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# Info Note

## Chanje Lavi Plantè in Haiti:

## Hillside soil conservation as a measure to increase yields and sequester carbon in Haiti

*A series analyzing low emissions agricultural practices in USAID development projects*

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### Key messages

- Analysis of the potential mitigation impacts of the agricultural development project Chanje Lavi Plantè in Haiti indicated that large amounts of carbon sequestration could be achieved through reforestation and perennial crop expansion. The project's strategy for watershed and landscape restoration links investments in profitable orchard systems with hillside stabilization. Reforestation of watersheds (–478,828 tCO<sub>2</sub>e/yr) and perennial crop expansion (–230,854 tCO<sub>2</sub>e/yr), drive 98% of the project's sizable climate change mitigation co-benefits that are foreseen under successful project implementation.
- Chanje Lavi Plantè's reduction in postharvest loss contribute to the reduced GHG emission intensity of cropping systems (GHG emissions per unit of production). Interventions are estimated to reduce postharvest loss substantially in these value chains: plantain (–53%), maize (–47%), rice (–44%), beans (–50%) and mango (–35%).
- The investments made by the project in irrigation infrastructure, terracing, and forest plantations aim to increase financial revenues of beneficiaries and reinforce the lasting provision of ecosystem services.

### About the Chanje Lavi Plantè project

Chanje Lavi Plantè is a three-year project in the Feed the Future (FTF) initiative. The project, implemented by Chemonics International, focuses its efforts in the Cul-de-Sac, Matheux, and lower Central Plateau areas of Haiti. The number of direct beneficiary smallholder farmers is 60,000 households, with a total of 90,000 households expected to benefit from improved income and nutrition. Established in 2015, this project builds on the results of a prior agriculture initiative, WINNER, which ran from 2009 to 2014.

As monitoring data on the Chanje Lavi Plantè project was not yet available at the time of this analysis, this analysis is based on estimates of the project's achievements foreseen at the time of completion. Monitoring data from the previous WINNER project has been instrumental in developing the impact estimates. Uncertainty regarding the achievement of anticipated project outcomes is an important factor in the overall accuracy of the GHG estimates presented. If project targets are to be changed during implementation, the GHG impacts reported here would change accordingly.

The project's goals are to stabilize hillside erosion in watersheds, increase agricultural productivity, and bolster farmers' access to markets and finance. To achieve the agricultural productivity goals, the project invests in infrastructure such as irrigation and fosters the transfer of modern agricultural technology. The project efforts in agricultural conservation measures, such as hillside stabilization and improved soil management, are an essential contribution to increased agricultural productivity, especially when considering longer time

periods. The project also includes technical innovations such as small farmer greenhouses and retention pond programs on hillsides that provide productivity benefits in the short run. Greenhouse farming increases yields and liberates space on hillsides for agroforestry and soil conservation activities.

While building the landscape foundation for productive agriculture and livelihoods by rehabilitating soil, the project also aims to build capacity and capabilities of local farmer associations and cooperatives. The project promotes usage of high productivity inputs, mechanized land preparation, and improved postharvest equipment and practices. To stimulate private investments and foster business opportunities, the project promotes market links between value chain participants and farmer organizations.

## 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<sub>2e</sub>). (For reference, each tCO<sub>2e</sub> is equivalent to the GHG emissions from 2.3 barrels of oil.) If the agricultural practices supported by the project lead to a decrease in net GHG emissions through an increase in GHG removals (e.g. carbon sequestration) 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 emissions 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 impacts resulting from interventions should collect field measurements needed to apply process-based biophysical models.

## Agricultural and environmental context: Haiti

Agriculture plays an important role in Haiti. It employs about 38% of the labor force, occupies 66% of the country, and is dominated by small-scale farming. There are over one million farms in Haiti and approximately 94% of these are family farms that average 0.7 ha (Lowder 2014). The primary crops are sugarcane, cassava, and maize; export crops include cocoa, mangoes and coffee. Haiti is the poorest country in the Americas, with 59% of the population living below the poverty line, 24% of them in extreme poverty (World Bank 2016a).

