Productive, environmental, and economic shifts of dairy systems by adopting silvo-pastoral systems and improved pastures

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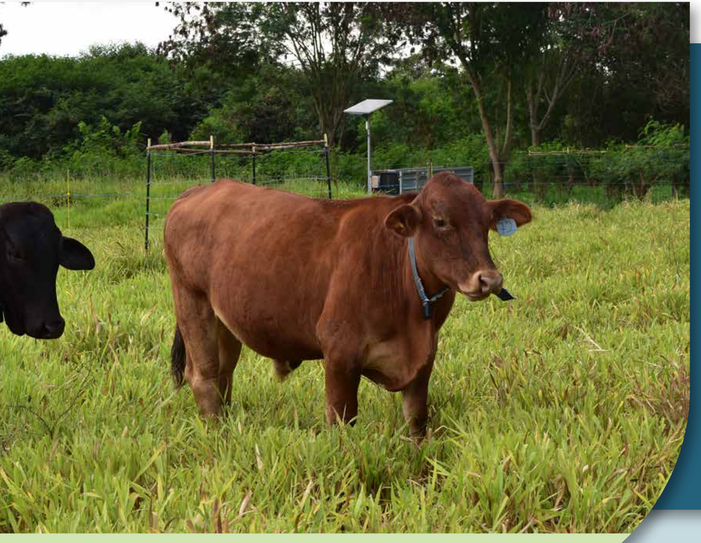

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Introduction

- Dairy systems emit around 20% of total livestock sector GHGE, which represents between 3 to 4% of emissions worldwide.
- A large share of the milk produced in the Colombian high tropics comes from smallholder production, with very little or no level of technological specialization, and low milk production figures.
- Cattle farming is practiced in all of Cauca's municipalities (southwestern Colombia), is focused on dairy production, and is mainly developed by small producers that depend on family labor.
- It has been reported that the adoption of silvopastoral systems (SPS) and improved pastures (IP) are not only strategies to enhance cattle productivity but also have a great potential to reduce GHGE.
- Identifying sustainable strategies to mitigate GHGE in the cattle sector will help the government meet its goal of a 51% reduction by 2030.
- In Colombia, the productive and environmental behavior of GHG mitigation practices, using primary data gathered on-farm after their implementation, has not been assessed yet.

Objective

1. To calculate the climate change impact, measured as the CF, of four dairy cattle farms located in the Cauca department, using a farm gate LCA approach with primary data gathered from producers.
2. To identify the main on-farm and off-farm sources of total GHGE.
3. To identify improvements in milk yields and GHGE intensities reductions after the implementation of SPS and IP as intervention scenarios, using primary data from the farms.
4. To estimate the economic feasibility and benefits of the intervention scenarios, considering also the monetary values of GHGE reductions.

Methodology

LCA approach, system boundary definition, functional unit, allocation rule

- The milk CF of 4 farms was evaluated by using the attributional LCA methodology, in a "cradle to farm-gate" perspective.
- Baseline scenario: main productive, reproductive, and cattle management characteristics of the farms prior to the implementation of IP and SPS as intervention practices. Improvement scenario: current state of the farms, where IP and SPS were already implemented.

Economic analysis

- An economic assessment that juxtaposes the financial and ecological advantages of implementing IP and SPS against the associated implementation expenses within farm settings.
- 5 scenarios were evaluated:

  i. Base scenario: Before the implementation of IP and SPS;

  ii. Real improved scenario: After the implementation of IP and SPS;

  iii. Improved scenario with ideal stocking rate: Simulation of a maximum stocking rate after the implementation of IP and SPS;

  iv. Improved scenario with minimum stocking rate (MSR): Simulation of the MSR to obtain profits after the implementation of IP and SPS;

  v. Whole farm with IP: Simulation of a maximum stocking rate if IP were implemented on the complete farm area.

