Net cash flows, real US$	***139.47***	***258.85***	***258.85***	***258.85***	***258.85***	***258.85***	***258.85***	***258.85***	***258.85***	***258.85***	***258.85***

NPV @12% Discount rate ETB	**28,516**
NPV @12% Discount rate US$	**1,602**

Table 10. Incremental cash-flow statement—total investment point of view (ETB, real), onions

Line Items (Year <<<)	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Receipts											
Marketed maize	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
In-house maize consumption	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Marketed onion	12,835.13	12,835.13	12,835.13	12,835.13	12,835.13	12,835.13	12,835.13	12,835.13	12,835.13	12,835.13	12,835.13
In-house onion consumption	225.00	225.00	225.00	225.00	225.00	225.00	225.00	225.00	225.00	225.00	225.00
Total inflows	**13,060.13**	**13,060.13**	**13,060.13**	**13,060.13**	**13,060.13**	**13,060.13**	**13,060.13**	**13,060.13**	**13,060.13**	**13,060.13**	**13,060.13**
Expenditures											
Investment cost											
Pump	2,125.00										
Input costs											
Maize seeds	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Onion seeds	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00
UREA (for maize production)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DAP (for maize production)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UREA (for onion production)	190.00	190.00	190.00	190.00	190.00	190.00	190.00	190.00	190.00	190.00	190.00
DAP (for onion production)	583.13	583.13	583.13	583.13	583.13	583.13	583.13	583.13	583.13	583.13	583.13
Mancozeb	560.00	560.00	560.00	560.00	560.00	560.00	560.00	560.00	560.00	560.00	560.00
Redomil Gold	1,800.00	1,800.00	1,800.00	1,800.00	1,800.00	1,800.00	1,800.00	1,800.00	1,800.00	1,800.00	1,800.00
Selecron	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
Endosulfan	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00
Karate	380.00	380.00	380.00	380.00	380.00	380.00	380.00	380.00	380.00	380.00	380.00
Pump repair and maintenance cost	212.50	212.50	212.50	212.50	212.50	212.50	212.50	212.50	212.50	212.50	212.50
Fuel (Gasoline)	2,688.00	2,688.00	2,688.00	2,688.00	2,688.00	2,688.00	2,688.00	2,688.00	2,688.00	2,688.00	2,688.00

Activity Costs											
Maize											
-Plowing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-Planting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-Fertilizer application	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-Weeding	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-Harvesting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Onion											
-Raising seedlings	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
-Plowing	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
-Planting	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00
-Fertilizer application	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
-Weeding	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00
-Harvesting	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00
-Pesticide application	125.00	125.00	125.00	125.00	125.00	125.00	125.00	125.00	125.00	125.00	125.00
Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Land tax	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total outflows	10403.63	8278.63	8278.63	8278.63	8278.63	8278.63	8278.63	8278.63	8278.63	8278.63	8278.63
Net cash flows	2656.50	4781.50	4781.50	4781.50	4781.50	4781.50	4781.50	4781.50	4781.50	4781.50	4781.50
Net cash flows, real US$	***149.24***	***268.62***	***268.62***	***268.62***	***268.62***	***268.62***	***268.62***	***268.62***	***268.62***	***268.62***	***268.62***

NPV @12% discount rate ETB	**29,673.04**
NPV @12% discount rate US$	**1,667.02**

Table 11. Incremental cash-flow statement—total investment point of view (ETB, real), tomatoes

Line Items	Year <<<	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Receipts												
Marketed maize		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
In-house maize consumption		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Marketed tomatoes		11,840.00	11,840.00	11,840.00	11,840.00	11,840.00	11,840.00	11,840.00	11,840.00	11,840.00	11,840.00	11,840.00
In-house tomato consumption		250.00	250.00	250.00	250.00	250.00	250.00	250.00	250.00	250.00	250.00	250.00
Total inflows		**12,090.00**	**12,090.00**	**12,090.00**	**12,090.00**	**12,090.00**	**12,090.00**	**12,090.00**	**12,090.00**	**12,090.00**	**12,090.00**	**12,090.00**
Expenditures												
Investment cost												
Pump		2,125.00										
Input costs												
Maize seeds		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tomato seeds		38.00	38.00	38.00	38.00	38.00	38.00	38.00	38.00	38.00	38.00	38.00
UREA (for maize production)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DAP (for maize production)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UREA (for tomato production)		190.00	190.00	190.00	190.00	190.00	190.00	190.00	190.00	190.00	190.00	190.00
DAP (for tomato production)		583.13	583.13	583.13	583.13	583.13	583.13	583.13	583.13	583.13	583.13	583.13
Tackling		100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Jute string		100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Mancozeb		560.00	560.00	560.00	560.00	560.00	560.00	560.00	560.00	560.00	560.00	560.00
Redomil Gold		1,800.00	1,800.00	1,800.00	1,800.00	1,800.00	1,800.00	1,800.00	1,800.00	1,800.00	1,800.00	1,800.00
Selecron		500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00	500.00
Endosulfan		700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00	700.00
Karate		380.00	380.00	380.00	380.00	380.00	380.00	380.00	380.00	380.00	380.00	380.00
Pump repair and maintenance cost		212.50	212.50	212.50	212.50	212.50	212.50	212.50	212.50	212.50	212.50	212.50

Fuel (gasoline)	2,142.00	2,142.00	2,142.00	2,142.00	2,142.00	2,142.00	2,142.00	2,142.00	2,142.00	2,142.00	2,142.00
Activity costs											
Maize											
-Plowing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-Planting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-Fertilizer application	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-Weeding	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-Harvesting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tomatoes											
-Raising seedlings	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
-Plowing	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
-Planting	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00
-Tackling	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00
-Fertilizer application	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
-Weeding	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00
-Harvesting	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00
-Pesticide Application	125.00	125.00	125.00	125.00	125.00	125.00	125.00	125.00	125.00	125.00	125.00
Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Land tax	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total outflows	10290.63	8165.63	8165.63	8165.63	8165.63	8165.63	8165.63	8165.63	8165.63	8165.63	8165.63
Net cash inflows	1799.38	3924.38	3924.38	3924.38	3924.38	3924.38	3924.38	3924.38	3924.38	3924.38	3924.38
Net cash flows, real US$	***101.09***	***220.47***	***220.47***	***220.47***	***220.47***	***220.47***	***220.47***	***220.47***	***220.47***	***220.47***	***220.47***

NPV @12% discount rate ETB	**23,973**
NPV @12% discount rate US$	**1,347**

Table 14 in the CBA depicts the cash-flow statement from the total investment point of view, excluding home consumption. Although home consumption definitely has value for the household, it does not represent a monetary inflow. Despite possibly reducing some expenditures for other types of food, it is excluded from the analysis to assess a household's ability to service its debt obligations. The same rationale holds for the opportunity cost of family labor: In this case, labor expense should be added back to the net cash flow over the period, because the income stays within the family and can therefore be used to cover debt obligations. Table 14 is also constructed on an incremental basis to determine the household's ability to repay the loan without requiring a contribution of financial resources from other activities.

