USAID FROM THE AMERICAN PEOPLE

Food and Agriculture Organization of the United Nations

CGIAR

RESEARCH PROGRAM ON Climate Change, Agriculture and Food Security

CCAFS

Info Note

Pastoralist Areas Resilience Improvement through Market Expansion (PRIME) in Ethiopia: Mitigation co-benefits of livestock productivity

A series analyzing low emissions agricultural practices in USAID development projects

Julie Nash, Uwe Grewer, Louis Bockel, Gillian Galford, Gillian Pirolli, Julianna White

NOVEMBER 2016

Key messages

- Pastoralist Areas Resilience Improvement through Market Expansion (PRIME) showed a notable decrease in emission intensity (GHG emissions per unit of meat or milk). PRIME enabled farmers to increase production significantly, between 24% and 96%, which led to a decrease in emission intensity ranging from -4% to -42%.
- Due to improvements in feed quantity, PRIME projected an increase in average animal weight for all livestock (8.3 million head), which resulted in an increase in GHG emissions by an estimated 1.5 million tCO_2e/yr.
- PRIME empowered stakeholders collectively to design and establish plans for effective management of pastures and water. The project supported soil and water conservation measures, enclosing degraded pastures, selective bush thinning, and clearing the invasive plant *Prosopis*. These practices improved pasture plant quality and reduced bare soil and overgrazing, which resulted in increased sequestration of soil carbon. These grassland improvements were estimated to sequester -0.1 million tCO_2e/yr.

About the PRIME project

Begun in 2012 with funding from the Feed the Future (FTF) initiative, PRIME employed a market-based facilitation approach to build the resilience of pastoralists in seven zones in the Afar, Oromiya, and Somali regions (Figure 1). Implemented by Mercy Corps, PRIME targeted 250,000 households as direct beneficiaries, including 50,000 that received direct activity support for animal husbandry practices.

PRIME aimed to promote the viability and resiliency of pastoralist communities by 1) improving the productivity and competitiveness of livestock; 2) enhancing the adaptive capacity of pastoralists to confront climate change; 3) strengthening alternative livelihoods to enable households to transition out of pastoralism; and 4) improving the nutritional status of targeted households through sustained and evidence-based interventions.

To improve livestock productivity and competitiveness, PRIME focused on increasing the supply of inputs and services to pastoralists and enhancing market links among traders, processors, and exporters. PRIME also aimed to improve natural resource usage through water management and by mapping landscape-level rangeland resources, thereby empowering stakeholders to collectively design and engage in targeted natural resource enhancement initiatives and establish systems to effectively manage pasture areas and water points.

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

Agricultural and environmental context: Ethiopia

Ethiopia (1,104,300 km^2) is home to about 99,390,000 people and has a population growth rate of approximately 2.5% (World Bank 2016). The poverty rate is 40%, and more than 40% of children suffer from stunting (ibid). Agriculture is a central component of the economic development of the country and accounts for approximately 41% of the gross domestic product (ibid).

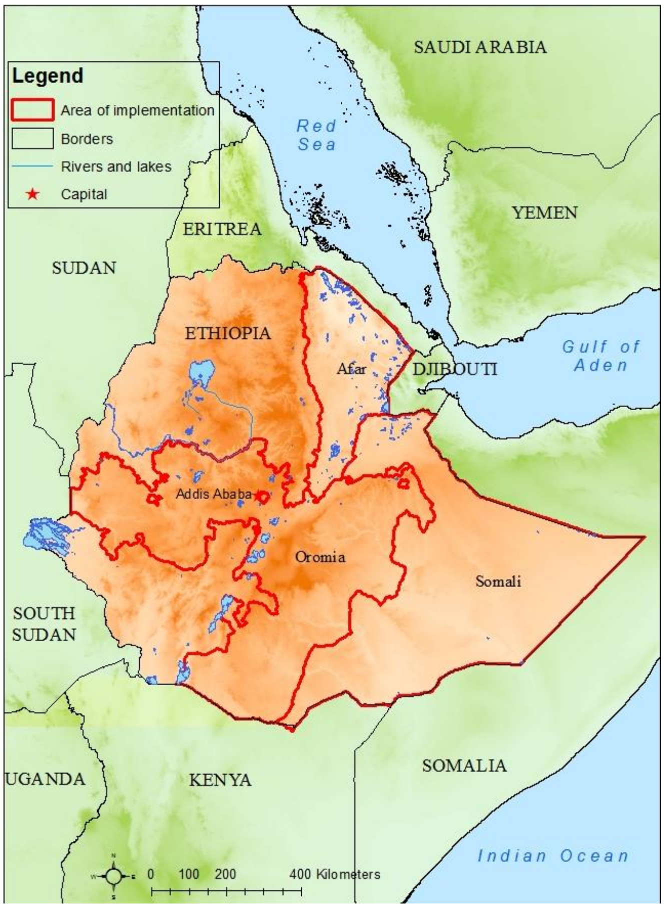
Livestock are important economically and socially. In 2013, there were 11.4 million livestock-producing households (Shapiro et al. 2015) with pastoral systems found on over 60% of the land (Retteberg 2010). Livestock serve as food source, household assets, a safety net when food or cash is scarce, and a source of draft power (Amenu et al. 2013). Ethiopia's livestock population accounts for more than 11% of all livestock in Africa (FAOSTAT 2016).