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CO_2-e

Methane (CH_4) = 28
Nitrous oxide (N_2O): 265
Carbon dioxide (CO_2): 1

The IPCC'S Fifth Assessment Report

Figure 1. System boundaries, functional units, allocation rule, and flows accounted for in the estimation of CF in the cattle systems in a "cradle to farm-gate" approach

Results

Figure 2. Contribution of on- and off-farm activities to total GHGE from four farms in Cauca, in a cradle-to-farm gate approach. BS: Baseline. IS: improvement scenario.

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Table 1. Total GHGE from different emission sources, and milk and meat CFs for studied farms: baseline and improvement scenario.

Farm number	Milk carbon footprint KgCO2eqkgFPCM-1	Meat carbon footprint KgCO2eqkgLWG-1	Milk production KgFPCM cow-1 yr-1
Baseline scenario			
Farm 1	3.2	22.1	1508.2
Farm 2	2.4	16.2	2450.8
Farm 3	3.0	21.3	1508.2
Farm 4	2.4	15.8	2262.3
Improvement scenario			
Farm 1	2.7 (-16%)	18.4 (-16%)	2073.7 (+38%)
Farm 2	1.4 (-40%)	9.4 (-42%)	3393.4 (+38%)
Farm 3	2.2 (-28%)	14.6 (-31%)	2262.3 (+3%)
Farm 4	2.0 (-17%)	12.8 (-19%)	3016.4 (+8%)

Table 2. Economic and environmental evaluation for the baseline and scenarios,

Farm number	Economic results			Economic and environmental results		
	NPV (US/yr)	IRR	B/C	NPV (US/yr)	IRR	B/C
Baseline scenario						
Farm 1	-32,531	Losses every year	0.37			
Farm 2	-8,885	Losses every year	0.81			
Farm 3	-39,874	Losses every year	0.33			
Farm 4	-32,941	Losses every year	0.48			
Improvement scenario						
Farm 1	-33,590	Losses every year	0.4	-32,806	Losses every year	0.42
Farm 2	-1,225	7%	0.97	2,914	43%	1.06
Farm 3	-33,736	Losses every year	0.42	-32,368	Losses every year	0.42
Farm 4	-53,334	Losses every year	0.41	-37,064	Losses every year	0.59
Improved scenario with ideal stocking rate						
Farm 1	-27,958	Losses every year	0.71	-25,509	Losses every year	0.74
Farm 2	18,731	619%	1.35	24,967	Earnings every year	1.46
Farm 3	-21,533	Losses every year	0.79	-14,691	Losses every year	0.86
Farm 4	-31,970	Losses every year	0.72	-28,504	Losses every year	0.75
Improved scenario with minimun stocking rate						
Farm 1	-28,686	Losses every year	0.71	-26,139	Losses every year	0.74
Farm 2	262	21%	1.01	1,736	39%	1.05
Farm 3	586	19%	1	17,348	47%	1.09
Farm 4	2,212	20%	1.01	9,144	29%	1.06
All farm area with IP						
Farm 1	-23,982	Losses every year	0.8	-20,650	Losses every year	0.83
Farm 2	45,309	Earnings every year	1.72	52,653	Earnings every year	1.84
Farm 3	27,733	76%	1.22	36,969	105%	1.29
Farm 4	-15,386	-2%	0.89	-10,186	5%	0.92

Conclusions

- In both scenarios, the GHGE sources that contributed the most to the CFs arose from the herd and corresponded to methane from enteric fermentation and nitrous oxide from excretions left on pastures.
- Milk and meat CFs are highly sensitive to changes in the total enteric CH_4 and N_2O emissions, as well as the total amount of milk and LWG.
- The inclusion of IP and SPS positively influenced the milk yields of the cows in all the farms and the milk and meat CFs.
- The economic performance of the farms significantly improves with increasing levels of inclusion of IP and SPS.
- Increases in milk and meat yields after the adoption of improved pastures and silvopastoral systems lead to lowering the GHGE intensities from the farms.

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