In recent decades, repeated natural disasters and other processes of environmental degradation have functioned as a severe limitation to economic development. Low economic development, together with limited physical and social infrastructure for disaster risk reduction, leave the country dangerously vulnerable to natural disasters such as hurricanes, tropical storms and earthquakes. Severe flooding and landslides are frequently recorded (World Bank 2016b). Climate change, with higher mean temperatures and altered rainfall patterns, will increase the risk of droughts in Haiti. In addition, low levels of soil organic matter resulting from degradation processes, poor availability of agricultural inputs (e.g. fertilizer and seeds) and weak links among participants in value chains contribute to a difficult agricultural environment (Molnar et al 2015). In 2014, the Climate Change Vulnerability Index classified Haiti as one of the nations that is most vulnerable. Haiti's submission to the UNFCCC's Paris Agreement included agriculture in their adaptation and mitigation priorities (Richards et al 2015).

Reforestation, water management, and soil conservation have become focal development interventions for food security in Haiti (Molnar et al 2015).

- **Reforestation.** Characterized by a mountainous topography, Haiti has experienced high rates of deforestation that have led to flash floods and landslides, topsoil erosion and erratic water supplies (USAID 2016).
- **Water management.** In the agricultural plains, fresh water levels have dropped due to growing urban demand and infiltration from seawater (USAID 2016). Water availability through inadequate irrigation is a major bottleneck for agricultural productivity (Chemonics 2015).

- **Soil rehabilitation and conservation.** Soil degradation and its negative impacts on livelihoods are particularly widespread. Soil conservation in Haiti is very relevant and effective for erosion protection, especially during extreme rainfall events (Roose et al. 2012). Improved soil management practices are effective for soil rehabilitation, particularly when soil and water management are linked or when vegetative boundaries across slopes are used (Saffache 2001).

Figure 1. Area of implementation



## Agricultural practices that impact GHG emissions and carbon sequestration

The improved agricultural practices of Chanje Lavi Plantè are estimated to result in GHG impacts from (1) watershed reforestation; (2) perennial crop expansion; (3) alternate wetting and drying (AWD); (4) soil management improvements; (5) water management improvements; and (6) fertilizer usage improvements.

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 C-supported by agricultural practices with impacts on emissions*

	Forest plantation (ha)	Plantain (ha)	Beans (ha)	Maize (ha)	Rice (ha)	Fruit trees including mango (ha)
Watershed reforestation	11,711					
Perennial crop expansion						28,600
Alternate wetting and drying					8,683	
Soil management improvements		8,683				
Water management improvements			8,683	8,683		
Fertilizer management		8,683	8,683	8,683	8,683	

### Watershed reforestation



Reforestation

**Background.** Watershed reforestation makes long-term contributions to the productivity of agricultural lands by increasing soil organic matter and conserving existing soil and water resources. Watershed-focused reforestation contributes to the regulation of streamflow and increases water infiltration,

thus decreasing the severity of flash floods and land slides (Versluis 2010). Intact riparian areas and forested slopes reduce the impacts of extreme weather events and changes in precipitation that are fostered by climate change (Fankap and Daphnis 2015).

**Project Plan.** Chanje Lavi Plantè efforts aim to strengthen the business and technical capabilities of existing reforestation organizations and establish subwatershed governance bodies to stabilize ravines and hillsides near productive agricultural plains and in strategic areas for waterflow regulation.

**Impact on emissions.** The project's reforestation interventions are projected to increase carbon stocks in soils (5.7 tCO<sub>2</sub>e/ha/yr), above-ground biomass (25.9 tCO<sub>2</sub>e/ha), and below-ground biomass (9.6 tCO<sub>2</sub>e/ha), which would result in an estimated total annual GHG impact of -40.89 tCO<sub>2</sub>e/ha (Figure 2). When scaled to the full area of implementation, reforestation results in sizable

carbon sequestration benefits (-478,828 tCO<sub>2</sub>e/yr, Figure 3). Since information on tree survival rates and choices of specific tree species have not been available for this analysis, the specific mitigation estimate for afforestation has a high level of uncertainty.

### Perennial Crop Expansion



Perennial crop expansion

**Background.** Perennial crops provide multiple benefits to cropping systems. They improve soil fertility, reduce runoff, prevent high water evaporation and protect soil from wind erosion (Jose, 2009). The increased organic matter inputs to soils through leaves and branches, shading from high temperatures and

physical protection from wind play an important role. From a global perspective, perennial crops increase terrestrial carbon by removing it from the atmosphere and storing it in plant biomass, thus mitigating carbon increases that reach the atmosphere from other sources. The addition of perennial crops can also improve farm household resilience through the diversification of products for sale or home consumption, or advantages during water stress. Depending on their complexity, these systems can conserve tree, bird, insect, and mammal species diversity (ibid.).



