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CGIAR RESEARCH PROGRAM ON Climate Change, Agriculture and Food Security CCAFS

Info Note

Peru Cacao Alliance: Carbon sequestration as a co-benefit of cacao expansion

A series analyzing low emissions agricultural practices in USAID development projects

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Key messages

- The agricultural development project, Peru Cacao Alliance (PCA), has contributed to climate change mitigation. Estimated carbon sequestration from perennial crop expansion, which was –211,467 tCO_2e metric tonnes of carbon dioxide equivalent per year, more than offset increased greenhouse gas emission (GHG) from fertilizer and pesticide management (10,286 tCO_2e). The net difference, –201,180 tCO_2e, is equivalent to the carbon content of 465,774 barrels of oil.
- The agroforestry system promoted by PCA included cacao and shade trees. Since PCA could not provide definitive data detailing the presence of existing shade trees compared to the planting of new shade trees, this analysis did not include carbon dynamics of shade trees. If new trees were planted for shade, there would be greater carbon uptake by the system than presented in this analysis.
- PCA reduced emissions intensity for cacao (CO_2e emitted per kg production) through improved carbon sequestration and increased yields. PCA improved cacao postharvest handling (proper pod selection, storage, drying and fermentation methods) by building knowledge and capacity in producer organizations.

About the Peru Cacao Alliance project

PCA is a public-private partnership that works with cacao farmers in the Ucayali, San Martín, and Huánuco regions of the Amazon basin (Figure 1). Established in 2012, PCA was a 4-year project implemented by Carana Corporation and funded through United States Agency for International Development's (USAID) alternative development initiative. A recently signed follow-on project, with the same name, will be implemented by Palladium, which has acquired Carana. PCA integrated almost 20,000 small-scale farmers into an inclusive, sustainable value chain that will facilitate legal sources of income and discourage a return to illegal coca production.

PCA promoted connections among farmers, buyers, technology providers, investors, and Peruvian government partners to increase Peru's market share of worldwide cacao production. The value chain approach featured: (1) establishing direct long-term commercial relationships between farmers and cacao buyers; (2) strengthening producer organizations; (3) facilitating the growth of areas under cacao cultivation; (4) enhancing cacao quality; and (5) improving postharvest handling.

PCA also focused on environmental protection and biodiversity and promoted the expansion of perennials systems on previously deforested land. PCA hoped that increased incomes from the cocoa value chain would encourage farmers to leave behind the insecurity of coca production.

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 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).

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.

Agricultural and environmental context: Peru

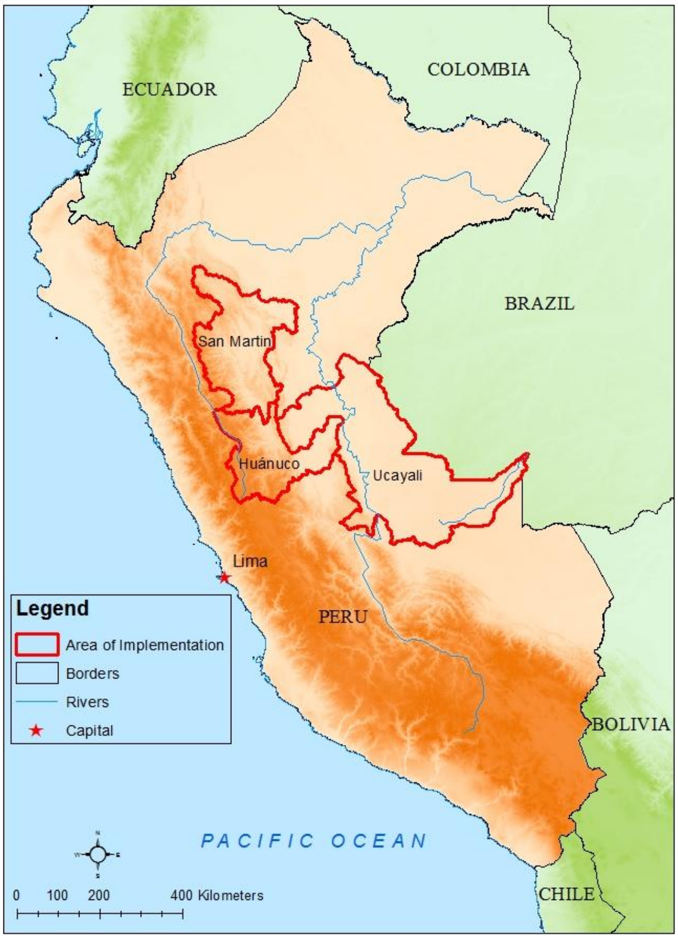
A quarter of the Peruvian population lives below the poverty line and nearly one in five children under five years old suffers from stunting (World Bank 2016b). Agriculture is an important component of Peru's economy. It consistently contributes about 7% to the gross domestic product (2008-2012) (World Bank et al. 2015), employs 26% of the labor force, and occupies 19% of the land (World Bank 2016a).

Peru's agriculture is primarily small-scale farming: 70% of farms are less than 5 hectares (ha) (Lowder 2014). Small and medium producers cultivate a mixture of grains, vegetables and fruits for domestic consumption, and coffee for export (World Bank et al. 2015). Peru is the third largest producer of organic cacao in the world and is increasing its market share (Arevalo-Gardini et al. 2015).

Amazon forest covers 60% of Peru (World Bank et al. 2015), which contributes to the country's ecosystem richness and biodiversity (Miranda et al. 2016). Although it is a large carbon stock, it is vulnerable to deforestation and degradation (Hansen et al. 2013). Conversion of primary forests is driven by complex, evolving dynamics, including the establishment of small-scale agriculture, land consolidation for industrial agriculture, and the expansion of artisanal mining (Miranda et al. 2016).

Climate change could greatly impact the Amazonian forest in Peru due to fluctuations in rainfall patterns (Levine et al. 2016) and the increased intensity of weather events (World Bank et al. 2015). In 2015, Peru identified agriculture as a contributor to GHG emission and included agricultural mitigation targets at the 2015 UNFCCC (Richards et al. 2015).

Figure 1. Area of implementation.



Agricultural practices that impact GHG emissions and carbon sequestration

PCA promoted two improved agricultural practices relevant to GHG emissions and carbon storage: perennial crop expansion and fertilizer/pesticide usage. A description of each practice follows, including a description of the intervention and its effects, the project plan for the practice, and estimated impacts on emissions.

Perennial crop expansion

Perennial crop expansion

Background. Perennial cropping systems have a number of benefits. Compared to annuals, they have deeper and larger root networks that serve to retain water and soil. These conservation measures for erosion and runoff keep soil, nutrients and water on the farm, a local benefit, as well as keeping them out of bodies of water (Glover et al. 2012). Perennial systems increase organic matter input to the soils, helping them to retain 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. Perennial crops can also support tree, bird, insect, and mammal diversity compared to annuals (ibid.). Addition of perennial crops to a farm can improve household resilience by increasing the diversity of products for sale and home consumption.

Project plan. PCA encouraged cacao farmers to expand cultivated areas and introduced new farmers to the crop. According to PCA, land used for expansion of the cocoa production system came from grasslands or annual croplands. PCA expected a planting density of 1,111 cocoa trees/ha.

The cacao production system promoted by PCA included shade trees, e.g. Bolaina *(Guazuma crinita)* and Capirona (*Calycophyllum spruceanum)*. With the expansion of the cacao production system, new shade trees were planted as part of the agroforestry system or existing trees were used when available. Carbon storage by shade trees was not included in this analysis because the implementing partners did not have definitive data on the extent of new plantings (an additional carbon storage factor) versus the use of existing trees. If monitoring data on shade tree planting were available, this component of PCA would provide sizable additional climate change mitigation.

Impact on carbon sequestration. Perennial crops provide mitigation benefits through carbon sequestration in soils and tree biomass. New cacao trees sequester carbon as biomass as they grow. In mature cacao trees, above-ground biomass ranges from 20–40 kg per tree (Zuidema et al. 2005, Somarriba et al. 2013, Mohammed et al. 2015). This analysis used an intermediate value of 27.4 kg of biomass per tree for those older than 15 years (Mohammed et al. 2015), and a shoot-to-root ratio of 87/13 (Norgrove and Hauser 2013). Given the planting density goal of PCA, enhanced carbon stocks from cacao biomass resulted in estimated sequestration of –17.495 t C/ha, a rate comparable to estimates for Central American smallholder cacao systems with lower tree densities (Somarriba et al. 2013). Increased tree biomass resulted in increased carbon sequestration (–3.89 tCO_2e/ha/yr, as shown in Figure 2). Note that biomass increase is not linear, but the annual averages are useful for comparison with other agricultural practices.

PCA also sequestered carbon in soils. As lands were converted from pasture (9,800 ha), degraded pasture (4,200 ha), and various annual crops (14,000 ha), soil carbon was sequestered at rates of –0.7 tCO_2e/ha/yr, –1.14 tCO_2e/ha/yr, and –6.42 tCO_2e/ha/yr, respectively.

PCA's practice of perennial crop expansion over the entire area of implementation resulted in GHG mitigation benefits of –211,467 tCO_2e/yr, as shown in Figure 3.