GHG emissions from livestock account for more than 90% of Ethiopia's total agricultural emissions, excluding land use change and forestry (FAOSTAT 2016). Primary sources of GHG emissions from livestock are enteric fermentation, manure management, and manure.

Ethiopia's livestock emissions have nearly doubled since 1994 (FAOSTAT 2016). Ethiopia identified livestock emissions in its 2015 Intended Nationally Determined Contribution submission to the UNFCCC, and included mitigation of agricultural emissions as a component of its plan (Richards et al. 2015).

Ethiopia's pastoralists regularly faced reoccurring droughts, water scarcity, and conflicts over common pool resources. Pastoralists are experiencing the effects of climate change at an increasing rate, including rising maximum temperatures and greater rainfall variability (Schmidt and Pearson 2016). Lack of availability of clean water remains a problem and can adversely affect livestock health and productivity (Amenu et al. 2013). Pastoralists are also experiencing loss of communal grazing areas and watering points due to agricultural expansion and urbanization (Rettberg 2010). Combined, these challenges have increased the vulnerability and impoverishment of many pastoralists (Rettberg 2010; Schmidt and Pearson 2016). Ethiopia's livestock sector has become a key focus area for economic development and food security.

Figure 1. Area of implementation.



In focus: Managing grasslands to increase productivity and reduce emissions intensity

Many biophysical and social factors determine the potential of soil carbon sequestration in grazing lands. Climate (rainfall and regime) and soils are key factors that determine carbon sequestration (Milne et al. 2016). Grassland interventions that increase the diversity of species, healthy plant growth, soil cover, and functioning ecosystem services improve soil carbon sequestration (ibid.). Reversing grassland degradation through improved management practices works only if it helps pastoral herders; for example, it may be economically feasible when it enhances forage production and livestock productivity (Herrero et al. 2016).

PRIME has empowered stakeholders to design and establish systems and plans for the effective management of rangelands collectively. Specifically, PRIME has conducted workshops with communities and local government representatives to share and interpret seasonal climate forecasts, thereby helping local stakeholders to plan wet and dry season fodder management. This can help livestock producers reduce pressure on the grasslands, and allow more time for pastures to regenerate.

Agricultural practices that impact GHG emissions and carbon sequestration

The emission analysis focused on PRIME's improved practices in the dairy cattle, non-dairy cattle, sheep, and goat value chains: grassland improvements, feed quality, and feed quantity and herd weight dynamics.

Table 1 shows estimates of the area of adoption for each practice by the end of the project. A discussion 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. PRIME—Agricultural practices with mitigation co-benefits by value chain

	Grassland	Cattle (non-dairy)	Dairy Cattle	Sheep	Goats
Grassland improvements (ha)	101,282				
Feed quality improvements		394,080	1,247,920	1,260,000	1,661,000
Feed quantity and herd weight dynamics		2,407,680	760,320	2,466,000	2,556,000

Grassland improvements


Grassland improvements

Background. Improving grassland management can influence the rate at which grasses grow and are removed, which affects carbon storage in soils (Gerber et al. 2013, Herrero et al. 2016). Grassland management practices that promote soil carbon accumulation include improved nutrient and water inputs, rotational grazing, and improvements to species composition (ibid). In Ethiopia, communities face shortages of animal feed during the long dry season (Kassahun et al. 2008). By providing adequate livestock feed during the dry season, livestock herders reduce pressure on the rangelands, which allows more time for the pastures to regenerate as well as reducing pasture degradation.