The loan structure initially proposed by the GRAD project's implementers has a loan repayment period of 1 year, with semi-annual repayments and a grace period of 5 months. The farmers who plant one rotation of vegetables will borrow before the planting period and repay this loan after the harvest.

The ADSCRs for the loan structure initially proposed by the GRAD implementers[9] are presented in table 12, below.

Table 12. ADSCRs for the initial loan structure

Intervention in potatoes value chain	**0.40**
Intervention in tomatoes value chain	**0.48**
Intervention in onions value chain	**0.43**

An ADSCR value below 1 indicates that the household will have insufficient incremental cash flows to cover its debt obligations. The projected ADSCRs for the potatoes, onions, and tomatoes value chains fall even lower, below the value of 0.5, so the household may need to finance more than 50 percent of the debt burden by contributing financial resources from another sources of income. Taking into consideration the loan's large amount, it would be problematic for the household to find the required amount of money to repay it.

The ADSCRs for the loan structure proposed in this analysis are presented in table 13, below.

Table 13. ADSCRs for the proposed loan structure

Year	*1*	*2*	*3*
Intervention in potatoes value chain	**0.80**	**1.30**	**2.33**
Intervention in tomatoes value chain	**0.86**	**1.36**	**2.33**
Intervention in onions value chain	**0.98**	**1.61**	**2.47**

With this structure, the ADSCRs are all still below 1 for the first year of the loan, but they are much higher than in the previous case. Therefore, GRAD project beneficiaries may have some flexibility in terms of the loan repayment.[10] In this case, the household would be allowed to repay only a fraction of the debt obligation for the first year in the following year. The ADSCRs for the second year are calculated using an amount of debt service that includes the remaining amount of the loan from the first year. The ADSCRs in all three cases is above 1, indicating the household's ability to cover its debt obligations over time. The ADSCRs in the third year of the loan

[9] Note: Interventions proposed by GRAD project implementers did not include the cost of the pump and fuel required for irrigation.

[10] SNV reported that the households will have flexibility in situations involving unforeseen circumstances or other difficulties faced by many farmers.

repayment period is above 2, so the household should not face any difficulties covering its debt obligation for that period as well.

Table 16 of the CBA model presents the cash-flow statement in real terms from the equity point of view. The only difference between the total investment and the equity points of view is the financing: The cash-flow statement from the total investment point of view is constructed to assess the project's overall attractiveness. The cash-flow statement from the equity point of view, in turn, determines the returns to the household after taking into consideration the loan inflow and the debt service outflow. The resulting FNPVs from the equity point of view are presented in table 14, below.

Table 14. FNPVs from the equity point of view (household point of view)

FNPV @ 12% discount rate	ETB	US$
Intervention in potatoes value chain	**28,075.06**	**1,577.25**
Intervention in tomatoes value chain	**23,651.80**	**1,328.75**
Intervention in onions value chain	**29,706.18**	**1,668.89**

As shown in table 14, the household impacts from these interventions are positive overall and quite substantial. In the 11-year period analyzed, they range from US$1,668.89 for onions to US$1,328.75 for tomatoes and US$1,577.25 for potatoes.

ECONOMIC ANALYSIS

Differences arise 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 (e.g., government taxes). To show the proposed intervention's true economic impact on the Ethiopian economy, the economic values are derived by adjusting the financial values by appropriate economic CFs. If no distortion is present in a market, then the financial value of an item is used to measure its economic value. The economic net present values (ENPVs) for each value chain are presented in table 15, below.

Table 15. ENPV for each intervention

ENPV @ 12% discount rate	ETB	US$
Intervention in potatoes value chain	**31,355.56**	**1,761.55**
Intervention in tomatoes value chain	**25,592.00**	**1,437.75**
Intervention in onions value chain	**32,070.47**	**1,801.71**

Ethiopia currently exports substantial quantities of vegetables to its neighboring countries, such as Kenya and Sudan. Because vegetables are quite perishable, exports from areas that are distant from the borders possess significant risks. The woredas selected for the vegetables value chain interventions are far from the border areas, so this analysis assumes that commodities there will only be consumed domestically. This assumption is also supported by the fact that the commodities see wide seasonal price fluctuations. No foreign exchange externality goes to the economy in this case for the internationally nontraded vegetables. Production inputs, such as fertilizers, pumps, and fuel, are imported to Ethiopia. Their economic cost is higher than their financial cost because of foregone foreign exchange. The foreign exchange premium (FEP) for Ethiopia is estimated to be 6.5 percent (Kuo, 2011), which means that every incremental dollar

spent on imports has an economic cost of 1.065 times the marked exchange rate. In the case of fertilizers, where there are no other tax distortions, this means that every incremental kilogram of fertilizer used should be attributed with a negative externality value of 6.5 percent.

However, a duty rate of 10 percent and VAT of 15 percent are applied on pumps when they are imported to the country. Costs are also associated with transporting the pumps from the port to the households; the economic CF for transportation is reported to be 0.84. A significant distortion is present in the market because of the high tax rate that is assessed in Ethiopia on fuel and spare parts. The resulting distortion for the pumps is reported to be 16 percent, so the economic cost of every incremental financial dollar spent on a pump has an economic cost of 84 cents.

Ethiopia has a high tariff rate and other taxes applied on fuel. Taxes, in turn, just represent a transfer of resources from consumers to the government. At the same time, fuel is internationally traded and requires a FEP of 6.5 percent. Overall, the economic cost of fuel to the economy is less than its financial cost. Every incremental dollar spent on fuel required for irrigation has an economic cost of 79 cents. Tables 16, 17, and 18 present the resource-flow statements from the economy's point of view.