**Project plan.** Chanje Lavi Plantè promotes planting of fruit trees, mainly mango, through its work with farmers' associations and cooperatives. The program works to increase the organizational capacity of producer organizations, promote improved practices, maintain irrigation systems, and improve access to key agricultural inputs. Specifically, Chanje Lavi Plantè expands mango crops on 5,500 ha and a diverse set of fruit trees on 23,100 ha. On average, tree density is estimated to remain rather low, at 100 trees/ha, as reported by IADB (2010), which is funding a mango-focused project in coordination with Chanje Lavi Plantè.

**Impact on emissions.** Expanding perennial cropping systems provide GHG benefits through carbon sequestration in soils as well as above and below ground tree biomass. The biomass carbon stocks result in an estimated annual GHG impact of  $-1.65 \text{ tCO}_2\text{e/ha}$ , owing to the sparse planting pattern (10 x 10 m, equivalent to 100 trees/ha) and an average estimated tree biomass of 80.2 kg/tree (in dry matter) as identified from reference studies (Kotur and Keshava Murthy 2004) (Figure 2). The soil carbon sequestration result in an estimated annual GHG impact of  $-6.42 \text{ tCO}_2\text{e/ha}$  (Figure 2). When scaled to the full area of implementation, perennial crop expansion (both soil carbon and tree biomass) is expected to result in GHG impacts of  $-230,854 \text{ tCO}_2\text{e}$  per yr, (Figure 3).

Due to the availability of information on biomass per tree and plant density, the biomass GHG estimates have a high degree of likelihood. On the other hand, soil carbon impact estimates have a lower level of certainty, stemming from the lack of site-specific soils monitoring data during and after project implementation.

### Alternate Wetting and Drying



Alternate wetting and drying

**Background.** AWD is a management practice in irrigated lowland rice fields characterized by periodic drying and reflooding of the fields. Traditional flooding of rice areas creates anaerobic decomposition of organic matter that causes methane production, a GHG 34 times more powerful at trapping heat in the atmosphere than  $\text{CO}_2$

(Myhre et al. 2013). AWD in irrigated rice fields reduces methane emissions due to shorter flooding periods. This practice also reduces the need for irrigation water and associated fuel consumption, while maintaining or increasing yields (Richards and Sander 2014).

**Project plan.** Chanje Lavi Plantè promotes AWD combined with improved rice management, including earlier transplanting of seedlings, regular plant spacing, reduction of the number of seeds per planting hole, and increased weeding and application of organic matter.

**Impact on emissions.** AWD is widely accepted as the most promising practice for reducing GHG emissions from irrigated rice fields due to its large reductions in methane production (Richards and Sander 2014). On a per-hectare basis, AWD provides strong annual mitigation benefits in the project area ( $-2.33 \text{ tCO}_2\text{e/ha}$ , Figure 2, and  $-20,263 \text{ tCO}_2\text{e}$  over the full area of implementation, Figure 3). While AWD reduces GHG emissions with high certainty, the magnitude of the GHG emission reduction is associated with an intermediate to high level of uncertainty due to lack of information on the intervals of drying and rewetting and associated GHG field measurements in Haiti.

### Water Management Improvements



Water management improvements

**Background.** Targeted water management can strongly increase crop yields. It also has the co-benefit of contributing to carbon storage in soils through higher crop residue returns (Smith et al. 2007). While crop residue can be used in various ways, the retention of a minimum quantity is strongly recommended to guarantee organic matter

inputs to soils. Improved water management can play an important role for ensuring a balance between soil nutrient withdrawal and nutrient replenishment.

**Project plan.** Chanje Lavi Plantè promotes irrigation improvements with regard to the technical irrigation infrastructure (e.g., solar power pumps and drip irrigation systems) and the socio-organizational management aspects of irrigation schemes (i.e., strengthening associations of water users). Watershed governance plans, described in the watershed reforestation section, emphasized improvements in hillside water management such as terracing and vetiver planting. Over 17,000 ha of maize and bean crops, grown in rotation with horticulture crops, are expected to benefit from improved plant water availability.