Practice plan. PRIME empowered stakeholders to design and establish plans collectively for the effective management of pastures and water points. The project supported soil and water conservation measures, enclosed degraded pastures, performed selective bush thinning, and cleared the invasive plant Prosopis. These practices improved pasture quality and reduced bare soil and overgrazing, which resulted in sequestration of carbon in the soil. Although PRIMES's pasture activities were linked to a total area of 5 million ha, effective improvements were conservatively estimated to take place on over 101,000 ha, the full area of implementation. The extent of improvements depended on agreement and enforcement by communities to follow their management plan.

Impact on carbon sequestration. PRIME's interventions enhanced soil carbon stocks (estimated change, 36.5 to 44.1 tC/ha). This assumed that the initial grassland state was moderately degraded and the improvements did not include practices such as active seeding or irrigation. Grassland improvements sequestered carbon at rates of –1.39 tCO_2e/ha/yr (Figure 1) or –141,120 tCO_2e/yr for the full area of implementation (Figure 2). These types of interventions are well documented with regard to their enhancement of soil carbon stocks, however more precise information on initial degradation state, area of implementation, and biomasses associated with specific practices would improve these estimates.

Feed quality improvements


Feed quality improvements

Background. Improvement in feed quality increases animal productivity and reduces GHG emissions. Low-digestibility feeds (high fiber to starch ratios) result in higher enteric emissions per unit of meat or milk, and are found more commonly in systems with low productivity (Herrero et al. 2016). Livestock producers can affect GHG emissions by changing their forage mix and by greater use of feed supplements (Gerber et al. 2013), which boost productivity. Feedstocks, such as fodder trees, decrease enteric fermentation (methane production) compared with grass silages.

Practice plan. PRIME introduced practices to improve feed quality for livestock. The project supported increased use of quality grasses, treatment of fodder (e.g., with molasses and/or urea), and crop residues and food processing waste for livestock feed. PRIME estimates that roughly half the dairy cattle (52% or about 1.2

million), sheep (51% or about 1.2 million), and goats (65% or about 1.6 million) benefited from improved feed within the intervention area.

Impact on emissions. The FAO team utilized the method of Smith et al. (2007), which provides estimates for emission reductions following feed improvement in sub-Saharan Africa. These are based on currently available and commonly used improved feed practices and do not require input data on changes in feed composition or digestibility. This yields a conservative estimate of -1% reduction in methane emissions from enteric fermentation or -0.01 tCO_2e/head for cattle and -0.001 tCO_2e/head for sheep (Smith et al. 2007) (Figure 1). Improved feeding for all sheep and cattle results in a change in GHG emissions of -35,590 tCO_2e per year (Figure 2). Even greater reductions would result if there were a greater increase in feed digestibility, but there is clear evidence of the direction and relative magnitude of these emissions (IPCC 2006). More precise information about the type of feed before and during activity implementation would improve the estimate methodology.

Feed quantity and herd weight dynamics

Feed quantity and herd weight dynamics

Background. Sufficient and stable feed supply is important for sustaining productive and efficient livestock systems (Richards et al. 2016). Henderson et al. (2016) identified significant yield gaps in smallholder crop–livestock systems, and suggested that narrowing them could lower the GHG intensity of agro-pastoral systems. Due to improvements in feed quality and quantity, PRIME estimated that the average animal weight would increase with project interventions.

Practice plan. PRIME utilized improvements in feed quality and quantity to increase average animal weight. PRIME estimated a 20% weight increase for cattle (250 to 300 kg/head) and in sheep and goats (collectively called “shoats,” up from 25 to 30 kg/head). By lowering the seasonal variation in feed availability, PRIME increased the weight of slaughtered livestock as well as milk yields. PRIME estimated the average milk yield per lactating cow increased 24% (330 to 410 l/yr).

Impact on emissions. For cattle, feed consumption increased 20% (6.25 to 7.5 kg dry matter/day), which led to increased GHG emissions. Based on IPCC Tier 2 methodology (IPCC 2006), cattle feed intake changes led to a 20% increase in annual methane emissions (49.2 to 59.1 kg CH4/head/yr), and manure management and deposition led to a 20% increase in N_2O emissions (0.004 to 0.005 kg/head/yr) due to increased manure excretion. Overall, this translates into an estimated increase in annual GHG emissions for cattle (0.43 tCO_2e/head/yr), sheep (0.05 tCO_2e/head/yr), and goats (0.02 tCO_2e/head/yr) (Figure 1). Although there is a high level of confidence that this depicts a reasonable improvement scenario for animal productivity, there is an intermediate level of uncertainty associated with estimating average changes at such very large scales, a total of 8.3 million livestock head in the case of PRIME.