Fertilizer and pesticide management

Fertilizer and pesticide management

Background. Soil nutrient stocks are affected by the removal of nutrients such as crops and stover, and the input of nutrients from crop residues, fertilizer, manure and other sources. Farmers employ new techniques in fertilizer management to balance inputs and losses of nutrients in order to boost crop yields. In Peru, cacao yields increased 40% over the last 10 years, but yield gaps still exist. Traditionally, efficient fertilizer management focused on the timing, type, placement, and quantity of nutrients to minimize loss and optimize crop uptake of nutrients to increase yields. Today, the focus is broader; it includes practices such as intercropping and rotations, as well as a focus of this project, perennials, to build agroecosystems that minimize N losses, maximize plant use of available nutrients, build soil organic matter to retain nutrients, and minimize external nutrient inputs.

GHG emissions result from the production of fertilizers and pesticides (Lal 2004; IFA 2009) and conversion of nitrogen fertilizers to nitrous oxide (N_2O) in fields (Butterbach-Bahl 2013). Fertilizer management can reduce emissions of (N_2O) emissions, a GHG 298 times more potent than CO_2 (Myhre et al. 2013), from fertilized soils as well as the emissions associated with the energy intensive production of fertilizers. One challenge of these perennial systems is an increased need to control pests associated with the shade trees, largely met by increased pesticide use. The emissions associated with the production, transportation and storage of pesticides are included in this analysis.

Project plan. To improve yields and product quality while minimizing costs, PCA conducted training and monitoring of safe pesticide use, fertilization, and composting. PCA also improved smallholders' access to fertilizers by making working capital available through microfinance institutions. Based on these interventions, most participating farmers were expected to use an intermediate quantity of synthetic fertilizer—roughly 30 kg N/ha from urea and diammonium phosphate (DAP)—and low amounts of fungicides (2 kg/ha copper sulfate).

Impact on emissions. PCA activities increased GHG emissions from fertilizers by 0.32 tCO_2e/ha annually (Figure 2) and 8,977 tCO_2e over the full area of implementation (Figure 3). Pesticide use increased GHG emissions by an estimated 0.05 tCO_2e/ha annually (Figure 2) and 1,309 tCO_2e over the full area of implementation (Figure 3).

Photo credit: USAID U.S. Agency for International Development, 2013

Summary of projected GHG emission and carbon sequestration co-benefits

PCA's interventions are estimated to result in a substantial increase in carbon sequestration from perennial crop expansion. This will more than offset increased GHG emissions from fertilizer and pesticides. There are clear benefits to PCA's increasing biomass (–3.89 $tCO_2e/ha/yr$) and improving soils (–2.75 $tCO_2e/ha/yr$) following the introduction of perennial crops.

There are increased emissions due to pesticide usage (0.05 $tCO_2e/ha/yr$) and fertilizers (0.32 $tCO_2e/ha/yr$) (Figure 2). Perennial crop expansion caused net GHG emissions of –211,467 tCO_2e (Figure 3). Increased annual GHG emissions from greater fertilizer and pesticide consumption are comparably minor (10,286 tCO_2e, Figure 3).

Figure 2: Impact of agricultural practices: Net GHG emissions on an area basis

($tCO_2e/ha/yr$)

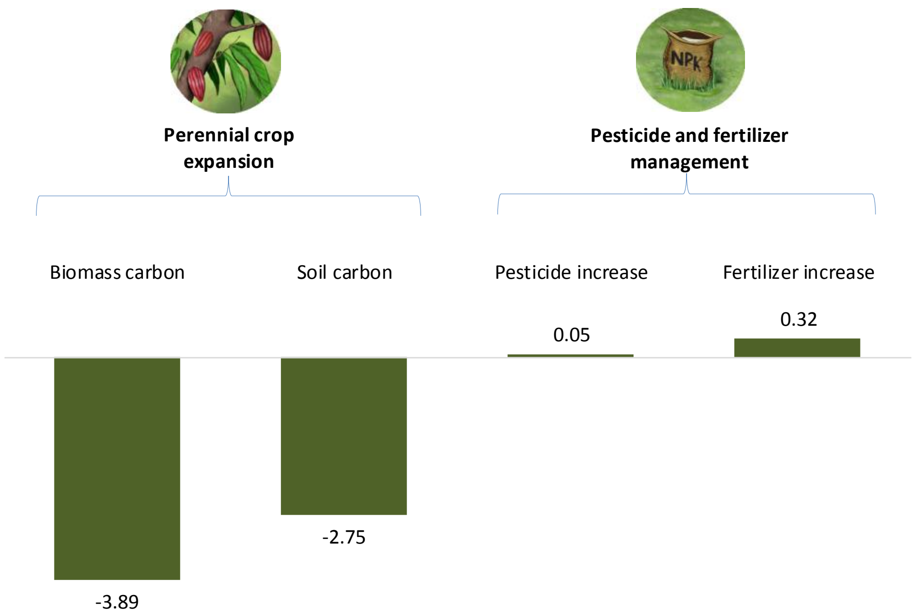
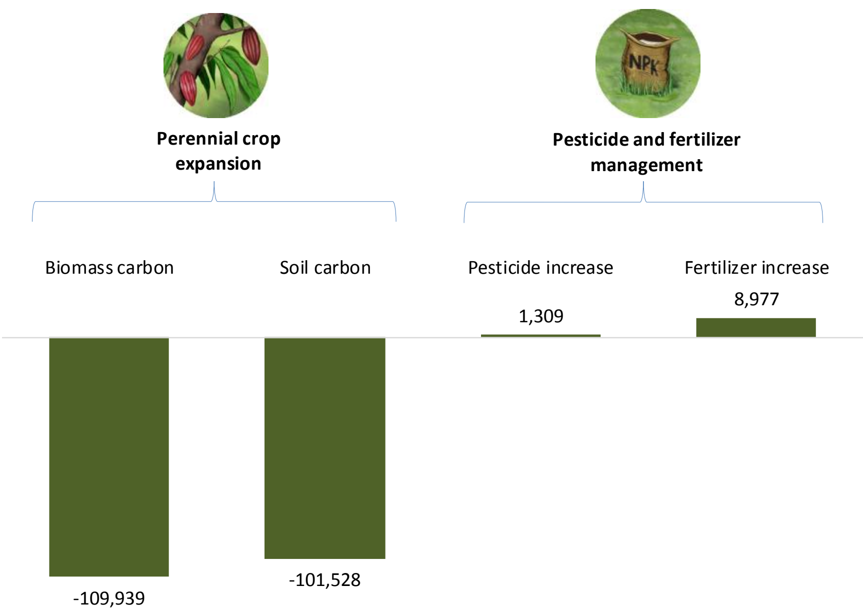


Figure 3. Impact of agricutural practices: Net GHG emissions on total area of impact

(tCO_2e/yr)



GHG emission intensity

LED aims to decrease emission intensity (GHG emissions per unit of output), a useful indicator in the agricultural sector. Table 2 summarizes emission intensity for cacao without and with agricultural practices supported by PCA.

Annual yield. Conventional cacao farmers in the region harvest 0.6 t/ha, while cacao farmers in PCA were expected to harvest 1.0 to 1.5 t/ha cacao by 2021, an increase of 67%.

Postharvest loss. Improved cacao postharvest handling (proper pod selection, storage, drying and fermentation methods) brought about increased value. However, since postharvest loss percentages shown in Table 2 measure only increases in cacao quantity, and not improved product quality, the analysis does not capture the full postharvest loss improvements.

Emission intensity. PCA's interventions resulted in reduced emission intensity for cacao (Table 1) due to increased carbon sequestration and yields. Analysis showed reduced emission intensity of cacao managed on degraded grasslands, grasslands, and annual croplands (–4.69 tCO_2e/t, –5.5 tCO_2e/t, and –11.97 tCO_2e/t, respectively.

Table 1. Emission intensity by product

	Project 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)
Cocoa (land use change from degraded grassland)	No project	0.00	0.60	15%	0.51	0.00
	Project	–3.99	1.00	15%	0.85	–4.69
	Difference (%)	–3.99 (-)	0.40 (67%)	0% (0%)	0.34 (67%)	–4.69 (-)
Cocoa (land use change from grassland)	No project	0.00	0.60	15%	0.51	0.00
	Project	–4.68	1.00	15%	0.85	–5.5
	Difference (%)	–4.68 (-)	0.40 (67%)	0% (0%)	0.34 (67%)	–5.50 (-)
Cocoa (land use change from annuals)	No project	0.00	0.60	15%	0.51	0.00
	Project	–10.18	1.00	15%	0.85	–11.97
	Difference (%)	–10.18 (-)	0.40 (67%)	0% (0%)	0.34 (67%)	–11.97 (-)

Notes:
1. Total GHG emissions per hectare signifies the emissions per hectare of product harvested.
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

Future program designers should consider the following issues raised by this analysis of GHG emissions and carbon sequestration in agriculture and food security projects when focused on smallholder farmers:

Agroforestry expansion. What incentives or changes to enabling conditions are needed to help farmers expand agroforestry systems? Can smallholder farmers individually finance the establishment of a cacao production system?

Forestry management. Are there appropriate shade trees that provide clear benefits to cocoa systems and avoid potential negative impacts from pest management? Which species and management practices allow for higher shade tree biomass within cocoa farms?

Fertilizer management. Can interventions that promote nutrient–use efficiency be expanded? Can the project expand the composting/recycling of postharvest waste within the agroecosystem?

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. 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, 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	

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