**Impact on emissions.** Improved water management increases soil carbon stocks due to higher soil organic matter inputs (Smith et al. 2007). For the climate conditions in Haiti, improved plant water management provides estimated annual GHG benefits of  $-1.14 \text{ tCO}_2\text{e/ha}$  (Figure 2) or  $-19,797 \text{ tCO}_2\text{e/year}$  at the scale of the project area (Figure 3). Estimation of rates of soil carbon sequestration were associated with a high level of

uncertainty, especially in the absence of detailed monitoring data on soil carbon levels during and after project implementation. Long term monitoring of soil carbon and other soil related quality indicators is commonly beyond the scope of development projects.

### Soil Management Improvements



Soil management improvements

**Background.** Improved soil management in smallholder farming can increase crop nutrient supply, soil water retention, prevention of erosion, and carbon sequestration (Cheesman et al. 2016). Regular and appropriate supply of organic matter to soils, such as compost, manure and crop residues, is essential to maintain or increase production

and soil carbon (ibid.).

**Project plan.** Chanje Lavi Plantè focuses on intercropping and application of organic material (compost or crop residues) in the plantain cropping system. Intercropping of plantain with annual crops will be promoted on an estimated 8,683 ha (Table 1). The project targeted a density of 2,500 plants/ha, which is higher than conventional practices due to the double row planting pattern.

**Impact on emissions.** For the climate conditions in Haiti, the application of increased organic matter to soils provides an estimated annual carbon sequestration rate of  $-0.88 \text{ tCO}_2\text{e/ha}$  (Figure 2). When scaled to the full area of implementation, these improvements result in estimated carbon sequestration of  $-7,640 \text{ tCO}_2\text{e}$  (Figure 3). Estimation of soil carbon sequestration rates are associated with a high level of uncertainty, especially in the absence of detailed soil carbon monitoring data. While there is high likelihood that *on average* soil carbon sequestration benefits will be realized, it can not be excluded that on a small number of fields soil carbon losses occur.

### Fertilizer Management



Fertilizer management

**Background.** Nutrient inputs, such as fertilizers, balance the nutrients removed in crop products and residues in order to maintain soil fertility. By this means applied synthetic fertilizer reaches higher efficiency when combined with measures that maintain or increase soil organic matter. Nitrogen fertilizers release nitrous oxide, a GHG 298 times as potent as  $\text{CO}_2$  (Myhre et al. 2013).

**Project plan.** In the plantain, bean, maize and rice value chains, Chanje Lavi Plantè works with collaborators to develop crop-specific recommendations for optimal fertilizer usage based on soil data. As a result, the project expects that fertilizer application rates will increase for all crops except irrigated rice systems. With the introduction of the System of Rice Intensification, rice is estimated to reduce its NPK fertilization rate from 132:27:45 kg/ha to 66:14:23 kg/ha. The targeted NPK fertilization rates on other crops were 93:23:23 kg/ha for maize, and 33 kg of N for beans. The intensive production system of plantain, with a high crop density and intercropping, anticipated high fertilization rates, with a target figure for annual NPK application rates of 553:136:553 g per plantain plant. This rate is significantly greater than reported elsewhere (e.g. 165, 53, 495 g of N, P, and K (Kuttimani et al., 2013); 250 kg/ha (Lahav and Turner, 1989); 240 kg/ha (Irizarry et al., 2002), and would imply high financial expenses per farm household. Due to this difference, the FAO team assumed that on average only half the projected rate of fertilization would be used by farmers on plantains.

**Impact on emissions.** Use of fertilizer increases GHG emissions, as the nitrogen-based fertilizers can convert to the potent GHG nitrous oxide ( $\text{N}_2\text{O}$ ). The IPCC reports that GHG emissions are proportional to the amount of fertilizer applied. Increased application rates lead to an estimated increase in annual GHG emissions by  $0.90 \text{ tCO}_2\text{e/ha}$  on maize,  $3.05 \text{ tCO}_2\text{e/ha}$  on plantain, and  $0.31 \text{ tCO}_2\text{e/ha}$  on beans. On average, the increases across cropping systems result in estimated GHG emissions of  $1.42 \text{ tCO}_2\text{e/ha}$  (Figure 2). Reduced fertilizer application rates on rice reduce GHG impacts by an estimated  $-0.65 \text{ tCO}_2\text{e/ha}$ . When scaled to the full area of implementation, the changing fertilizer application rates across all crops result in an estimated increase of  $31,377 \text{ tCO}_2\text{e}$  (Figure 3).

The estimated changes in average fertilization rates are associated with higher levels of uncertainty, as the actual choice of a specific fertilizer dose relies on the individual farm household situation, including issues of cash availability, land fertility, exposure to climatic shocks, and the experience and preference of the farmer regarding application rates. In addition, the specific estimates of field related  $\text{N}_2\text{O}$  emissions may differ greatly in any given year (e.g., due to interannual variations in the timing of rainfall events and management practices).

## Summary of projected GHG emission and carbon sequestration co-benefits

Figures 2 and 3 summarize projected GHG emissions and carbon sequestration per hectare and for the entire area of planned project implementation. Watershed restoration ( $-40.89 \text{ tCO}_2\text{e/ha}$ ) and investments in perennial crops ( $-8.07 \text{ tCO}_2\text{e/ha}$ ) provide the strongest estimated mitigation benefit per ha (Figure 2). AWD, water, and soil management improvements have comparably lower estimated GHG impact per ha but have agronomic benefits.

It is important to note that while each practice can be analyzed separately for its GHG impact, the adoption of reforestation and perennial crop expansion measures depended on improvements in practices that had been identified earlier. Improved management practices should thus not be considered in isolation, but as part of an interlinked landscape approach

Figure 2. Impact of agricultural practices:  
Net GHG emissions on an area basis  
( $\text{tCO}_2\text{e/ha/yr}$ )

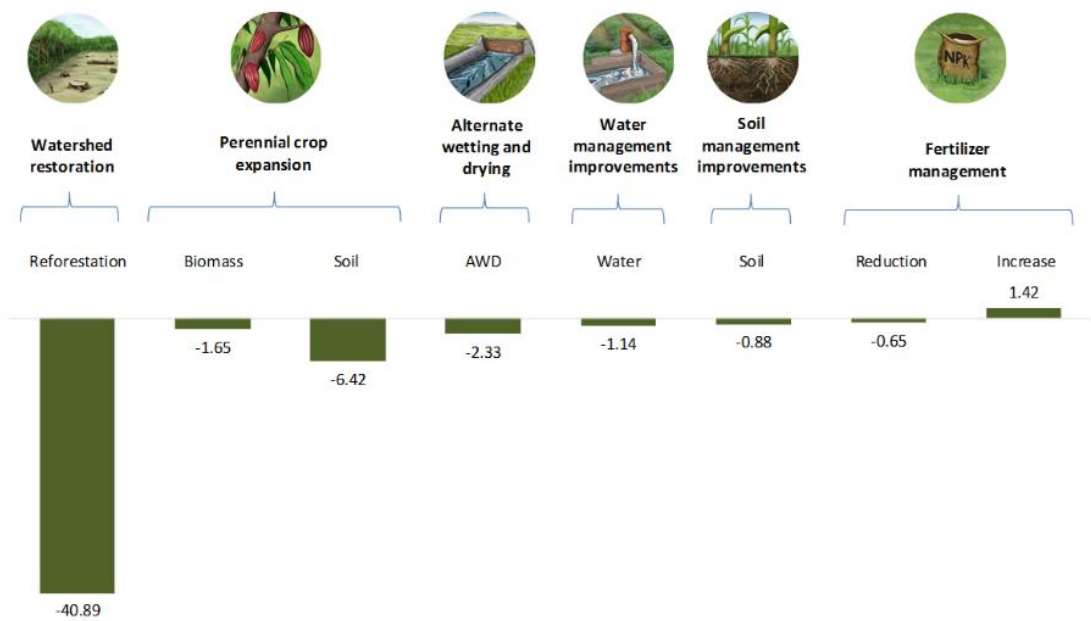
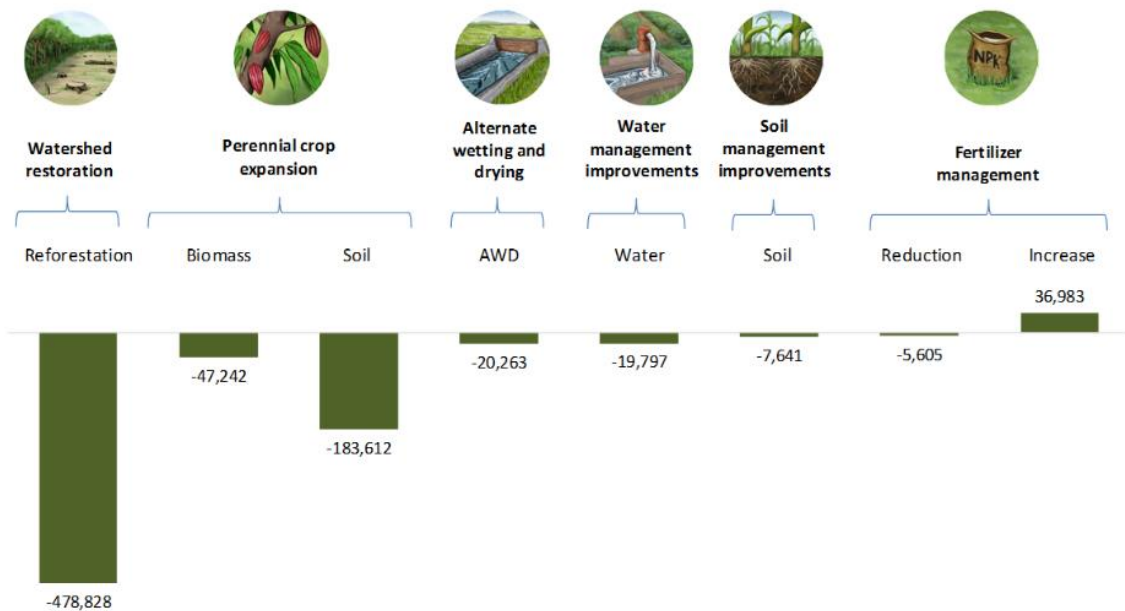


Figure 3. Impact of agricultural practices:  
Net GHG emissions on total area of impact  
( $\text{tCO}_2\text{e/yr}$ )



## 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 plantain, maize, rice, beans, and mango without and with agricultural practices supported by Chanje Lavi Plantè.

**Annual yield.** Plantain, maize, rice, and beans are expected to have significant yield increases of 56%, 413%, 139%, and 100%, respectively. The progress in yields is due to a combination of water, soil, and fertilizer improvements. Mango yields remain the same with or without project intervention.

**Postharvest loss.** Interventions aimed at improving transportation, harvesting, storage, and processing infrastructure all contribute to reductions in postharvest loss. Specific interventions include 1) increased access for farmers to moisture meters for the grain drying process; 2) construction of grain silos; 3) tools that reduce

cuts and trauma to mangos during harvest; 4) improved packaging frames for mango transportation; and 5) mobile washing centers. Due to these interventions, the project estimates reductions in postharvest loss in the value chains for plantain (32 to 15 percent), maize (30 to 16 percent), rice (27 to 15 percent), beans (30 to 15 percent), and mango (25 to 16 percent).

**Emission intensity.** For all crops except plantain, the project's value chain interventions are expected to result in reduced emission intensity (Table 2) due to per hectare emission reductions (Figure 1), increased crop yield, and reduced postharvest loss. Irrigated rice is a net GHG emission source (estimated at 0.81 tCO<sub>2</sub>e/t) even though the emissions intensity before project intervention was significantly higher (estimated at 4.11 tCO<sub>2</sub>e/t). For plantain, although the estimated GHG increases per hectare on plantain are sizeable (2.17 tCO<sub>2</sub>e/ha), the estimated emission intensity remains very low (0.13 tCO<sub>2</sub>e/t).

Table 2. Emission intensity by product

	Project agricultural practices	Total GHG emissions per ha (tCO <sub>2</sub> e/ha) (1)	Annual yield (t/ha) (2)	Postharvest loss (%) (3)	Remaining annual yield (t/ha) (4)	Emission intensity (tCO <sub>2</sub> e/t product) (5)
<b>Plantain</b> (soil management, fertilizer management)	No project	0.00	13.00	32%	8.84	0.00
	Project	2.17	20.30	15%	17.26	0.13
	Difference (%)	2.17 (-)	7.30 (56%)	-17% (-53%)	8.41 (95%)	0.13 (-)
<b>Maize</b> (water management, fertilizer management)	No project	0.00	0.80	30%	0.56	0.00
	Project	-0.24	4.10	16%	3.44	-0.07
	Difference (%)	-0.24 (-)	3.30 (413%)	-14% (-47%)	2.88 (515%)	-0.07 (-)
<b>Irrigated rice</b> (AWD, fertilizer management)	No project	6.60	2.20	27%	1.61	4.11
	Project	3.62	5.26	15%	4.47	0.81
	Difference (%)	-2.98 (-45%)	3.06 (139%)	-12% (-44%)	2.86 (178%)	-3.30 (-80%)
<b>Beans</b> (water management, fertilizer management)	No project	0.00	0.60	30%	0.42	0.00
	Project	-0.83	1.20	15%	1.02	-0.81
	Difference (%)	-0.83 (-)	0.60 (100%)	-15% (-50%)	0.6 (143%)	-0.81 (-)
<b>Mango</b> (perennial crop expansion)	No project	0.00	7.50	25%	5.63	0.00
	Project	-8.07	7.50	16%	6.28	-1.29
	Difference (%)	-8.07 (-)	0 (0%)	-9% (-35%)	0.65 (12%)	-1.29 (-)

Notes:

1. Total GHG emissions per hectare specifies the emissions per hectare of product harvested.
  2. Annual yield specifies 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:

- **Watershed restoration.** Under what circumstances is further expansion of the reforestation program feasible? Which factors endanger the sustainability of reforestation measures and how can they be addressed? How can forested areas contribute to provide sustainable cash flows to beneficiaries? Can these interventions be coupled with initiatives to combat forest degradation?
- **Agroforestry expansion.** Which support factors and farming household characteristics determined whether high or low seedling survival rates were achieved during plant establishment? How can low mortality rates and sufficient water availability during plantation establishment be ensured? Which farm types particularly participate in agroforestry measures?
- **Soil management.** Which strategies enable farmers to ensure sufficient availability of organic matter for application to soils? Which mechanization devices, suitable for small-scale farmers, can be scaled up in order to reduce the costs and labor of sustainable land management?
- **Water management.** What are the barriers to increased irrigation for high value crops? Under which conditions can landscape level links between watershed restoration, agroforestry expansion, and soil management improvements be replicated in other locations?

## In focus: Farmer participation in watershed forest restoration may reverse degradation trend

Chanje Lavi Plantè promotes a landscape approach to LED by combining sustainable hillside agriculture with watershed restoration. The project area is experiencing reduced soil productivity and increased flood threats following deforestation. The project intervenes at a landscape level with critical hillside stabilization through reforestation, ravine treatment, soil conservation works and agroforestry as well as sustainable hillside agricultural practices and greenhouses (Chemonics 2015). In addition, Chanje Lavi Plantè strengthens the business and technical capabilities of existing farmer organizations and establishes subwatershed governance bodies to stabilize ravines and hillsides near productive agricultural plains. Efforts to strengthen collective management of open access resources require long-term investments into social institutions. It is essential to ensure a supporting structure of incentives that prevents "free-riding" behavior.

By providing increased opportunities for sustainably intensified agriculture that is profitable, the project may contribute to a reduction of short term pressures to cut down forests, which would further destabilize the watershed. While it is important to note that sustainable intensification may also provide incentives to expand cropland into uncultivated land, this is especially true where increases in productivity on cultivated land have already largely been achieved.

In addition, business models of forestry plantations provide direct financial incentives to reverse current levels of watershed degradation.

The introduction of profitable agricultural technology — drip irrigation, access to improved crop seed and tree seedlings — as well as a stable institutional land tenure situation and functioning mechanisms of managing common resources are important elements of the enabling policy environment.

## Methods for estimating GHG impacts

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 GHG 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 GHG emissions and strength of the intervention. The 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, monitoring data, and estimates regarding the adoption of improved agricultural practices, annual yields, and postharvest losses. The GHG analysis is based on the provided information as input data.

The team estimated GHG emissions and carbon sequestration associated with agricultural and forestry practices by utilizing EX-ACT, an appraisal system developed by 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
<b>Accelerating Agriculture Productivity Improvement</b>	Bangladesh		X			X
<b>ACCESO</b>	Honduras	X			X	X
<b>Agricultural Development and Value Chain Enhancement Activity II</b>	Ghana		X			X
<b>Better Life Alliance</b>	Zambia	X		X		X
<b>Chanje Lavi Planté</b>	Haiti	X	X	X		X
<b>Pastoralist Resiliency Improvement and Market Expansion</b>	Ethiopia				X	
<b>Peru Cocoa Alliance</b>	Peru	X				X
<b>Resilience &amp; Economic Growth in Arid Lands-Accelerated Growth</b>	Kenya				X	
<b>Rwanda Dairy Competitiveness Program</b>	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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