Low emission program design considerations

The analysis of GHG emissions and carbon sequestration by agricultural practice illustrates issues that those designing or implementing programs may want to consider in the context of LED and food security. These issues include:

- **Grassland improvements.** What incentives or changes to enabling conditions are needed to help livestock producers reap the benefits of grazing land improvements, given agricultural expansion and urbanization? Is it possible to implement additional interventions that sequester soil carbon, for example, through improving grass species composition?

- **Livestock forage quality and quantity management**. What value chain interventions can improve fodder management (cultivation, conservation, and processing) and feed rationing (concentrated and complete feeds)? What is the best way to support feed producers and processors so they can achieve high production volumes and low prices? Which forage varieties balance increased production, farmer affordability, and adaptation potential with reduced GHG emissions? Under what circumstances is it feasible to include energy-intense feeds?

- **Herd size dynamics.** What incentives or changes to enabling conditions (insurance and financial services) are needed to enable livestock producers to reduce unproductive animals without facing production risks? What kind of training or capacity building in benefit/cost analyses of herd sizes and productivity would help livestock producers make informed decisions about herd size?

Summary of projected GHG emission and carbon sequestration co-benefits

PRIME's interventions result in an estimated increase in GHG emissions of 17% per year. Increased GHG emissions from feed quantity and herd weight partially offset the carbon sequestration from grassland improvements and lower GHG emissions from improved feed quality. Grassland improvements result in carbon sequestration from increased productivity (-1.39 $tCO_2e/ha/yr$) (Figure 1). Feed quality improvements reduce emissions slightly (-0.01 tCO_2e/cattle head and -0.001 tCO_2e/sheep head).

Increased feed quantities and herd weight lead to net increases in GHG emissions from goats, sheep, and cattle livestock systems, most significantly in cattle (0.43 $tCO_2e/head/yr$). Grassland improvements had a large impact per hectare but were implemented over 2% of the project area so they made only a modest contribution to PRIME's net emissions (-141,120 tCO_2e/yr) (Figure 2). The majority of GHG emission impacts by PRIME were due to the increase in feed quantity and herd weight (Figure 2).

Figure 1. Impact of agricultural practices: Net GHG emissions on an area/animal basis

($tCO_2e/ha/yr$ or $tCO_2e/head/yr$)

Figure 2. Impact of agricultural practices: Net GHG emissions on total area of impact/animals

(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 the targeted value chains without and with agricultural and pastoral practices supported by PRIME.

Livestock productivity. PRIME projected sizable productivity increases in the non-dairy cattle (96%), sheep (87%), and goat (87%) value chains, and a moderate productivity increase in dairy milk output (24%). PRIME's productivity interventions include enhanced animal health, support for feed/fodder services, and improved livestock and dairy value chain development.

Post-production loss. Post-production losses remain unchanged by PRIME's practices.

Emissions intensity. All livestock systems reduced emission intensity. The improvements in productivity of meat and milk production offset the increases in GHG emissions per animal head. The project's interventions improved (reduced) emissions intensity for dairy cattle (–4%), non-dairy cattle (–39%), sheep (–36%), and goats (–42%).

Table 2. PRIME—GHG emission intensity for selected products

	Project agricultural practices	Total GHG emissions per head (tCO_2e/head) (1)	Annual yield (1,000 l/head or t meat/head*) (2)	Postharvest loss (%) (3)	Remaining annual yield (1,000 l/head or t meat/head*) (4)	Emissions intensity (tCO_2e/1,000 l or tCO_2e/t meat*) (5)
Dairy cattle (feed quality, feed quantity)	No project	2.14	0.33	15%	0.28	7.63
	Project	2.55	0.41	15%	0.35	7.32
	Difference (%)	0.41 (19%)	0.08 (24%)	0% (0%)	0.07 (24%)	-0.31 (-4%)
Non-dairy cattle* (feed quality, feed quantity)	No project	2.21	0.04	N/A	0.04	61.96
	Project	2.64	0.07	N/A	0.07	37.72
	Difference (%)	0.43 (19%)	0.03 (96%)	N/A (-)	0.03 (96%)	-24.24 (-39%)
Sheep* (feed quality, feed quantity)	No project	0.27	0.01	N/A	0.01	21.81
	Project	0.33	0.02	N/A	0.02	13.93
	Difference (%)	0.05 (19%)	0.01 (87%)	N/A (-)	0.01 (87%)	-7.88 (-36%)
Goats* (feed quantity)	No project	0.29	0.01	N/A	0.01	23.42
	Project	0.32	0.02	N/A	0.02	13.55
	Difference (%)	0.02 (8%)	0.01 (87%)	N/A (-)	0.01 (87%)	-9.87 (-42%)