Table 16. Resource-flow statement—economy point of view (ETB, real), potatoes

Line items	CF	Year<<<<	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	PV
Receipts														
Marketed maize	**1.02**		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
In-house maize consumption	**1.02**		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Marketed potato	**1.00**		10,162.50	10,162.50	10,162.50	10,162.50	10,162.50	10,162.50	10,162.50	10,162.50	10,162.50	10,162.50	10,162.50	**67,582.89**
In-house potato consumption	**1.00**		1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	**6,650.22**
Total inflows			**11,162.50**	**11,162.50**	**11,162.50**	**11,162.50**	**11,162.50**	**11,162.50**	**11,162.50**	**11,162.50**	**11,162.50**	**11,162.50**	**11,162.50**	**74,233.11**
Expenditures														
Investment cost														
Pump	**0.84**		1,792.02											**1,792.02**
Input costs														
Maize seeds	**1.02**		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Potato seeds	**1.00**		2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	**13,300.45**
UREA (for maize production)	**1.06**		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
DAP (for maize production)	**1.06**		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
UREA (for potato production)	**1.06**		300.85	300.85	300.85	300.85	300.85	300.85	300.85	300.85	300.85	300.85	300.85	**2,000.75**
DAP (for potato production)	**1.06**		820.75	820.75	820.75	820.75	820.75	820.75	820.75	820.75	820.75	820.75	820.75	**5,458.19**
Mancozeb	**1.07**		298.20	298.20	298.20	298.20	298.20	298.20	298.20	298.20	298.20	298.20	298.20	**1,983.10**
Redomil Gold	**1.07**		479.25	479.25	479.25	479.25	479.25	479.25	479.25	479.25	479.25	479.25	479.25	**3,187.12**
Pump repair and maintenance cost	**0.84**		179.20	179.20	179.20	179.20	179.20	179.20	179.20	179.20	179.20	179.20	179.20	**1,191.74**
Fuel (gasoline)	**0.79**		1,649.81	1,649.81	1,649.81	1,649.81	1,649.81	1,649.81	1,649.81	1,649.81	1,649.81	1,649.81	1,649.81	**10,971.59**
Activity costs														
Maize														
-Plowing	**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**
-Planting	**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**
-Fertilizer application	**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**
-Weeding	**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**
-Harvesting	**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**
Potatoes														
-Plowing	**1.00**		60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	**399.01**
-Planting	**1.00**		45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	45.00	**299.26**

-Hilling	**1.00**	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	**997.53**
-Fertilizer application	**1.00**	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	**199.51**
-Weeding	**1.00**	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	**498.77**
-Harvesting	**1.00**	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	**266.01**
-Pesticide application	**1.00**	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	**332.51**
Land	**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**
Land tax	**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**
Total outflows		7970.09	6178.07	6178.07	6178.07	6178.07	6178.07	6178.07	6178.07	6178.07	6178.07	6178.07	**42,877.56**
Net cash inflows		3192.41	4984.43	4984.43	4984.43	4984.43	4984.43	4984.43	4984.43	4984.43	4984.43	4984.43	**31,355.56**
Net cash flows, real US$		***179.35***	***280.02***	***280.02***	***280.02***	***280.02***	***280.02***	***280.02***	***280.02***	***280.02***	***280.02***	***280.02***	**1,761.55**

NPV @12% discount rate ETB	**31,355.56**
NPV @12% discount rate US$	**1,761.55**

Table 17. Resource-flow statement—economy point of view (ETB, real), onions

Line items	CF	Year<<	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	PV
Receipts														
Marketed maize	**1.02**		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
In-house maize consumption	**1.02**		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Marketed onion	**1.00**		12,835.13	12,835.13	12,835.13	12,835.13	12,835.13	12,835.13	12,835.13	12,835.13	12,835.13	12,835.13	12,835.13	**85,356.44**
In-house onion consumption	**1.00**		225.00	225.00	225.00	225.00	225.00	225.00	225.00	225.00	225.00	225.00	225.00	**1,496.30**
Total inflows			**13,060.13**	**13,060.13**	**13,060.13**	**13,060.13**	**13,060.13**	**13,060.13**	**13,060.13**	**13,060.13**	**13,060.13**	**13,060.13**	**13,060.13**	**86,852.74**
Expenditures														
Investment cost														
Pump	**0.84**		1,792.02											**1,792.02**
Input costs														
Maize seeds	**1.02**		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Onion seeds	**1.00**		40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	**266.01**
UREA (for maize production)	**1.06**		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
DAP (for maize production)	**1.06**		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
UREA (for onion production)	**1.06**		200.57	200.57	200.57	200.57	200.57	200.57	200.57	200.57	200.57	200.57	200.57	**1,333.83**
DAP (for onion production)	**1.06**		615.57	615.57	615.57	615.57	615.57	615.57	615.57	615.57	615.57	615.57	615.57	**4,093.64**
Mancozeb	**1.07**		596.40	596.40	596.40	596.40	596.40	596.40	596.40	596.40	596.40	596.40	596.40	**3,966.19**
Redomil Gold	**1.07**		1,917.00	1,917.00	1,917.00	1,917.00	1,917.00	1,917.00	1,917.00	1,917.00	1,917.00	1,917.00	1,917.00	**12,748.48**
Selecron	**1.07**		532.50	532.50	532.50	532.50	532.50	532.50	532.50	532.50	532.50	532.50	532.50	**3,541.24**
Endosulfan	**1.07**		745.50	745.50	745.50	745.50	745.50	745.50	745.50	745.50	745.50	745.50	745.50	**4,957.74**
Karate	**1.07**		404.70	404.70	404.70	404.70	404.70	404.70	404.70	404.70	404.70	404.70	404.70	**2,691.35**
Pump repair and maintenance cost	**0.84**		179.20	179.20	179.20	179.20	179.20	179.20	179.20	179.20	179.20	179.20	179.20	**1,191.74**
Fuel (gasoline)	**0.79**		2,111.75	2,111.75	2,111.75	2,111.75	2,111.75	2,111.75	2,111.75	2,111.75	2,111.75	2,111.75	2,111.75	**14,043.63**
Activity costs														
Maize														
-Plowing	**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**
-Planting	**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**
-Fertilizer application	**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**
-Weeding	**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**
-Harvesting	**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**
Onion														
-Raising seedlings	**1.00**		30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	**199.51**
-Plowing	**1.00**		60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	**399.01**
-Planting	**1.00**		120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	**798.03**

