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Info Note

Better Life Alliance in Zambia:

Climate change mitigation as a co-benefit of improved landscape, agroforestry, soil, and fertilizer management

A series analyzing low emissions agricultural practices in USAID development projects

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Key messages

- Analysis of agricultural activities in the Better Life Alliance (BLA) project in Zambia showed potential reduction in greenhouse gas emissions (GHG), mostly (85%) due to avoided savanna degradation and conversion. The GHG impact due to BLA's interventions is estimated at –902,531 tCO_2e/yr, equivalent to saving 2,089,550 barrels of oil.
- BLA's business model linked prevention of degradation and conversion of shrubland to market-based incentives for agricultural crops, thereby providing farmers with economic incentives for conservation and climate change mitigation.
- BLA promoted a comprehensive approach to soil fertility management. It promoted agro-ecological approaches such as recycling farm organic resources, planting nitrogen-fixing trees, minimal tillage, and cover crops.
- BLA reduced postharvest loss (PHL) through improved product processing, storage, and packaging. Changes in PHL were estimated for groundnuts (–100%), maize (–40%), rice (–80%), and soybeans (–67%), which contributed to decreases in emission intensity (GHG emissions per unit of production) for each of these products.

About the Better Life Alliance project

Established in 2011, BLA was a 4-year project funded by the Feed the Future (FTF) initiative and implemented by Community Markets for Conservation Ltd. (COMACO) in the Luangwa valley in the Eastern Province of Zambia (Figure 1). BLA aimed to achieve poverty reduction, sustainable land management, and improved conservation by linking smallholder farmers to market incentives. This area encompasses communal lands for 63 chiefdoms that surround five national parks and protected forests. BLA focused on improvements to agricultural value chains and market links. BLA provided direct training and capacity building for small-scale farmers to adopt conservation practices. BLA also introduced natural resource management plans that targeted conservation of wildlife habitats to prevent conversion to agriculture.

BLA connected farmers to consumer markets through a product label called "*It's Wild!*" COMACO offered premium prices (10–20% above market prices) to farmers who complied with wildlife conservation standards and practiced conservation agriculture (COMACO 2015). To ensure compliance, the project developed a scoring system based on sustainable agriculture, forestry, and wildlife criteria. COMACO validates compliance for individual chiefdoms with this scoring system. Its strategy was based on the assumption that its market-based approach would provide incentives to conserve critical shrubland from degradation and from conversion to agriculture.

Low emission development

In the 2009 United Nations Framework Convention on Climate Change (UNFCCC) discussions, countries agreed to the Copenhagen Accord, which included recognition that “a low-emission development strategy is indispensable to sustainable development" (UNFCCC 2009). Low emission development (LED) has continued to occupy a prominent place in UNFCCC agreements. In the 2015 Paris Agreement, countries established pledges to reduce emission of GHGs that drive climate change, and many countries identified the agricultural sector as a source of intended reductions (Richards et al. 2015).

In general, LED uses information and analysis to develop strategic approaches to promote economic growth while reducing long-term GHG emission trajectories. For the agricultural sector to participate meaningfully in LED, decision makers must understand the opportunities for achieving mitigation co-benefits relevant at the scale of nations, the barriers to achieving widespread adoption of these approaches, and the methods for estimating emission reductions from interventions. When designed to yield mitigation co-benefits, agricultural development can help countries reach their development goals while contributing to the mitigation targets to which they are committed as part of the Paris Agreement, and ultimately to the global targets set forth in the Agreement.

In 2015, the United States Agency for International Development (USAID) Office of Global Climate Change engaged the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) to examine LED options in USAID’s agriculture and food security portfolio. CCAFS conducted this analysis in collaboration with the University of Vermont’s Gund Institute for Ecological Economics and the Food and Agriculture Organization of the United Nations (FAO). The CCAFS research team partnered with USAID’s Bureau of Food Security to review projects in the FTF program. FTF works with host country governments, businesses, smallholder farmers, research institutions, and civil society organizations in 19 focus countries to promote global food security and nutrition.

As part of the broader effort to frame a strategic approach to LED in the agricultural sector, several case studies, including this one, quantify the potential climate change mitigation benefits from agricultural projects and describe the effects of low emission practices on yields and emissions. Systematic incorporation of such emission analyses into agricultural economic development initiatives could lead to meaningful reductions in GHG emissions compared to business-as-usual emissions, while continuing to meet economic development and food security objectives.

The team analyzed and estimated the project’s impacts on GHG emissions and carbon sequestration using the FAO Ex-Ante Carbon Balance Tool (EX-ACT). EX-ACT is an appraisal system developed by FAO to estimate the impact of agriculture and forestry development projects, programs, and policies on net GHG emissions and carbon sequestration. In all cases, conventional agricultural practices (those employed before project implementation) provided reference points for a GHG emission baseline. The team described results as increases or reductions in net GHG emissions attributable to changes in agricultural practices as a result of the project. Methane, nitrous oxide, and carbon dioxide emissions are expressed in metric tonnes of carbon dioxide equivalent (tCO_2e). (For reference, each tCO_2e is equivalent to the emissions from 2.3 barrels of oil.) If the agricultural practices supported by the project lead to a decrease in net emissions through an increase in GHG removals (e.g., carbon sequestration, emission reductions) and/or a decrease in GHG emissions, the overall project impact is represented as a negative (–) value. Numbers presented in this analysis have not been rounded but this does not mean all digits are significant. Non-significant digits have been retained for transparency in the data set.

This rapid assessment technique is intended for contexts where aggregate data are available on agricultural land use and management practices, but where field measurements of GHG and carbon stock changes are not available. It provides an indication of the magnitude of GHG impacts and compares the strength of GHG impacts among various field activities or cropping systems. The proposed approach does not deliver plot, or season-specific estimates of GHG emissions. This method may guide future estimates of GHG impacts where data are scarce, as is characteristic of environments where organizations engage in agricultural investment planning. Actors interested in ex-post verification of changes in GHG emissions resulting from interventions should collect field measurements needed to apply process-based models.

Researcher inspecting Gliricidia alley cropping field International Institute of Tropical Agriculture, 2012

Agricultural and environmental context: Zambia

Zambia (752,618 km^2) has a population of over 15 million people. Over 64% of the population lives in extreme poverty and 40% of children suffer from stunting (World Bank 2016a). Agriculture employs a large portion of Zambia's labor force (Day et al. 2014) and occupies 32% of its land (World Bank 2014). Small-scale farming (<2 ha) accounts for 70% of farms, yet represents for less than a third of agricultural production (Hichaambwa et al. 2015).

Smallholders harvest a number of crops, but maize dominates, with 86% of small-scale farms growing this crop (Weitz et al. 2015). It accounts for 48% of the area dedicated to agriculture (FAOSTAT 2015). Relying on a unimodal rainfall pattern, the majority of smallholder farmers produce one harvest each year and struggle to reach production sufficient for household consumption and market sales. Reliance on rain-fed maize as the main staple crop contributes to the vulnerability of smallscale farmers (Weitz et al. 2015).

Land degradation, climate variability, and low soil fertility contribute to poverty and food insecurity in Zambia. Excessive wood extraction for charcoal production and savanna burning drive land degradation (FAO 2015a), and agricultural expansion is a primary driver of land use change (Day et al. 2014). In recent decades, Zambia has experienced decreases in average rainfall, increases in temperatures, and numerous extreme weather events such as droughts and flooding (Funder et al. 2013). Climate change is widely recognized as a serious food security issue for Zambia due to its potential to reduce crop yields (World Bank 2016b). Soil fertility is generally low, and prolonged periods without vegetative soil cover during the dry season due to droughts may further deplete the soil (FAO 2015b). As a result, agricultural development programs are focusing on land management, climate change adaptation, and integrated soil fertility.

In Zambia, savannah degradation and conversion are major GHG sources (Day et al. 2014, FAO 2015a). Zambia's Intended Nationally Determined Contribution submitted to the UNFCCC identified agriculture and land use change as major contributors to national GHG emissions and included mitigation targets for the agricultural sector (Richards et al. 2016).

Figure 1. Area of implementation

Agricultural practices that impact GHG emissions and carbon sequestration

The emission analysis of BLA focused on groundnut, maize, rice, and soybean value chains. GHG emissions and carbon sequestration changed due to avoided degradation and conversion of savanna; agroforestry expansion; soil and manure management improvements; crop-residue burning reduction; and fertilizer management.

Table 1 shows estimates of the area of adoption for each practice by the end of the project. A description of each practice follows, including a description of the intervention and its effects on the environment, the project plan for the intervention, and estimated impacts on emissions.

Table 1. Area (ha) in BLA-supported agricultural practices with impacts on emissions

	Savanna	Agroforestry	Groundnut	Maize	Rice	Soybean
Avoided degradation and conversion of savanna	394,307 15,450					
Agroforestry expansion		6,506				
Soil and manure management			15,362	17,742		3,370
Fertilizer management				17,742		
Crop-residue burning reduction				17,742	12,000	

Avoided degradation and conversion of shrubland

Avoided degradation and conversion of shrubland

Background. Avoided degradation and conversion of savanna are important practices that minimize loss of habitat and maintain carbon stored in woody biomass. In savannas, nearly 50% of biomass carbon can be stored underground in roots. Clearing, burning or slow degradation of these ecosystems leads to biomass/carbon loss both above and below ground. In Zambia, charcoal production, agricultural expansion, and hunting are drivers for savanna degradation and conversion (COMACO 2015, FAO 2015a).

Practice plan. BLA introduced community conservation plans to prevent savanna fires (avoided degradation) and to reduce savanna conversion to annual crops (avoided conversion). To validate compliance with the plans by individual chiefdoms, the project developed a monitoring and evaluation system that included forestry and wildlife criteria. BLA estimated these plans avoided degradation on about 395,000 ha (5% of the 7.8 million ha of natural savanna) and avoided conversion of 15,450 ha (5% of the 309,000 ha under active stewardship plans).

Impact on emissions. In BLA, an annual estimated GHG mitigation benefit of –1.50 tCO_2e/ha in emissions results from avoided degradation, while –10.89 tCO_2e/ha is achieved by avoided conversion (Figure 2). When scaled to the full area of implementation, avoided degradation and conversion result in estimated annual GHG mitigation benefits of -590,509 tCO_2e and -168,279 tCO_2e in emissions (Figure 3). Emission factors and carbon stocks are relatively well-known for savanna systems, so the largest source of uncertainty in this portion of the analysis is the area and extent of reduced degradation and conversion.

Agroforestry expansion

Agroforestry expansion

Background. Agroforestry systems have a number of benefits for carbon storage. These systems increase available water and nutrients in the soil and act to protect soil from wind and water erosion (Glover et al. 2012). These conservation measures for erosion and runoff keep soil, nutrients and water on the farm, which is a local benefit, as well as keeping them out of bodies of water. Compared to annual crops, tree crops have deeper and larger root networks that store carbon in their biomass. They increase organic matter input to the soils, helping them hold more water and nutrients (Jose, 2009). From a

global perspective, perennial crops increase terrestrial carbon storage by removing carbon from the atmosphere and storing it in plant biomass, thus mitigating carbon increases in the atmosphere from other sources. Addition of perennial crops to a farm can improve household resilience by increasing the diversity of products for sale and home consumption. Agroforestry systems that contain nitrogen-fixing woody perennials ("fertilizer trees") support long-term soil fertility (Sileshi et al. 2014) that can be intercropped with food plantings. The fertilizer trees also provide farmers with firewood, construction materials, and fodder (Kuntashula and Mafongoya 2005). Research demonstrates that the benefits of agroforestry can enhance smallholder farmer resilience to climate change in Africa (Lasco et al. 2014).

Practice plan. BLA promoted alley agroforestry systems of Gliricidia (*Gliricidia sepium*) and maize. Project staff estimated the tree density at roughly 4,000 trees/ha (based on dense crop spacing of 5 x 0.5 m), which was used for carbon sequestration estimates. BLA estimated farmers would convert about 6,500 ha of annual cropland to such agroforestry systems.

Impact on sequestration. To estimate the specific carbon sequestration rate for BLA, FAO assumed each Gliricidia tree had at maturity an above-ground biomass in dry matter (DM) of 30.18 kg (Fuwape and Akindele 1997), equivalent to 121 t DM biomass/ha. Conversion of annual cropland to agroforestry systems resulted in carbon sequestration of –13.5 tCO_2e/ha/yr. Increased tree biomass contributes the greatest share of these benefits (–10.5 tCO_2e/ha/yr), complemented by improvements in soil carbon changes (–3.0 tCO_2e/ha/yr). Considering the full area of implementation, agroforestry expansion resulted in carbon sequestration benefits of –87,859 tCO_2e (Figure 3). The greatest uncertainty in these estimates is the tree survival rate, which BLA notes can be roughly 50%. These calculations assumed 100% survival based on the initial information collected but can be scaled linearly to estimate the impacts of mortality. These estimates have a higher level of certainty for biomass and a lower level of certainty for soil carbon impacts, stemming from the lack of site-specific soils monitoring data during and after project implementation.

Soil and manure management

Soil and manure management

Background. Improved soil management practices involve cropping, fertilizer, organic resources and other amendments that are essential to maintain or increase productivity and input use efficiency. These changes can increase crop resilience to drought, such as by increasing rooting depth, while reducing emissions from soils and fertilizers (Lal 2004; Cheesman et al. 2016). Many improved soil management practices confer mitigation benefits for GHG emissions by increasing N recovery by crops and retention of nitrate in soils, thus limiting N_2O production. The regular and appropriate supply of organic matter to soils, such as compost, is essential to maintain or increase production and soil carbon. In Zambia, low soil fertility limits the productivity of groundnuts, maize, and soybean systems.

Practice plan. BLA supported improved soil management and manure usage as part of groundnut, maize, and soybean value chains (Table 1). Specific practices included the retention of crop residues, minimal tillage, and incorporation of green manure and/or cover crops. The adoption of improved seed contributed to greater yields as well as to biomass in crop residues.

Impact on emissions. Mitigation benefits resulted from changes in soil management (–0.29 tCO_2e/ha) and manure usage practices (–1.45 tCO_2e/ha) (Figure 2). When scaled to the full area of implementation, these usage practices result in carbon sequestration of –4,455 tCO_2e and –30,535 tCO_2e, respectively (Figure 3). These estimates are based on IPCC Tier 1 estimates, which may overestimate N_2O emissions in some tropical soils by a factor of 2 to 4 (e.g., Hickman et al. 2015) although the direction and magnitude of change relative to N inputs remain linear. Soil carbon storage increases due to incorporation of crop residues, minimal tillage, cover crops and green manure are well studied. Improvement of these estimates would require process-based models parameterized for tropical fertilized crop systems, additional soils and climate data. Further refinements in estimates could come from constraining the estimates of farmer adoption.

Fertilizer management

Fertilizer management

Background. Soil nutrient stocks are a function of the removal of nutrients in the form of crops and stover, balanced with the input of nutrients from crop residues, fertilizer, manure, and other sources. Farmers employ fertilizer management to balance inputs and losses of nutrients to boost crop yields. Traditionally, efficient fertilizer management focused on the timing, type, placement, and quantity of nutrients to minimize nutrient loss and optimize crop nutrient uptake to increase yields. Today, the focus is broader and includes practices such as intercropping as well as rotations to build agroecosystems that minimize N losses, maximize plant use of available nutrients, build soil organic matter to hold nutrients, and minimize external nutrient inputs. GHG emissions result from production of fertilizers and pesticides (Lal 2004) and conversion of nitrogen fertilizers to N_2O in fields (Butterbach-Bahl et al. 2013). Fertilizer management can reduce emissions of N_2O from fertilized soils (a GHG 298 times as potent as CO_2) (Myhre et al. 2013), as well as emissions associated with the energy intensive production of fertilizers.

Practice plan. BLA promoted manure application as a substitute for synthetic fertilizer for maize on 17,742 ha. Reductions in fertilizer purchases reduced costs to the farmer and dependence on agrochemical inputs. During interviews, BLA estimated that, prior to interventions, the average maize fertilization rates were 250 kg/ha (compound D) plus 150 kg/ha (urea), which were used in these estimates. Subsequent discussions with local experts suggested that typical rates are around 200 kg each for compound D and urea. BLA also promoted a certification with the label “It’s Wild!” to signify that neither synthetic fertilizers nor pesticides were used in production (COMACO 2015).

Impact on emissions. Reduction in synthetic fertilizer application impacted GHG emissions by an estimated –0.95 tCO_2e/ha annually (Figure 2) and would reach –16,822 tCO_2e at full project scale (Figure 3). Constraints that affect this practice are similar to those detailed under soil and manure management. Please note the differences in the estimated fertilization rates would change the net GHG impact by only a few hundredths of a percent.

Crop residue burning reduction


Crop-residue burning reduction

Background. The burning of crop residues left over after harvest leads to GHG emissions and air pollution (Smil 1999, Turmel et al. 2015, WHO 2014) as carbon in biomass is converted to GHGs and particulates. Burning removes a valuable resource that could be used for animal feed, composting, or soil amendment (Rusinamhodzi et al. 2016, Turmel et al. 2015). The calculation of overall benefits includes both the GHG from combustion that is avoided and the benefits from recycling crop residues on the farm.

Practice plan. BLA encouraged farmers to discontinue all crop-residue burning in rice (12,000 ha) and maize (17,742 ha) systems. Data from monitoring indicate that discontinuation of burning was widely adopted.

Impact on emissions. FAO estimated the rates of residue return from reported crop grain yields (IPCC 2006), which are well known for maize and rice systems. Reduced crop residue burning resulted in a net reduction in GHG emissions (–0.13 tCO_2e/ha/yr) (Figure 2) from maize (–0.154 tCO_2e/ha) and rice (–0.111 tCO_2e/ha). When scaled to the full area for these crops, reduced residue burning would lessen GHG emissions by–4,072 tCO_2e/yr (Figure 3). These reductions have a high level of certainty due to the availability of crop specific data on residues.

In focus: development models link value chain and landscape approaches to LED

BLA linked prevention of savanna degradation and conversion (landscape approach) to market-based incentives for agricultural crops (value chain approach). Specifically, the project encouraged farmers to practice conservation agriculture and comply with wildlife conservation standards through providing price premiums for certain agricultural products. This approach created incentives for farmers to invest in existing production systems instead of clearing new cropland to overcome soil nutrient depletion in current annual systems. BLA actions reduced postharvest losses through changes in handling, processing, storage, and packaging, with notable increases in remaining annual yield for rice (131%) and soybean (55%).

Summary of projected GHG emission and carbon sequestration co-benefits

BLA's interventions reduced net GHG emissions (–902,531 tCO_2e/yr), 85% of which was due to avoided savanna degradation and conversion. Expanded agroforestry and avoided savanna conversion provided the greatest mitigation per ha (Figure 2). Avoided savanna degradation (burning) with improvements in manure and fertilizer usage provided moderate mitigation benefits per ha. Soil management improvements and reduced crop residue burning had relatively lower emission impact per ha but have important agronomic benefits. Overall, the large area of avoided savanna degradation accounted for 65% of BLA's GHG mitigation impact (Figure 3). Avoided savanna conversion, the second largest practice by area, accounted for 19% of GHG mitigation. Expansion of agroforestry, reduction of crop-residue burning, and improvements in soil, manure, and fertilizer management contributed about 16% of total annual GHG mitigation.

Figure 2: Impact of agricultural practices: Net GHG emissions on an area basis
(tCO_2e/ha/yr)

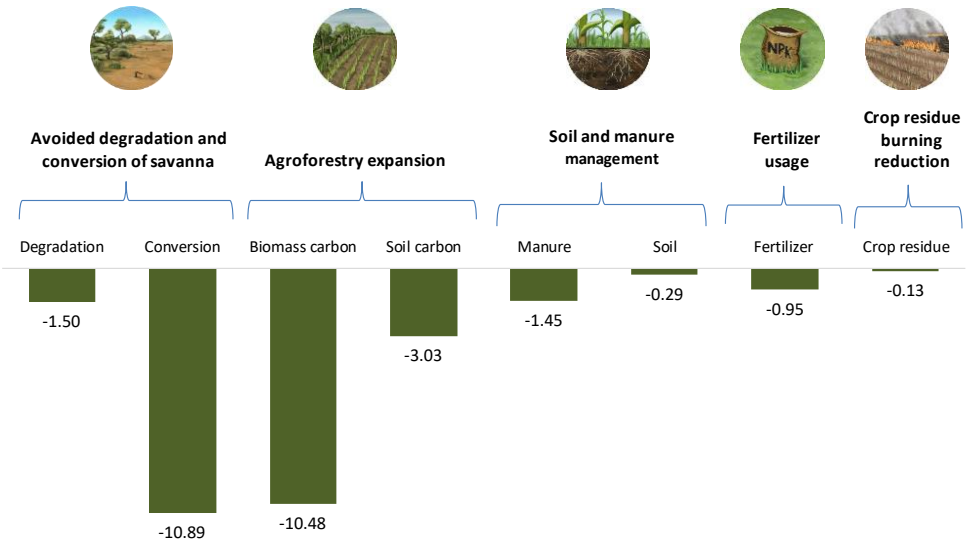
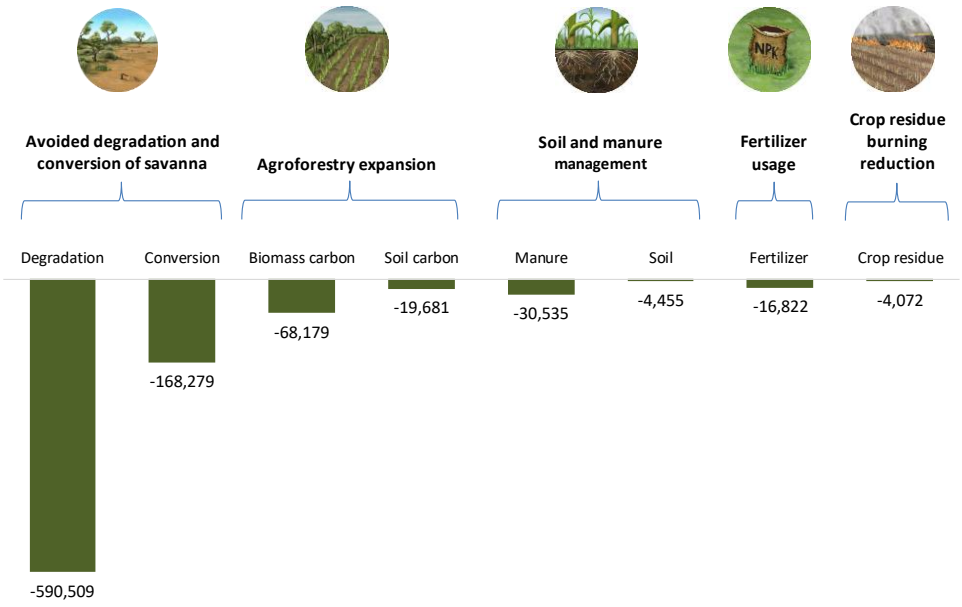


Figure 3: Impact of agricultural practices: Net GHG emissions on total area of impact
(tCO_2e/yr)



GHG emission intensity

Emission intensity (GHG emissions per unit of output) is a useful indicator of LED in the agricultural sector. Table 2 summarizes emission intensity for groundnuts, maize, rice, and soybeans without and with agricultural practices supported by BLA.

Annual yield. BLA increased yields tremendously for rice and soybeans (133% and 55%, respectively) and more moderately for maize (13%) and groundnuts (20%). Rice yield improvements were due to improved seed, integrated pest management, and plant spacing. Soybean crops benefited from the retention of crop residues, incorporation of organic material, and reduced tillage.

Postharvest loss. BLA reduced PHL through improvements in postharvest handling, processing, and packaging in the four crops considered here. BLA also invested in physical infrastructure, including the construction and maintenance of 21 community-owned depots for crop storage. COMACO estimated that PHL decreased for groundnuts, maize, rice, and soybeans (Table 2). BLA conducted a targeted, standardized, computer-assisted survey of PHL with farmers to provide clear quantification of PHL changes.

Emission intensity. BLA reduced emission intensity (Table 2), increased crop yields, and reduced PHL. Groundnut, maize, and soybean systems all resulted in net carbon storage (carbon sinks). Interventions in maize systems had the greatest impact on emission intensity, a change from being a source of emissions to becoming a sink. Rice systems tend to have high emissions compared to other annual crops, so the 65% reduction in the emission intensity achieved through BLA is notable.

Table 2. Emission intensity by product

	Supported agricultural practices	Total GHG emissions per ha (tCO_2e/ha) (1)	Annual yield (t/ha) (2)	Postharvest loss (%) (3)	Remaining annual yield (t/ha) (4)	Emission intensity (tCO_2e/t product) (5)
Groundnut (soil management)	No project	0.00	0.85	1%	0.84	0.00
	Project	–0.29	1.02	0%	1.02	–0.28
	Difference (%)	–0.29 (-)	0.17 (20%)	–1% (–100%)	0.18 (22%)	–0.28 (-)
Maize (reduced crop residue burning, manure management, fertilizer management)	No project	1.10	1.66	5%	1.58	0.70
	Project	–1.45	1.88	3%	1.82	–0.79
	Difference (%)	–2.55 (–231%)	0.22 (13%)	–2% (–40%)	0.25 (16%)	–1.49 (–213%)
Rainfed rice (deepwater; reduced crop residue burning)	No project	1.33	1.30	15%	1.11	1.20
	Project	1.22	3.00	3%	2.91	0.42
	Difference (%)	–0.11 (–8%)	1.70 (131%)	–12% (–80%)	1.81 (163%)	–0.78 (–65%)
Soybean (manure management)	No project	0.00	1.10	30%	0.77	0.00
	Project	–1.45	1.70	10%	1.53	–0.95
	Difference (%)	–1.45 (-)	0.60 (55%)	–20% (–67%)	0.76 (99%)	–0.95 (-)

Notes:

1. Total GHG emissions per ha signifies the net emissions per hectare of product harvested per year.
2. Annual yield signifies the tonnes of product produced per hectare harvested each year.
3. Postharvest loss is the measurable product loss during processing steps from harvest to consumption per year.
4. Remaining annual yield is calculated by subtracting postharvest loss from annual yield.
5. Emission intensity is calculated by dividing the total GHG emissions per hectare by the remaining annual yield.

(-) Denotes that the percent difference could not be calculated.

Low emission program design considerations

This analysis of GHG emissions and carbon sequestration by agricultural practice raises issues that those designing or implementing other programs will need to consider in the context of low emission agriculture and food security for smallholder farmers, including:

- **Soil management.** Which soil management practices benefit yields while also increasing sequestration of carbon? Which practices can farmers adopt easily? Which practices require training or technology improvements? Which practices should be adopted individually or bundled with other practices, given biophysical, social, and economic circumstances?
- **Crop residue burning.** Are there any negative side effects from reducing crop residue burning regarding pest and disease management or pasture renewal?
- **Agroforestry expansion.** What incentives or changes to enabling conditions are needed to help farmers invest in agroforestry establishment? What kind of technical knowledge and market analysis will help farmers choose agroforestry species that are also adaptable to expected climate changes?
- **Avoided degradation of savanna.** What elements of sustainable land management programs are most effective at reducing the degradation of savanna? What is the feasibility of scaling BLA's value chain approach across other food security programs?

Methods for estimating emissions

A comprehensive description of the methodology used for the analysis presented in this report can be found in Grewer et al. (2016); a summary of the methodology follows. The selection of projects to be analyzed consisted of two phases. First, the research team reviewed interventions in the FTF initiative and additional USAID activities with high potential for agricultural GHG mitigation to determine which activities were to be analyzed for changes in GHG emissions and carbon sequestration. CCAFS characterized agricultural interventions across a broad range of geographies and approaches. These included some that were focused on specific practices and others designed to increase production by supporting value chains. For some activities, such as technical training, the relationship between the intervention and agricultural GHG impacts relied on multiple intermediate steps. It was beyond the scope of the study to quantify emission reductions for these cases, and the research team therefore excluded them. Next, researchers from CCAFS and USAID selected 30 activities with high potential for agricultural GHG mitigation based on expert judgment of anticipated emissions and strength of the intervention. he analysis focused on practices that have been documented to mitigate climate change (Smith et al. 2007) and a range of value chain interventions that influence productivity.

Researchers from FAO, USAID, and CCAFS analyzed a substantial range of project documentation for the GHG analysis. They conducted face-to-face or telephone interviews with implementing partners and followed up in writing with national project management. Implementing partners provided information, data, and estimates regarding the adoption of improved agricultural practices, annual yields, and postharvest losses. The underlying data for this GHG analysis are based on project monitoring data.

The team estimated GHG emissions and carbon sequestration associated with agricultural and forestry practices by utilizing EX-ACT, an appraisal system developed by the FAO (Bernoux et al. 2010; Bockel et al. 2013; Grewer et al. 2013), and other methodologies. EX-ACT was selected based on its ability to account for a number of GHGs, practices, and environments. Derivation of intensity and practice-based estimates of GHG emissions reflected in this case study required a substantial time investment that was beyond the usual effort and scope of GHG assessments of agricultural investment projects. Additional details on the methodology for deriving intensity and practice-based estimates can be found in Grewer et al. (2016).

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Info note series						
USAID project	Country	Agroforestry, perennial crop expansion	Irrigated rice	Land use, inc. reforestation & avoided degradation	Livestock	Soil, fertilizer management
Accelerating Agriculture Productivity Improvement	Bangladesh		X			X
ACCESO	Honduras	X			X	X
Agricultural Development and Value Chain Enhancement Activity II	Ghana		X			X
Better Life Alliance	Zambia	X		X		X
Chanje Lavi Planté	Haiti	X	X	X		X
Pastoralist Resiliency Improvement and Market Expansion	Ethiopia				X	
Peru Cocoa Alliance	Peru	X				X
Resilience & Economic Growth in Arid Lands-Accelerated Growth	Kenya				X	
Rwanda Dairy Competitiveness Project	Rwanda				X	

All info notes are available at: https://ccafs.cgiar.org/low-emissions-opportunities-usaid-agriculture-and-food-security-initiatives

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