Notes:
1. Total GHG emissions per head identifies the emissions per head of livestock harvested.
2. Annual yield identifies the tonnes of meat produced per head of livestock or volume of milk produced per head in 1,000 liter increments.
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 losses from annual yield.
5. Emissions intensity is calculated by dividing the total GHG emissions per tonne of meat or 1,000 liters of milk by the remaining annual yield.
* Denotes product measured in tonnes of meat per head of livestock.

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 emissions reductions for these cases, and the research team therefore excluded them. Next researchers from CCAFS and USAID then 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. Deriving 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).

References

- Amenu K, Markemann A, Roessler R, Siegmund-Schultze M, Abebe G, Zarate AV. 2013. Constraints and challenges of meeting the water requirements of livestock in Ethiopia: cases of Lume and Siraro districts. *Tropical Animal Health and Production* 45: 1539-1548.
- [FAOSTAT] Food and Agriculture Organization of the United Nations Statistics Division. 2015. (Available at http://faostat3.fao.org/download/Q/QC/E) (Accessed on 5 July 2016)
- Gerber PJ, Steinfeld H, Henderson B, Mottet A, Opio C, Dijkman J, Falcucci A, Tempio G. 2013. Tackling climate change through livestock: a global assessment of emissions and mitigation opportunities. Rome: FAO.
- Grewer U, Bockel L, Bernoux M. 2013. EX-ACT quick guidance manual: estimating and targeting greenhouse gas mitigation in agriculture. Rome: FAO. (Available from: http://www.fao.org/tc/exact/user-guidelines) (Accessed on 1 September 2016)
- Grewer U, Bockel L, Galford G, Gurwick N, Nash J, Pirolli G, Wollenberg E. 2016. A methodology for greenhouse gas emissions and carbon sequestration assessments in agriculture: Supplemental materials for USAID case studies of low emissions development in agriculture. CCAFS Working Paper no. 187. Copenhagen, Denmark: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Available online at: www.ccafs.cgiar.org
- Henderson B, Godde C, Medina-Hidalgo D, van Wijk M, Silvestri S, Douxchamps S, Stephenson E, Power C, Rigolot C, Cacho O, Herrero M. 2016. Closing system-wide yield gaps to increase food production and mitigate GHGs among mixed crop–livestock smallholders in Sub-Saharan Africa. *Agricultural Systems* 143: 106-113.
- Herrero M, Henderson B, Havlík P, Thornton PK, Conant RT, Smith P, Wirsenius S, Hristov AN, Gerber P, Gill M, Butterbach-Bahl K, Valin H, Garnett T, Stehfest E. 2016. Greenhouse gas mitigation potentials in the livestock sector. *Nature Climate Change* 6(5): 452–461.
- [IPCC] Intergovernmental Panel on Climate Change. 2006. IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme. In: Eggleston HS, Buendia L, Miwa K, Ngara T, Tanabe K, eds. *Agriculture, Forestry and Other Land Use* 4: IGES, Japan.
- Kassahun A, Snyman HA, Smit GN. 2008. Impact of rangeland degradation on the pastoral production

systems, livelihoods and perceptions of the Somali pastoralists in Eastern Ethiopia. *Journal of Arid Environments* 72(7): 1265-1281. ISSN 0140-1963 (http://dx.doi.org/10.1016/j.jaridenv.2008.01.002)