-Fertilizer application	**1.00**	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	**399.01**
-Weeding	**1.00**	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	**997.53**
-Harvesting	**1.00**	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	**532.02**
-Pesticide application	**1.00**	125.00	125.00	125.00	125.00	125.00	125.00	125.00	125.00	125.00	125.00	125.00	**831.28**
Land	**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**
Land tax	**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**
Total outflows		9760.22	7968.19	7968.19	7968.19	7968.19	7968.19	7968.19	7968.19	7968.19	7968.19	7968.19	**54,782.27**
Net cash flows		3299.91	5091.93	5091.93	5091.93	5091.93	5091.93	5091.93	5091.93	5091.93	5091.93	5091.93	**32,070.47**
Net cash flows, real US$		***185.39***	***286.06***	***286.06***	***286.06***	***286.06***	***286.06***	***286.06***	***286.06***	***286.06***	***286.06***	***286.06***	**1,801.71**

NPV @12% discount rate ETB	**32,070.47**
NPV @12% discount rate US$	**1,801.71**

Table 18. Resource-flow statement—economy point of view (ETB, real), tomatoes

Line items	**CF**	Year<<<<	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	**PV**
Receipts														
Marketed maize	**1.02**		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
In-house maize consumption	**1.02**		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Marketed tomatoes	**1.00**		11,840.00	11,840.00	11,840.00	11,840.00	11,840.00	11,840.00	11,840.00	11,840.00	11,840.00	11,840.00	11,840.00	**78,738.64**
In-house tomatoes consumption	**1.00**		250.00	250.00	250.00	250.00	250.00	250.00	250.00	250.00	250.00	250.00	250.00	**1,662.56**
Total inflows			**12,090.00**	**12,090.00**	**12,090.00**	**12,090.00**	**12,090.00**	**12,090.00**	**12,090.00**	**12,090.00**	**12,090.00**	**12,090.00**	**12,090.00**	**80,401.20**
Expenditures														
Investment cost														
Pump	**0.84**		1,792.02											**1,792.02**
Input costs														
Maize seeds	**1.02**		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Tomato seeds	**1.00**		38.00	38.00	38.00	38.00	38.00	38.00	38.00	38.00	38.00	38.00	38.00	**252.71**
UREA (for maize production)	**1.06**		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
DAP (for maize production)	**1.06**		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
UREA (for tomato production)	**1.06**		200.57	200.57	200.57	200.57	200.57	200.57	200.57	200.57	200.57	200.57	200.57	**1,333.83**
DAP (for tomato production)	**1.06**		615.57	615.57	615.57	615.57	615.57	615.57	615.57	615.57	615.57	615.57	615.57	**4,093.64**
Tackling	**1.00**		100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	**665.02**
Jute string	**1.00**		100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	**665.02**
Mancozeb	**1.07**		596.40	596.40	596.40	596.40	596.40	596.40	596.40	596.40	596.40	596.40	596.40	**3,966.19**
Redomil Gold	**1.07**		1,917.00	1,917.00	1,917.00	1,917.00	1,917.00	1,917.00	1,917.00	1,917.00	1,917.00	1,917.00	1,917.00	**12,748.48**
Selecron	**1.07**		532.50	532.50	532.50	532.50	532.50	532.50	532.50	532.50	532.50	532.50	532.50	**3,541.24**
Endosulfan	**1.07**		745.50	745.50	745.50	745.50	745.50	745.50	745.50	745.50	745.50	745.50	745.50	**4,957.74**
Karate	**1.07**		404.70	404.70	404.70	404.70	404.70	404.70	404.70	404.70	404.70	404.70	404.70	**2,691.35**

Pump repair and maintenance cost	**0.84**	179.20	179.20	179.20	179.20	179.20	179.20	179.20	179.20	179.20	179.20	179.20	**1,191.74**
Fuel (gasoline)	**0.79**	1,682.80	1,682.80	1,682.80	1,682.80	1,682.80	1,682.80	1,682.80	1,682.80	1,682.80	1,682.80	1,682.80	**11,191.02**
Activity costs													
Maize													
-Plowing	**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**
-Planting	**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**
-Fertilizer application	**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**
-Weeding	**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**
-Harvesting	**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**
Tomatoes													
-Raising seedlings	**1.00**	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	**199.51**
-Plowing	**1.00**	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	**399.01**
-Planting	**1.00**	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	**598.52**
-Stacking	**1.00**	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	**498.77**
-Fertilizer application	**1.00**	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	**199.51**
-Weeding	**1.00**	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	**997.53**
-Harvesting	**1.00**	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	300.00	**1,995.07**
-Pesticide application	**1.00**	125.00	125.00	125.00	125.00	125.00	125.00	125.00	125.00	125.00	125.00	125.00	**831.28**
Land	**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**
Land tax	**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**
Total outflows		9764.27	7972.24	7972.24	7972.24	7972.24	7972.24	7972.24	7972.24	7972.24	7972.24	7972.24	**54,809.21**
Net cash flows		2325.73	4117.76	4117.76	4117.76	4117.76	4117.76	4117.76	4117.76	4117.76	4117.76	4117.76	**25,591.99**
Net cash flows, real US$		***130.66***	***231.33***	***231.33***	***231.33***	***231.33***	***231.33***	***231.33***	***231.33***	***231.33***	***231.33***	***231.33***	**1,437.75**

NPV @12% discount rate ETB	**25,591.99**
NPV @12% discount rate US$	**1,437.75**

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 used to produce the item, such as capital, land, and labor. The GRAD interventions in the vegetables value chains yield two groups of beneficiaries: the targeted households and the government of Ethiopia.

The government of Ethiopia benefits from an additional inflow of taxes coming from the tradable inputs used in the production of vegetables. Such inputs are importable goods, where the total tax rates on the item are higher than the FEP. Hence, the inflow of tax revenues is greater than the outflows arising from the additional costs associated with the use of foreign exchange.

High tax rates are assessed on the fuel required for running the pumps. A 10 percent duty rate and a 15 percent VAT are also applied to the pumps when they are imported. These tax rates on fuel and pumps reduce the economic costs below the financial costs and generate tax revenues for the government of Ethiopia.

The fertilizers used for vegetable cultivation are importable goods. The country, however, uses its foreign exchange when such goods are imported, which makes the economic cost of such inputs greater than their financial cost. In Ethiopia, no import duties are assessed for fertilizers used in agriculture.

The values of each of the stakeholders' gains from the three value chain interventions are presented in table 19, below.

Table 19. Stakeholder and beneficiary impacts of project (in US$)

	Potatoes	Onions	Tomatoes
Economic NPV (FNPV + externalities)	1,761.55	1,801.71	1,437.75
• **Financial NPV (households)**	1577.25	1,668.89	1,328.75
• **Externalities**	184.30	132.38	109.00
○ **Government**	159.53	134.69	90.96
○ **Financing contribution**	24.77	–1.86	18.04

The shares of all stakeholders add up to the total value of the net ENPV generated by each of the proposed interventions.

Table 19 shows that the principal beneficiaries of these vegetable interventions are the farming households. In each case, they receive about 90 percent of the total net economic benefits. The government receives about 10 percent of the difference between the ENPV and the FNPV through the additional taxes that it earns via these interventions.

SENSITIVITY ANALYSIS

The variables factored into the sensitivity analysis for the GRAD vegetables value chains include price of improved seeds, rate of post-harvest losses, vegetable prices, price of fuel for irrigation pumps, vegetable yield, effect of drought, and joint impact of vegetable prices and yields as well as joint impact of the price of fuel and price of seeds.

Sensitivity Analysis Findings

1. **Improved seeds:** In all cases, the change in cost of improved seeds does not seriously affect project outcomes, indicating that not much effort is needed to attempt to reduce their cost. Seed availability, however, is a serious issue.

2. **Vegetable losses:** Post-harvest loss rates for potatoes are much lower than the losses for tomatoes and onions: only 6 percent, as compared to 19.4 percent and 10.7 percent, respectively. The much lower loss rate for potatoes is because of their less-perishable nature and because of their greater popularity for in-house consumption as compared to other vegetables. Post-harvest loss is a significant factor when determining the net benefits for households from the interventions. In all cases, however, even a dramatic increase in the post-harvest loss rate results in a positive project outcome. An increase in the potato post-harvest loss rate from 6 to 15 percent, for instance, results in a decrease of additional annual income from US$258 to US$198. A similar result holds for the other varieties of vegetables. (Please see their corresponding CBA models.)

3. **Vegetable prices:** The potato price is a very significant variable, subject not only to variations according to different regions in Ethiopia but also to yields in the current year. An increase in the price of potatoes from 2.50 ETB to 3 ETB allows farmers to earn US$384 in additional income per year. A decrease in price from 2.50 ETB to 2 ETB lowers their additional income to US$133 per year.

4. **Price of fuel:** The interventions' outcomes are affected significantly by the usual changes in the cost of fuel.

5. **Fuel requirements:** The fuel requirement is a significant factor in the cost of water required for irrigation. The water requirement, in turn, is dependent on the rain levels. The agricultural production system of Ethiopia is a rain-feed system, with supplementary water coming from irrigation.

6. **Drought effect:** Drought is a very serious issue for agricultural production in Ethiopia, currently occurring almost twice every 5 years. An attempt has been made to incorporate the drought problem into the analysis by assuming that drought can occur zero, one, two, and three times at most during a 5-year period. Zero occurrences are the base case. If drought occurs once, it occurs during the second year of the 5-year period. If it happens twice, it occurs every second and fourth year; lastly, if drought happens three times, it occurs every second, fourth, and fifth year in the 5-year period. The corresponding vegetable yields during the drought season were obtained from field interviews. It is important to understand that extreme climatic events, such as droughts, have different levels of impact, making it extremely difficult to incorporate them into analysis. Yields, irrigation water requirements, and so forth differ according to the level of drought. In very bad cases, farmers may stop production after planting, hoping that the land will preserve the seeds for the next year's cultivation period.

7. **Vegetable yields:** A major effort should be spent to provide adequate training to the farmers to help them achieve yields that allow them to earn an additional US$365 annually. Inputs to the production also play a significant role; for instance, having access to improved seeds and good-quality fertilizers is very important.

Potatoes Value Chain Sensitivity Analysis

Table 20, below, presents the joint impact of the price of potatoes and the yield on the FNPV.
In the base-case scenario, the price of potatoes is 2.50 ETB/kg, and the yield is 19,000 kg/Ha. The FNPV in this case is US$1,577.25. If the price of potatoes increases to 4.50 ETB/kg and the yield stays at the same level of 19,000 kg/Ha, the FNPV increases to US$4,943.14. The sensitivity analysis shows that if the price of potatoes remains 2.50 ETB/kg but the yield decreases to 12,000 kg/Ha or lower, the FNPV becomes negative. If the potato yield increases to 23,000 kg/Ha or higher within the tested range of potato prices (1.50 to 4.50 ETB/kg), the FNPV is always positive.

Table 20. Joint impact of potato price and yield on FNPV (US$)

	Yield kg/ha						
Price ETB/kg	**8,000.00**	**9,000.00**	**12,000.00**	**15,000.00**	**19,000.00**	**23,000.00**	**25,000.00**
1.50	–2,420.23	–2,247.58	–1,729.66	–1,211.73	–521.16	169.41	512.70
2.00	–1,983.08	–1,752.89	–1,062.32	–371.75	549.01	1,438.94	1,826.32
2.50	–1,545.93	–1,258.19	–394.98	468.23	1,577.25	2,484.80	2,923.79
3.00	–1,108.78	–763.50	272.36	1,308.21	2,440.90	3,494.48	4,021.26
3.50	–671.63	–268.80	939.70	2,045.81	3,274.98	4,504.15	5,118.74
4.00	–234.48	225.90	1,600.22	2,704.29	4,109.06	5,513.83	6,216.21
4.50	202.66	720.59	2,177.51	3,362.78	4,943.14	6,523.50	7,313.68

Table 21, below, presents the joint impact of potato prices and the yield on the net cash flows (NCFs) for years 4 and later. Under the assumed scenario (potato price of 2.50 ETB/kg and yield of 19,000 kg/Ha), the NCF is US$258. The sensitivity analysis shows that when the price of potatoes remains 2.50 ETB/kg but the yield ranges between 12,000 and 25,000, the NCF is always positive. On the other side, if the potato yield decreases to 9,000 kg/Ha or less, a price of 2.50 ETB/kg or less causes the NCF to become negative.

Table 21. Joint impact of potato price and yield on NCFs, years 4 and after (in US$)

	Yield kg/ha						
Price ETB/kg	**8,000.00**	**9,000.00**	**12,000.00**	**15,000.00**	**19,000.00**	**23,000.00**	**25,000.00**
1.50	–209.83	–190.03	–130.62	71.21	8.01	87.20	127.00
2.00	–157.02	–130.62	–51.40	27.81	133.43	239.00	292.00
2.50	–104.21	–71.21	27.81	126.83	258.85	390.90	457.00
3.00	–51.40	–11.80	107.02	225.84	384.27	542.70	622.00
3.50	1.40	47.61	186.24	324.86	509.69	694.50	787.00
4.00	54.21	107.02	265.45	423.88	635.11	846.30	952.00
4.50	107.02	166.43	344.66	522.89	760.53	998.20	1,117.00

Table 22, below, presents the joint impact of the price of fuel for the irrigation pumps and the price of potato seeds on the FNPV of the intervention. Under the assumed scenario, with a fuel price of 21 ETB/L and a price for potato seeds of 400 ETB/kg, the FNPV is US$1,577.25. If the price of fuel increases to 25 ETB/L and the price of potato seeds increases to 500 ETB/kg, the FNPV drops to US$1,146.39. The FNPV is always positive within the tested ranges of seed prices (350 ETB to 500 ETB) and fuel prices (19 ETB/L to 25 ETB/L).

Table 22. Joint impact of fuel price (for irrigation pump) and price of potato seeds on the FNPV (in US$)

	Fuel price ETB/L				
Price of seeds ETB/kg	**19.00**	**20.00**	**21.00**	**23.00**	**25.00**
350.00	1,770.98	1,727.93	1,684.88	1,598.78	1,512.67
375.00	1,717.17	1,674.11	1,631.06	1,544.96	1,458.86
400.00	1,663.35	1,620.30	1,577.25	1,491.15	1,405.05
450.00	1,555.73	1,512.67	1,469.62	1,382.79	1,277.72
500.00	1,448.10	1,405.05	1,356.52	1,251.45	1,146.39

Table 23 presents the results of the sensitivity analysis of the drought effect on the NPV of the interventions. The analysis evaluates the impact of a drought on households that have access to irrigation after participating in the GRAD program. During the drought seasons, irrigation will also help farmers grow and harvest maize. However, additional costs are associated with the fuel and amortization of the pump, which reduce the resulting benefits.

Table 23. Sensitivity analysis of drought effect on the NPV of the intervention

# of Droughts /5-year period	**NPV US$ Potatoes VC**	**NPV US$ Onions VC**	**NPV US$ Tomatoes VC**
0	1,577.25	2,147.83	1,328.75
1	1,714.68	2,287.84	1,466.19
2	1,824.24	2,399.46	1,575.75
3	1,922.07	2,499.12	1,673.57

Due to the impact that droughts have on the "without" intervention scenario, the incremental positive impact of the intervention is strengthened. For farmers who are located close to sources

of water and have access to irrigation pumps. The intervention is of great help to save not only the vegetable crops but also the maize crop that is either intercropped with vegetables or planted in crop rotation with vegetables.

Tomatoes Value Chain Sensitivity Analysis

Table 24, below, presents the joint impact of the price and yield of tomatoes on the FNPV. Under the base-case scenario, with the price of tomatoes set at 5 ETB/kg and a yield of 12,000 kg/Ha, the FNPV is US$1,328.75. If the price of tomatoes increases to 6 ETB/kg and the yield level remains 12,000 kg/Ha, the FNPV increases to US$2,255.68. The sensitivity analysis shows that if the price of tomatoes drops to 4 ETB/kg and the yield decreases to 11,000 kg/Ha or less, the FNPV becomes negative. If the tomato yield increases to 14,000 kg/Ha or above, within the tested range of tomato prices (3.75 ETB/kg to 6 ETB/kg), the FNPV is always positive.

Table 24. Joint impact of tomato price and yield on FNPV (US$)

	Yield kg/ha						
Price	**10,000.00**	**11,000.00**	**12,000.00**	**14,000.00**	**15,000.00**	**17,000.00**	**18,000.00**
3.75	–830.60	–460.52	–90.44	649.72	1,016.38	1,634.60	1,916.91
4.00	–585.33	–190.58	204.17	993.67	1,330.92	1,954.55	2,255.68
5.00	395.74	889.18	1,328.75	2,105.11	2,481.52	3,234.34	3,610.75
5.50	886.27	1,369.68	1,803.98	2,632.09	3,046.14	3,874.24	4,288.29
6.00	1,326.58	1,803.98	2,255.68	3,159.06	3,610.75	4,514.14	4,965.83

Table 25, below, presents the joint impact of the tomato price and the yield on the NCFs for years 4 and later, or around the time that the GRAD program ends. In this scenario, when the tomato price is 5 ETB/kg and the yield is 12,000 kg/Ha, the NCF is US$220.47. The sensitivity analysis shows that when the price of tomatoes is 5 ETB/kg or above and the range of tomato yields is 10,000 kg/Ha to 18,000 kg/Ha, the NCF is always positive. On the other hand, if the tomato yield decreases to 10,000 kg/Ha and the price drops to 4 ETB/kg or lower, the NCF becomes negative.

Table 25. Joint impact of tomato price and yield on NCF, year 4 and after (in US$)

	Yield kg/Ha						
Price	**10,000.00**	**11,000.00**	**12,000.00**	**14,000.00**	**15,000.00**	**17,000.00**	**18,000.00**
3.75	–34.23	8.22	50.67	135.57	178.02	262.90	305.00
4.00	–5.93	39.35	84.63	175.19	220.47	311.00	356.00
5.00	107.27	163.87	220.47	333.67	390.27	503.50	560.00
5.50	163.87	226.13	288.39	412.91	475.18	599.70	662.00
6.00	220.47	288.39	356.31	492.16	560.08	695.90	764.00

Table 26, below, presents the joint impact of the price of fuel for irrigation and the fuel requirements on the FNPV of the tomato-growing intervention. Under the assumed base-case scenario, with a fuel price of 21 ETB/L and fuel requirements of 102 L, the FNPV is US$1,328.75. If the price of fuel increases to 25 ETB/L and the fuel requirements increase to 140 L, the FNPV drops to US$669.22. Within the tested range of fuel prices (19 ETB to 25 ETB) and fuel requirements (50 L to 140 L), the FNPV is always positive.

Table 26. Joint impact of fuel price (for irrigation pump) and fuel requirements on FNPV (in US$)

ETB/L					
Fuel Requirements L/0.25 Ha	**19.00**	**20.00**	**21.00**	**23.00**	**25.00**
50.00	1,796.81	1,778.16	1,759.52	1,722.23	1,684.93
60.00	1,725.95	1,703.58	1,681.20	1,636.45	1,591.70
80.00	1,584.25	1,554.41	1,524.58	1,458.77	1,389.88
90.00	1,513.39	1,475.99	1,437.24	1,359.75	1,282.26
102.00	1,416.58	1,372.66	1,328.75	1,240.93	1,153.11
110.00	1,351.14	1,303.78	1,256.43	1,161.72	1,063.22
120.00	1,269.34	1,217.68	1,166.02	1,057.96	931.89
140.00	1,105.75	1,036.95	963.41	816.31	669.22

Onions Value Chain Sensitivity Analysis

Table 27, below, presents the joint impact of the price of onions and their yield on the FNPV. Under the base-case scenario, with onions priced at 4.50 ETB/kg and a yield of 13,000 kg/Ha, the FNPV is US$1,668.89. If the price of onions decreases to 3.25 ETB/kg with a yield level of 13,000 kg/Ha, the FNPV drops to –US$13.02. The sensitivity analysis shows that if the price of onions decreases to 3.25 ETB/kg but the yield increases to 18,000 kg/Ha, the FNPV increases to US$1,672.

Table 27. Joint impact of onion price and yield on FNPV (in US$)

Yield kg/ha							
Price ETB/kg	**10,000.00**	**11,000.00**	**13,000.00**	**14,000.00**	**15,000.00**	**17,000.00**	**18,000.00**
3.25	–1,079.09	–723.73	–13.02	342.34	697.69	1,369.00	1,672.00
3.50	–807.19	–424.50	340.89	723.58	1,106.27	1,756.30	2,048.00
3.75	–535.29	–125.26	694.79	1,104.82	1,461.06	2,110.80	2,424.00
4.00	–263.39	173.97	1,048.69	1,437.24	1,798.01	2,465.30	2,799.00
4.50	280.41	772.44	**1,668.89**	2,048.24	2,423.57	3,174.20	3,550.00
5.00	824.21	1,341.98	2,215.05	2,632.09	3,049.13	3,883.20	4,300.00
5.50	1,340.90	1,839.72	2,757.20	3,215.95	3,674.69	4,592.20	5,051.00
6.00	1,798.01	2,298.46	3,299.36	3,799.80	4,300.25	5,301.10	5,802.00

Table 28, below, presents the joint impact of onion price and yield on the NCFs for years 4 and later. Under the base-case scenario, with onions priced at 4.50 ETB/kg and a yield of 13,000 kg/Ha, the NCF is US$268.62. The sensitivity analysis shows that when the price of onion is 4.50 ETB/kg but the yield increases to 18,000 kg/Ha and above, the NCF increases to US$551. If the price of onion drops to 3.25 ETB/kg and the yield increases to 18,000 kg/Ha, the NCF remains US$269.

Table 28. Joint impact of onion price and yield on NCF, year 4 and after (in US$)

Yield kg/Ha

Price ETB/kg	10,000.00	11,000.00	13,000.00	14,000.00	15,000.00	17,000.00	18,000.00
3.25	–57.47	–16.71	64.81	105.58	146.34	227.86	268.62
3.50	–26.12	17.78	105.58	149.47	193.37	281.17	325.06
3.75	5.24	52.27	146.34	193.37	240.40	334.47	381.50
4.00	36.59	86.76	187.10	237.27	287.44	387.77	437.94
4.50	99.30	155.74	**268.62**	325.06	381.50	494.38	550.82
5.00	162.02	224.73	350.15	412.86	475.57	600.99	663.70
5.50	224.73	293.71	431.67	500.65	569.63	707.60	776.58
6.00	287.44	362.69	513.20	588.45	663.70	814.21	889.46

Table 29, below, presents the joint impact of the price of fuel for irrigation pumps and fuel requirements on the FNPV. Under the base-case scenario, with a fuel price of 21 ETB/L and fuel requirements of 128 L, the FNPV is US$1,668.89. If the price of fuel increases to 25 ETB/L and the fuel requirements increase to 180 L, the FNPV drops to US$804.61. Within the range fuel prices (19 ETB to 25 ETB) and fuel requirements (50 L to 180 L) analyzed, the FNPV is always positive.

Table 29. Joint impact of fuel price (for irrigation pump) and fuel requirements on FNPV (in US$)

Gasoline price ETB/L					
Fuel requirements L	19.00	20.00	21.00	23.00	25.00
50.00	**2,321.03**	2,302.38	2,283.74	2,246.45	2,209.15
70.00	2,179.32	2,153.22	2,127.11	2,074.90	2,022.70
90.00	2,037.61	2,004.05	1,970.49	1,903.36	1,836.24
120.00	1,825.05	1,780.30	1,735.55	1,637.89	1,534.57
128.00	1,768.37	1,720.63	**1,668.89**	1,558.68	1,448.47
140.00	1,680.94	1,620.67	1,560.40	1,439.86	1,319.31
150.00	1,599.14	1,534.57	1,469.99	1,340.84	1,198.61
180.00	1,353.75	1,276.26	1,182.85	993.73	**804.61**

RECOMMENDATIONS

The CBA shows that the interventions in the potatoes, tomatoes, and onions value chains yield positive FNPVs and ENPVs. It is recommended that these interventions be implemented in the GRAD woredas. Upon implementation, GRAD-targeted chronically food-insecure households will achieve an increase in their yearly incomes and will reach higher levels of food security. Nevertheless, the interventions in the vegetables value chains do not guarantee (in the base-case scenario) the expected increase in yearly income of US$365 per household.

The interventions need to be redesigned to allow farmers to have access to financial resources that are sufficient to purchase not only the main inputs for vegetable cultivation but also the pumps and fuel required for irrigation. Each pump can be shared by a group of four farmers.

The CBA reveals that households will not be able to cover their loan debt obligations if the loan repayment period is limited to 1 year. Hence, it is recommended that the term of the loan be expanded to 3 years. The targeted households, however, may face difficulties repaying their debt obligations for the first year, so they should be able to move a fraction of the loan repayment to the second year when necessary. In this scenario, households will be able to cover their debt service obligations for the second year of the loan plus the amount of unpaid debt service carried over from the previous year.

The GRAD consortium needs to carefully address such issues as training programs and access to improved seeds by the households, two parameters that are critical to helping the farmers attain high vegetable yields. The sensitivity analysis shows that yield is one of the most significant factors affecting the project's overall outcome.

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APPENDIX

Table A. GRAD-selected woredas and their choice of commodities (as per CARE plan)

Region	Woreda	Type of value chains selected for GRAD woredas
SNNPR	Shebedino	Fattening (shoat and cattle), vegetables (potato and onion), honey
	HawassaZuria	Shoat fattening, red pepper, vegetables (potato and onion)
	Loka Abaya	Shoat fattening, **pulse (beans),** honey
	Hawale Tula	Vegetables (potato and onion), fattening (shoat and cattle), honey
	Mareko	Red pepper, fattening (shoat and cattle), onion
	Meskan	Red pepper, shoat and cattle fattening, vegetables (onion and tomato)
Tigray	Alamata	Vegetables (onion and tomato), cattle fattening, honey
	Ofla	Shoat rearing, honey, vegetables (garlic and pepper), fattening (shoat and cattle), **pulse (faba beans**)
	EndaMehoni	Vegetables (potato and garlic), shoat rearing, cattle fattening, honey, **pulse (faba bean)**
	Raya Azebo	Shoat fattening and rearing, cattle fattening
Amhara	Lay Gayint	Cereals (malt barley), **pulse (white pea beans),** potato, shoat fattening,
	Libokemkem	Cattle fattening, honey, vegetables (onion)
Oromia	ArsiNegele	Shoat fattening, **pulse (white pea beans),** red pepper
	ZewayDugda	**Pulse (white pea beans),** vegetables (tomato and onion), shoat fattening
	Shalla	Shoat fattening, **pulse (white pea beans),** potato
	Adami Tulu	Red pepper, **pulse (white pea beans),** shoat fattening

Table B. FtF indicators proposed for the monitoring and evaluation of the GRAD project

Results	Indicator	Target
Overall Objective: **To graduate chronically food-insecure households from food support**	Graduation of chronically food-insecure households from food aid by increasing their yearly household income	50,000 households that will have increase in yearly income of US$365 by year 5
Result 1: **Enhanced livelihood options for chronically food-insecure households**	4.5-2 Number of jobs attributed to FTF implementation (RiA)	Higher is better
	3.1.9.1-3 and 4.7-4 Prevalence of households with moderate or severe hunger (RiA)	Lower is better
Result 2: **Improved community and household resilience**	3.1.9-16 Prevalence of underweight children under 5 years of age (R)	Lower is better
	3.1.9-13 Prevalence of underweight women (R)	Lower is better
	3.1.9-4 and 3.1.9.1-4 Prevalence of exclusive breastfeeding of children under 6 months of age (RiA)	Lower is better
	3.1.9-11 Prevalence of stunted children under 5 years of age (R)	Lower is better
	4.5.2-14 Number of vulnerable households benefiting directly from USG assistance (S)	Lower is better
Result 3: **Strengthened enabling environment to promote scale-up and sustainability**	4.5 Women's Empowerment in Agriculture Index Score (R)	Higher is better
	4.5.1-27 and CBLD-5 Score, in percent, of combined key areas of organization capacity among USG direct and indirect local implementing partner levels	Higher is better
	4.5.2-38 Value of new private-sector investment in the agriculture sector or food chain leveraged by FTF implementation (RiA)	Higher is better

Table C. Conversion factors used in the economic analysis of GRAD interventions in the potatoes value chain

Summary of conversion factors	
Potato	**1.00**
Potato seeds	**1.00**
Maize	**1.02**
Maize seeds	**1.02**
Pump	**0.84**
Amortization cost of pump (spare parts)	**0.84**
Mancozeb	**1.07**
Redomil Gold	**1.07**
Gasoline	**0.78**
Transportation	**0.84**
Labor	**1.00**
Land	**1.00**
UREA	**1.05**
DAP	**1.05**

Table D. Conversion factors used in the economic analysis of GRAD interventions in the tomatoes value chain

Summary of conversion factors	
Tomatoes	**1.00**
Tomato seeds	**1.00**
Maize	**1.02**
Maize seeds	**1.02**
Pump	**0.84**
Amortization cost of pump (spare parts)	**0.84**
Tackling	**1.00**
Jute string	**1.00**
Mancozeb	**1.07**
Redomil Gold	**1.07**
Selecron	**1.07**
Endosulfan	**1.07**
Karate	**1.07**
Gasoline	**0.78**
Transportation	**0.84**
Labor	**1.00**
Land	**1.00**
UREA	**1.05**
DAP	**1.05**

Table E. Conversion factors used in the economic analysis of GRAD interventions in the onions value chain

Summary of conversion factors	
Onions	**1.00**
Onion seeds	**1.00**
Maize	**1.02**
Maize seeds	**1.02**
Pump	**0.84**
Amortization cost of pump (spare parts)	**0.84**
Tackling	**1.00**
Jute string	**1.00**
Mancozeb	**1.07**
Redomil Gold	**1.07**
Selecron	**1.07**
Endosulfan	**1.07**
Karate	**1.07**
Gasoline	**0.78**
Transportation	**0.84**
Labor	**1.00**
Land	**1.00**
UREA	**1.05**
DAP	**1.05**