- Milne E, Aynekulu E, Bationo A, Batjes NH, Boone R, Conant R, … Nkonya, E. (in press). Grazing lands in Sub-Saharan Africa and their potential role in climate change mitigation: What we do and don't know. *Environmental Development*.
- Opio C, Gerber P, Mottet A, Falcucci A, Tempio G, MacLeod M, Vellinga T, Henderson B, Steinfeld H. 2013. Greenhouse gas emissions from ruminant supply chains – a global life cycle assessment. Rome: FAO.
- Rettberg S. 2010. Contested narratives of pastoral vulnerability and risk in Ethiopia's Afar region. *Pastoralism* 1(2): 248-273.
- Richards M, Bruun TB, Campbell B, Gregersen LE, Huyer S, Kuntze V, Madsen STN, Oldvig MB, Vasileiou I. 2015. How countries plan to address agricultural adaptation and mitigation: An analysis of Intended Nationally Determined Contributions. CCAFS Info Note. Copenhagen, Denmark: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). (Available from: https://cgspace.cgiar.org/rest/bitstreams/63683/retrieve) (Accessed on 1 September 2016)
- Richards S, VanLeeuwen JA, Shepelo G, Karuoya Gitau G, Wichtel J, Kamunde C, Uehlinger F. 2016. Randomized controlled trial on impacts of dairy meal feeding interventions on early lactation milk production in smallholder dairy farms of Central Kenya. *Preventive Veterinary Medicine* 125: 46-53. (Available from http://dx.doi.org/10.1016/j.prevetmed.2016.01.006).
- Shapiro BI, Gebru G, Desta S, Negassa A, Nigussie K, Aboset G, Mechal H. 2015. Ethiopia livestock master plan: roadmaps for growth and transformation. Nairobi, Kenya: International Livestock Research Institute (ILRI).
- Schmidt M, Pearson O. 2016. Pastoral livelihoods under pressure: Ecological, political and socioeconomic transitions in Afar (Ethiopia). *Journal of Arid Environments* 124: 22–30.
- Smith P, Martino D, Cai Z, Gwary D, Janzen H, Kumar P, McCarl B, Ogle S, O'Mara F, Rice C, Scholes B, Sirotenko O, Howden M, McAllister T, Pan G, Romanenkov V, Rose S, Schneider U, Towprayoon S, Wattenback M. 2007. Agriculture. *Climate change 2007: mitigation, contribution of working group III to the fourth assessment report of the Intergovernmental Panel on Climate Change*. Cambridge, UK: Cambridge University Press. (Available from: http://www.ipcc.ch/publications_and_data/ar4/wg3/en/ch8.html)
- (UNFCCC) United Nations Framework Convention on Climate Change. 2009. Draft decision CP.15 Copenhagen Accord. (Available from: http://unfccc.int/resource/docs/2009/cop15/eng/l07.pdf) (Accessed on 6 October 2016)
- World Bank. 2016. World Bank World Development Indicators. (Available from http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators) (Accessed on 5 April 2016)

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

Authors:

Julie Nash *(Julie.nash@uvm.edu) is a Research Leader for Low Emission Agriculture at CCAFS and a Research Associate at the Gund Institute for Ecological Economics and the Rubenstein School of Environment and Natural Resources at the University of Vermont.*

Uwe Grewer *is a consultant for climate smart agriculture in the Agricultural Development Economics Division of the Food and Agriculture Organization of the United Nations (FAO).*

Louis Bockel *is a Policy Officer in the Agricultural Development Economics Division of FAO.*

Gillian Galford i*s a Research Assistant Professor at the Gund Institute for Ecological Economics and the Rubenstein School of Environment and Natural Resources at the University of Vermont.*

Gillian Pirolli *is an independent consultant specializing in data management and GIS.*

Julianna White *is program manager of CCAFS low emissions agriculture research, based at Gund Institute for Ecological Economics and the Rubenstein School of Environment and Natural Resources at the University of Vermont.*

Citation:

Nash J, Grewer U, Bockel L, Galford G, Pirolli G, White J. 2016. Pastoralist Areas Resilience Improvement through Market Expansion (PRIME) in Ethiopia: Mitigation co-benefits of livestock productivity. CCAFS Info Note. Published by the International Center for Tropical Agriculture (CIAT) and the Food and Agriculture Organization of the United Nations (FAO).

CCAFS and Info Notes

The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) is a strategic partnership of CGIAR and Future Earth, led by the International Center for Tropical Agriculture (CIAT). CCAFS brings together some of the world's best researchers in agricultural science, development research, climate science and Earth System science, to identify and address the most important interactions, synergies and tradeoffs between climate change, agriculture and food security.

CCAFS Info Notes are brief reports on interim research results. They are not necessarily peer reviewed. Please contact the author for additional information on their research.

www.ccafs.cgiar.org

CCAFS is supported by: