THE LIVESTOCK SECTOR'S READINESS TO ACCESS CLIMATE FINANCE

LESSONS LEARNED AND BLUEPRINTS FOR IMPLEMENTATION

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Contents

Executive Summary

The livestock sector, which emitted about 8.1 gigatons CO_2-eq in 2010, is poised to continue growing in size and importance with increasing global prosperity, offers real opportunities for innovation to reduce Greenhouse gas (GHG) emissions. The tools, mechanisms and strategies already exist, as this report demonstrates, and can be further improved by adopting the measures outlined here. Indeed, the sector offers one of the most significant channels for reducing GHG emissions generated by the agriculture and food system, and climate finance can make a real difference to reduce global emissions.

Activities under this ASA have demonstrated the possible extent of this positive impact with a conceptual study and the identification of six channels through which climate finance could both make a difference and make a profit through a mutually beneficial, symbiotic relationship. In fact, productivity, profitability and long-term sustainability of the sector can be intrinsically linked to positive modifications along the supply chain to reduce the negative climate impacts of the livestock sector. Hence, the “cost” of innovation for the climate, for both farmers and those who invest in them, can be offset by the extra profits it can generate on the mid-term. Incentives are required, however to overcome transition costs, monitor results and build momentum.

The challenge confronted under this ASA is to find ways both to attract climate finance to the sector and to prepare the sector to access such resources. The concept study identified six entry points for climate finance into the livestock sector:

1. Condition credit lines on climate mitigation actions
2. Encourage value-chain finance for native ecosystem protection
3. Drive clean investment through Emissions Trading Schemes
4. Verify sustainable sourcing of livestock feed
5. Reward innovation in livestock climate finance through prize-based programs
6. Reward proactive policy commitments through Official Development Assistance

Of these, the first two were identified as the most promising for real-world implementation; in Kenya – with credit-line financing for climate-friendly innovations – and in Colombia, with value-chain financing that seeks to reduce negative impacts along the value chain, beyond the farm and on to the market.

While each case has its specifics and particularities, they both offer concrete evidence of how climate finance for the livestock sector can work in practice to reduce the contribution of the sector to GHG emissions. Common to both cases, the importance of an appropriate regulatory environment is stressed to protect investors and farmers and to align activities with national plans and objectives. Both cases illustrate the need for technical assistance and training to ensure that every link in the supply chain and beyond – including policy makers – understands the challenges and benefits and develop the systems and practices required to ensure climate finance flows and their demonstrated effects on emissions. While the livestock sector is, undeniably, among the most intensive in terms of GHG emissions in the food system, the reality is that increasing prosperity will lead to more demand for animal products. Meeting that demand, while protecting the planet, will require innovative solutions, not only on-farm and along the supply chain, but also within financial institutions that will need new mechanisms and instruments to meet the demand.

The dairy industry in Kenya is well-established and growing. Offering a range of products for the most dairy-conscious and dairy-consuming populations in Africa. Moreover, the sector supports a significant proportion of rural households and provides direct income to women. Investments by dairy producers are difficult because of the reluctance of the local financial institutions to assume the risk associated with the sector. However, studies and consultations under this ASA show that a concessional credit-line with mitigation conditionality could be a product developed by financial institutions, provided that TA is offered both to the borrower and the lender in order to close the skills gap. In addition, financial institutions need to be supported by guarantees in order to assume the perceived risk of lending to fairy farmers.

In Colombia, the beef sector is growing and the danger is that it will encroach on forest cover, which would have negative consequences for the environment. This is the justification for adopting a value-chain approach to the industry since the connection between the final product of beef ranching and the impact on the environment of its production can be very far-removed. Interventions need to change economic incentives for value chain actors to eliminate the temptation to expand into forested areas and fragile ecosystems, and to invest in sustainable intensification practices instead. Transparency and accountability can add value to the final product on the market, which benefits every stage on the value chain, and can encourage low carbon (or low methane) modes of production. Consumers will be more attracted to beef that can be justifiably labelled "sustainable" and can claim to be sensitive to animal welfare.

Moreover, the value-chain approach has the advantage of impacting spatially-spread producers who may not have any direct connection to each other, but who share the same intermediaries. Thus, value chain finance can reduce deforestation, lessen the emissions intensity of production, and improve livelihoods and incomes, animal welfare and production quality, based on consumer demand for sustainable sources of animal protein.

Backed by a thorough stakeholder engagement process, involving consultations and discussions through a Community of Purpose, this ASA succeeds in clarifying obstacles and identifying opportunities for the livestock sector's readiness to access climate finance. It has also contributed to building momentum and to designing practical implementation solutions and mechanisms. The sector needs to be better equipped to access climate finance and the financial institutions need to be more responsive and equipped to deal with the demands. The WBG has an opportunity to operationalize climate finance flows to the livestock sector at scale, mobilizing its own portfolio, climate funds and new instruments, such as guarantees or de-risking mechanisms.

Policy financing through IBRD instruments such as IPF, PforR and DPOs can support the overall framework necessary to enable the livestock sector to adapt to the needs of climate change and to meet the challenge of the expected surge in demand for animal protein without increasing pressure on the environment. While large-scale beef producers supplying developed economies tend to attract most attention, it is the vast army of livestock farmers that will be essential to meeting increasing demand for eggs, meat, milk and their products in developing and graduating economies as prosperity increases. IDA and IFC are well-positioned to stimulate private- and public-sector investment in the livestock sector as a contribution to raising living standards in rural communities, as well as advising potential investors on the benefits and opportunities to be found in livestock. Overall, the WBG has a specific interest in supporting the livestock sector as a core strategy to reduce poverty and promote secure livelihoods in rural areas, while attacking vectors of climate change at source. Indeed, the participation of WBG agencies in the livestock sector is, in itself, a testimony to the importance of the sector in reducing poverty and raising nutrition levels.

While Donor countries may be able to envisage alternative sources of protein and quality nutrition at scale, developing countries remain dependent on the livestock sector, both as producers and consumers. The reports and studies that form this ASA demonstrate conclusively that – for the moment – livestock will continue to make an essential contribution to enhanced nutrition and improved diets in the developing and graduating countries. Ignoring this reality will be costly for the WBG both in terms of its international image and, therefore, its ability to produce change, and in lost opportunities to support struggling rural communities in the face of climate change. Most importantly, reducing the impact of the livestock sector on the environment is an opportunity that the WBG is perfectly poised to support through its financing mechanisms. Additional sources of climate finance, e.g. in the form of carbon markets and green bonds can be mobilised in blended funding setups that will most effectively fulfil the needs and requirements of value chain stakeholders on the one hand, and financiers on the other.

Robust measurement, reporting and verification (MRV) systems can generate verifiable results from the provision of climate finance. However, MRV for disperse projects can be complex and expensive. Under this ASA, shortcomings and gaps in MRV for climate finance interventions in the livestock sector have been addressed. This is an important step in refining MRV instruments that will provide an additional layer of security to potential climate-finance investors going forward.

Four strategic directions are being explored to continue this work: (1) delivering proof of concept for the livestock sector as a recipient of climate finance by utilizing the growing range of climate finance-related initiatives at WBG; (2) addressing the question of consumption and growth in the sector more systematically by assessing how climate finance could more directly influence consumption patterns; (3) developing a global communications and outreach strategy around climate-change mitigation in the livestock sector; and (4) extending support to three elements of the previous work: implementing credit-line finance in Kenya, extending value-chain finance strategies in Colombia, and continuing to manage the Community of Purpose.

1. Introduction

The series of studies, consultations, and reports develop under this ASA[1] addresses an apparent paradox: a major emitter with significant mitigation potential, the livestock sector has so far received only a marginal share of climate finance: 0.01% of overall mitigation finance (USD 63 million of the total USD 364 billion). Although it represents 60% of the agriculture emissions, the sector received only 1 to 2% of climate finance dedicated to agriculture[23].

Reducing emissions from the livestock sector is crucially important. Food production is responsible for some 37% of global GHG emissions, over half of which are directly attributable to the livestock sector[4]. Livestock value chains emitted about 8.1 gigatons CO_2-eq in 2010[5], and within the livestock sector, beef and dairy cattle produce the most significant contribution to GHG emissions at 62% of the total.

Climate-smart interventions that can effectively reduce emissions do exist. Their adoption is however limited for number of reasons, e.g. lack of track record for the new practice or technologies, biased risk perception of potential lenders due to limited familiarity with the sector, underdeveloped supply chains (e.g., for quality feed), need for upfront investment. However, the efficiency gains generated by many of these climate-smart interventions can offset the increased costs in the medium to long-term. Several interventions do also generate long-term environmental – and broader co-benefits (e.g., improved soil health, improved health outcomes from the use of cleaner energy).

Growing prosperity will continue to lead to increased demand and consumption of livestock-protein products – although at a reduced pace compare to the past decades[6]. COP26 recognized the role of livestock in methane emissions and resolved to reduce its impact by including the sector in a targeted response alongside fossil fuels. The consensus thus underlined the urgency of attracting climate finance to the sector in a bid to hasten action along the value chain to reduce emissions and contribute to reaching the United Nations Sustainable Development Goals (SDGs) by 2030.

Activities under this ASA were split into two phases: Phase 1 led to a diagnostic of the sector and identification of obstacles and opportunities for GHG mitigation in livestock supply chains. This produced a concept paper on pathways towards a deepened integration of the animal protein sector into climate finance. The report, *Opportunities for Climate Finance in the Livestock Sector: Removing Obstacles and Realizing Potential*[7] was released in Spring 2021 (Box 1).

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[1] The Development Objective of the ASA is to increase the readiness of public and private entities within the animal protein sector to access climate finance towards a low-carbon transformation of the sector.
[2] Global Climate Finance: An Updated View 2018. 2018 Climate Policy Initiative
[3] FAO, 2021, Climate finance in the agriculture and land use sector – global and regional trends between 2000 and 2018 https://www.fao.org/3/cb6056en/cb6056en.pdf
[4] For ease of reference and reading, we will continue to refer to "livestock" as a "sector", although, technically, it is a sub-sub-sector of "agriculture/food".
[5] FAO "GLEAM 2.0 - Assessment of greenhouse gas emissions and mitigation potential" available at: https://www.fao.org/gleam/results/en/
[6] OECD-FAO Agricultural Outlook 2021-203 https://www.fao.org/documents/card/en/c/cb5332en
[7] https://www.worldbank.org/en/topic/agriculture/publication/opportunities-for-climate-finance-in-the-livestock-sector-removing-obstacles-and-realizing-potential

Box 1. Main Messages of the Phase 1 report, *Opportunities for Climate Finance in the Livestock Sector: Removing Obstacles and Realizing Potential*

i. The livestock sector contributed high GHG emissions, but large and bankable mitigation options exist.
ii. Increased climate finance can accelerate a green transition. This opportunity is being missed due to investors' perception that profitability is low and the risk is high; the difficulty and cost of measuring the economic impact of mitigation pathways; and the low degree of technical knowledge about its benefits related to mitigation.
iii. Opportunities to invest in reducing the amount of carbon already in the atmosphere and from current emissions include: increasing productivity and production efficiency; improving animal feed digestibility and nutritional levels; extracting methane from manure for fuel; reducing the number of unproductive animals in the herd; adopting energy-efficient equipment and through efficient land management. Such mitigation interventions also present many co-benefits, such as more stable revenues and improved livelihoods for smallholder producers, improved food security, and better adaptation to climate change.
iv. The report identifies six investment opportunities to drive the sector's sustainable transformation with climate finance.

   1. Condition credit lines on climate mitigation actions
   2. Encourage value-chain finance for native ecosystem protection
   3. Drive clean investment through Emissions Trading Schemes
   4. Verify sustainable sourcing of livestock feed
   5. Reward innovation in livestock climate finance through prize-based programs
   6. Reward proactive policy commitments through Official Development Assistance

Link to full publication: https://www.worldbank.org/en/topic/agriculture/publication/opportunities-for-climate-finance-in-the-livestock-sector-removing-obstacles-and-realizing-potential

Informed by the findings of the first phase, phase 2 focused on concretization and implementation: it included the convening of a global community of purpose to increase the readiness of the animal protein sector to access climate finance; the preparation of a Measurement Reporting and Verification (MRV) conceptual framework; and the development of a blueprint for implementation in two locations. The present report presents the findings and lessons learned from this work.

1.1. Identifying models for testing via blueprints

The initial review of opportunities for Climate Finance to contribute to the transformation of the livestock sector identified six initial potential blueprints (Box 1 and Figure 1).

Figure 1. Opportunities for Climate Finance in the Livestock Sector Value Chain

The initial stock-tacking phase identified Climate Finance instruments and mechanisms adapted to each blueprint (Table 1). The initial analysis made use of the diversity of financial tools available to fund Climate-Smart projects in the livestock sector, from traditional plain grants to carbon markets or more innovative mechanisms such as Verified Sourcing areas. Most of the suggested Climate Finance options rely on blended-finance mechanisms, meaning that concessional funds such as grants are used to unlock investment flows by offering a de-risking layer.

Table 1. Overview of Key Elements of Potential Financial Practices

FINANCIAL PRACTICE	FUNDING SOURCE/FLOW	POTENTIAL TRANSFORMATIVE LEVERS	RECIPIENTS
1. Sector-specific credit line with climate conditionalities	- MDBs/IFIs ideally as mezzanine or risk bearing capital blended with: - Local rural banks - Local green banks and strategic investment funds	- Sector policies - Financial sector reform - Climate intelligence and data	- Local project level farms and communities - Local FIs and second tier banks

	- Microfinance - IFIs or similar - Government credit lines - Philanthropic funds		- Financial intermediaries with a good rural outreach
2. Value chain finance promoting native ecosystem protection	- Corporations - Own finance, FDI - Local green banks and strategic investment funds - Consumer crowdfunding or blockchain smart contracting - Philanthropic funds -	- Project-based policy - Fiscal policy - Innovation and tech transfers	- Upstream value chain actors, including producers
3. Animal protein sector participation in emissions trading schemes	- Carbon market finance from private operators or government - Supplementary funding sources possible, for example, own finance or project finance, such as an innovation fund supplied by share of proceeds or allowance auctioning	- Carbon markets - Climate intelligence and data	- Project owners (farmers) potentially through financial intermediaries such as offset providers and traders - Funding stream depends on market design, for example, who owns the resulting credits
4. Programmatic support for policy changes	- ODA grants from donor countries MDBs - IFIs	- Project-based policy - Fiscal policy - Trade policy - Innovation and tech transfers	- Budgets of authorities or policy areas owning legislation
5. Sourcing deforestation-free feed from Verified Sourcing Areas (VSAs)	- Grants, precommercial loans, or concessional loans by MDBs - Technical assistance and know-how by supply chain operators and local authorities - Own finance of relevant offtakers, traders, or supply chain actors	- Fiscal policy - Financial sector reform - Sector policies - Climate intelligence and data	- Local VSA specific special purpose vehicles operated and controlled by relevant actors
6. Prize-based climate finance programs for technical innovation	- Private impact investors - Microfinance - Competition managers (e.g., AgResults) - Philanthropic funds	- Innovation and tech transfers - Climate intelligence and data	- Local project level farms and communities - Financial service providers for rural producers (MFIs)

The June 2020 consultation of the Community of Purpose (CoP – see section 1.3. below) sent these blueprint opportunities to a panel of 72 experts from the livestock and climate-finance sectors. Their participation in an online questionnaire, two online workshops and a final poll shed light on the relative feasibility and impact and replication potential of these potential blueprints. Two approach opportunities stood out:

- A sector-specific credit line with conditionalities to boost climate mitigation investments, and
- Value-chain finance promoting Zero Deforestation.

In addition to the CoP consultation, the task team assessed four additional criteria related to the WBG: (i) potential synergies with the current portfolio of World Bank projects; (ii); the presence of World Bank/IFC teams and networks on the ground; (iii) ongoing conversations and consultations with public and private stakeholders; and (iv) interest among climate-finance organizations.

These assessments and consultations allowed the team to narrow down and further refine the opportunities to two (Table 2). Together, the two blueprints address all major mitigation pathways identified in the Phase 1 report (Box 2).

Table 2. Selection of the locations for blueprints and criteria for inclusion

	CREDIT LINE FINANCE (Kenya)	**VALUE-CHAIN FINANCE (Colombia)**
Climate Finance opportunity "archetype", as initially formulated	Condition credit lines on climate mitigation actions	Encourage value-chain finance for native ecosystem protection
Revised opportunity as selected following the consultation of the CoP and the assessment process	Credit line with mitigation conditionality for the dairy sector in Kenya	Value chain finance promoting native ecosystems protection in Latin America and the Caribbean
Elements considered for the selection of the blueprint	**Potential synergies with the existing World Bank projects portfolio in Kenya.** Two World Bank operations (KSCAP and NARIGP) and another in preparation, all with strong dairy focus. These operations can be mobilized to provide technical assistance (TA) and information systems. **Country commitment.** Kenya's Nationally Determined Contribution (NDC) emphasizes efficient livestock management as a mitigation priority. The current national development policy, Kenya Vision 2030, includes dairy as fundamental to employment creation. **Readiness of the Kenyan dairy and private finance sectors.** The value chain is well structured. Local financial institutions have had experience with the dairy sector and in lending to smallholder farmers and	**Beef value chain in Latin America.** The beef value chain was identified as focus area since concept stage of the ASA. This is in light of the high level of emissions, and the link to deforestation – thus with the objectives of the FCPF. **Collaboration with IFC.** They team engaged in conversations with the IFC on how to collaborate. Among the ongoing projects of the IFC in the beef sector in Latin America, Orinoquia and Colombia offered a particularly opportunity as IFC had been engaging previously with the enterprise Hacienda San José. **Multiple relevant scales from farm to value chain level, with large potential impact**. The case of HSJ and the beef value chain in Orinoquia allowed to explore both the immediate carbon balance of a farm expansion and the cumulative effect of such improvements and downstream transformation at value chain level.

	FPOs/cooperatives, dealing with constraints on take-up. **Replicability.** The dairy sector is the livestock sub-sector that combine rapid growth with substantial mitigation potential. The lessons learned from this blueprint could be replicated elsewhere and especially in Africa.	**Existing initiatives and analytical work on sustainability of Colombian beef sector**. There is much interest in the case of Colombia's native ecosystems and the sustainability of its agriculture sector in general and beef sector in particular. Much data and proven models to improve the emission profile of beef production are available. Multiple operations and ASA by WB and other partners are active and could be leveraged.

Box 2. Mitigation pathways identified in the Phase 1 report, *Opportunities for Climate Finance in the Livestock Sector: Removing Obstacles and Realizing Potential*, along with an overview of their application in the two blueprints (see corresponding sections 2 and 3 for additional details).

Major mitigation pathways identified in the Phase 1 report	Potential co-benefits	Kenya blueprint	Colombia blueprint
Emission intensity reduction through efficiency and productivity gains: - Feed and nutrition - Animal health and husbandry - Animal genetic resources	- Productivity gains will have strong co-benefits for income and food security - Productivity (higher capital) and efficiency (lower reliance on inputs) can also have co-benefits for resilience	Practices considered: improved breeds (crossbred), improved nutrition (diet, zero-grazing units), improved herd management Results (compared to same farms before implementing improved practices): - 50-100% increase in milk yield - 18-33% reduction in emission intensity	Practices considered: improved breeds and herd management (short cycle Nelore breed), improved nutrition (pasture improvement, feed supplements) Results (compared to traditional, low-productivity systems): - Up to 200% increase in produced live weight - Up to 60% reduction in emission intensity
Emission removals through land management	Land management and restoration will have co-benefits for pasture (and subsequently livestock) productivity and resilience	Not tested	Grassland improvement resulted in net C removals of 2.6 t CO_2eq. / ha / year (over 10 years)
Technical options to reduce direct emissions: - Biogas and manure management - Renewable energy/energy efficiency - Feed additives - Pilot technologies (vaccines, rumen modification)	- Certain practices can reduce costs or even generate income (energy, biogas) - Other technologies as feed additives can have productivity co-benefits but not always (in that case they merely represent a cost to achieve emission reductions)	Results for the whole blueprint over 10 years: - 0.4 Mt CO_2eq for biogas - 0.4 Mt CO_2eq for energy efficiency in milk chilling and processing	Feed additives (3-NOP) could result in up to 20% reduction in enteric methane emissions

1.2. Measurement reporting and verification

Measurement Reporting and Verification (MRV) methodologies are typically costly, complex and often inaccurate but countries and operations need MRV to establish whether the transition to a "green" livestock sector expansion is taking place. This part of the project creates the conceptual framework for a reliable MRV system that entails fewer costs to the country and/or project implementers, while supplying reliable data for project design and implementation. It was clear from the outset that the MRV methodology should be generic and highly adaptable to the diversity of local conditions concerning livestock systems and their interaction with forests.

1.3. Community of Purpose

Designed as a space for knowledge exchange, learning, collaboration and peer support to mainstream climate change in the livestock sector, the Community of Purpose (CoP) aims to increase capacity and effectiveness in accessing Climate Finance, and to explore investment opportunities. It is an essential element of process in the implementation of the ASA.

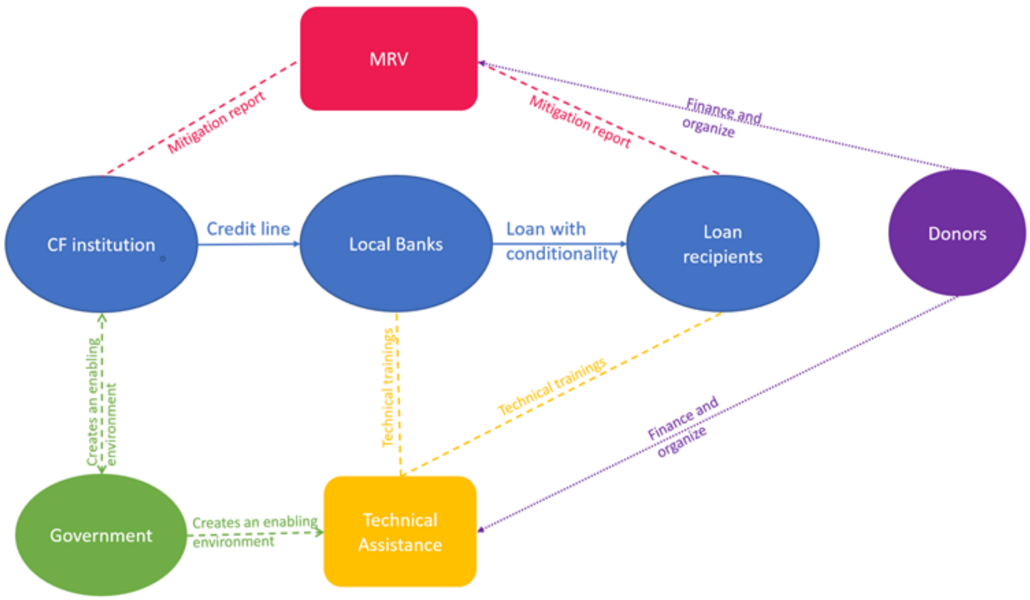
2. Blueprint #1: Credit Line with Climate Conditionality in the Kenyan Dairy Sector

While GHG mitigation interventions in the dairy sector can be profitable and have a substantial impact, dairy value chain actors still struggle to access commercial loans. Private banks consider the sector risky, and credit conditions offered to farmers and processors hinder the profitability of projects. A credit line provided by a Climate Finance institution to local commercial banks can provide them with additional funding at lower cost and, in return, they will be able to lend to farmers with conditions that better fit the profitability profile of climate interventions, such as longer tenor or longer grace periods. In exchange, loan beneficiaries will use these credits to implement a specific set of GHG mitigation interventions. Some technical assistance will either make the projects less risky, such as farmer training, or make the disbursement of the loans cheaper, such as sourcing of beneficiaries and help with due.

The Climate Finance institution will work with the government to create an enabling environment for the beneficiaries to succeed in their project. An MRV mechanism will be able to track the environmental impact of the project and report it to the Climate Finance institution diligence (Figure 2).

As described in Table 1, the development of the credit line will rely on several types of funds: concessional credit from Climate Finance institutions, grants to support the necessary technical assistance and de-risking mechanisms such as first-loss tranche or guarantee.

Figure 2. Archetype of the Credit Line with Climate Conditionality



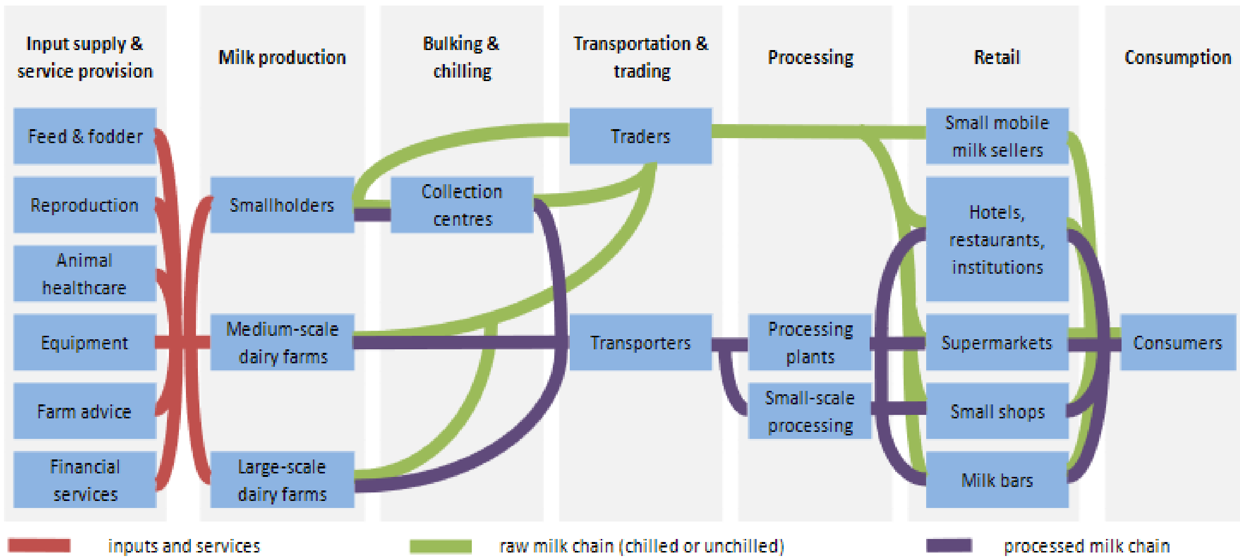
2.1. The Kenyan dairy sector

The dairy sector is the sixth largest agricultural sub-sector by market value in Kenya, contributing 14% to agricultural GDP and representing 3.5% of total GDP. It contributes to farmers' incomes, food security and nutrition, and generates employment. Most milk (~70%) is produced by smallholder farmers, who on average hold 1-3 dairy cows. Annual per capita milk consumption in Kenya is among the highest in sub-Saharan Africa, and demand for dairy products is projected to continue to grow rapidly, in line with population growth and increasing urbanization.

Kenya's 2020 Tier 2 inventory produced an estimate that GHG emissions from dairy cattle accounted for some 26% of total agricultural GHG emissions, and they have been gradually increasing because of an increase in herds and their average emission factor. Most emissions are due to on-farm milk production; low milk yields per cow are directly related to high GHG emission intensity. Poor on-farm manure management contributes to GHG emissions and affects local environmental pollution. Water and energy use in milk collection, cooling and processing facilities are high, with machinery often outdated, inefficient and using high-emission energy sources, such as fuel wood, diesel, oil, and "dirty" electricity.

The dairy supply chain is made up of informal and formal market channels in three product categories: (a) unchilled raw milk, (b) chilled raw milk, and (c) chilled, processed milk (Figure 3).

Figure 3. Overview of Kenya's dairy supply chain



Source: Rademaker et al. (2016)

Input and service provision

Agro-vet suppliers, large (inter)national firms and extension providers provide a range of inputs and services to smallholder, medium and large-scale farmers. Feed manufacturers are grouped into the Association of Kenya Feed Manufacturers (AKEFEMA) and satisfy approximately 60% of the demand. Access to feed and products is more difficult and more expensive the further the farmer is located from Nairobi and the main producing areas.

The growing demand for fodder has created business opportunities because of the inability of small- and medium-scale farmers to produce sufficient material. The Rift Valley Hay Growers Association, with 250 farmer-members, established a hay value chain as an investment opportunity for commercial fodder producers. This model has been replicated elsewhere. Public and private enterprises, including the government's Kenya Animal Genetics Resource Centre (KAGRC), offer breeding, veterinary and extension services to farmers. Veterinary products, both preventive and curative, are widely available in agro-vet shops and through farmer producer organizations (FPOs).

On-farm dairy production

Two million farming households – or 35% of the rural total – produce milk, and women play a major role in dairy production. Milk sales contribute significantly to farmers' incomes, especially for rural women. Average dairy cow productivity is low and production costs per kilogram of milk are high, so profit margins for many farmers are slim. Women, in particular, are not able to benefit from the technology, extension and marketing opportunities that may be offered to men.

Milk collection and processing

Bulking and chilling of milk is mainly done at milk collection centers, which are operated by producer organizations, processors or small private entrepreneurs but the cost of chilling is usually covered by the farmers. Some 200 milk cooling centers are linked to processors and producer groups, but they are insufficient for the volume of milk produced and limit expansion. Major constraints to expanding the services of cooling centers include the lack of or unreliable electricity supply, a poor-quality road network, poor management, and high investment and maintenance costs. Two processors handle some 75% of raw milk, producing white liquid milk (pasteurized and long life), flavored liquid milk, fermented milk (yoghurt and cheese), milk powder, cheese, butter, ghee, and cream.

Dairy farm producer organizations (FPOs)

FPOs provide a reliable market outlet for smallholders and are able to reach a high number of farmers. Some have milk chilling plants and offer services to their farmers to increase and stabilize their milk supply. They are, thus, logical, recipients of credit-line finance aimed at climate-change mitigation.

Mitigation options for Kenyan Dairy Farmers

The Government of Kenya supports the dairy sector in reducing its GHG emissions, specifically through the provision of extension services. The Kenya Climate Smart Agriculture Project (KCSAP) is a USD 250 million, five-year project (2017-2022) jointly supported the World Bank and the Government of Kenya (USD 29 million co-financing), whose objective is to increase agricultural productivity and enhance resilience to climate change risks in the targeted smallholder farming and pastoral communities in Kenya, while The National Agricultural and Rural Inclusive Growth Project (NARIGP) is a USD 200 million jointly supported the World Bank and the Government of Kenya (USD 19 million co-financing), whose objective is to increase agricultural productivity and profitability of targeted rural communities in selected counties and in the event of an Eligible Crisis or Emergency, to provide immediate and effective response.

2.2. Credit line design

The objective of the credit line is to deliver appropriately structured, affordable and flexible credit finance to loan recipients (FPOs, farmers, commercial fodder (hay and silage) producers, and dairy processors), to enable them to implement mitigation interventions. Funding, therefore, needs to flow to the loan recipients under appropriate terms and conditions, which can be achieved in several ways:

- Structuring a new climate-finance fund that will be managed by an experienced professional familiar with the dairy sector and with Kenyan conditions. This option allows the fund sponsor (the World Bank) more leeway to influence the operation and rationale of the fund and ensure that it is aimed at the relevant targets;
- Working with an existing fund to establish a dedicated climate-finance sub-fund. This could be achieved and operational more quickly but would have to operate within the limitations of the fund's existing rules and structures;
- Offering an incentive structure – such as a risk-sharing facility – to an existing fund to work with the target beneficiaries of small-scale dairy farmers investing in climate mitigating improvements to their farms. Under such a scheme, the risk-sharing facility would have to be backed up by technical assistance to the fund managers.

Target beneficiaries

The project identified 150 FPOs that participate in projects with KSCAP and NARIGP and divided them into three tiers: Tier 1 (operational, formally registered as a business-oriented institution, and have established operational structures, accountability systems, and constitutions), Tier 2 (operational, formally registered as a business-oriented institution, but with limited operational structures, and low accountability systems), and Tier 3 (minimal structural existence). Only those FPOs in Tiers 1 and 2 would be considered as eligible for credit, the latter with targeted support. The FPOs under consideration cover some 3,770 members, with wide variations in farm size, structure and expertise across the country.

Dairy smallholder farmers and related agricultural micro-enterprises are largely served by microfinance banks, credit-only microfinance institutions (MFIs) and non-profit Savings and Credit Co-operative Societies (SACCOs), who seem to allocate more funds to the agriculture sector in general, and specifically to the dairy sector. Therefore, to reach a high number of dairy smallholder farmers and related agricultural micro-enterprises, microfinance banks, credit only MFIs and SACCOs are the best channels. However, their inability to attract large loan capital is a problem that needs to be addressed.

Investments supported

The maximum total size of the credit line was estimated at USD 130 million (assuming participation of the 150 identified FPOs); the total potential investment universe is estimated at 350 M USD. The size of each investment 'bucket' is based on the individual investment size (e.g. for a chaff cutter, or zero-grazing unit) and the estimated number of loan recipients (Table 3).

Table 3. Investment buckets along the supply chain (USD)

	FEED AND FODDER	ON-FARM DAIRY PRODUCTION	BULKING AND CHILLING	PROCESSING
Investments (individual investments packaged together)	Machinery (tractor, baler, silage wrapper) Transport (lorry) Storage facilities Working capital	Improved dairy cattle Zero-grazing unit Chaff Cutter, pulverizer Biogas digester Working capital	Milk chilling equipment Pasteurization equipment Transport (lorry) Working capital	Energy efficient processing equipment Working capital
Size of the investment bucket	20M	80M	15M	15M
Mitigation potential	0.1 Mt CO2eq. over 10 years (increased yield and reduced losses)	On-farm: 1.8-3.6 Mt CO2eq. Over 10 years at farm level (improved efficiency and feeding) Biogas: 0.4 Mt CO2eq. over 10 years	0.3 Mt CO2eq. over 10 years (energy efficiency/renewable energy in milk chilling and processing)	
Loan recipient	Commercial fodder producer	Dairy farmer	FPOs	Dairy processor

Financial analysis

Within this credit line design, rather than banks' offering lower – or much lower – interest rates, the proposal is to propose a grace period that can run to several years followed by a longer repayment tenor, as below.

A cash-flow analysis of each project along the dairy value chained revealed that they can be profitable enough to absorb commercial interest rates with the addition of grace periods and the increase of loan tenors. To assess this, a sensitivity analysis was performed to find out the least concessionality required for the projects still to be profitable. The goal was to ensure that the cash balance was positive for each project, and that the debt service covering ratio was acceptable. The analysis showed that the cash flows were more sensitive to changes in tenors and flexibility in loan repayments than to reduction of interest rates. This finding is important, as providing interest rates in line with current bank offerings will avoid market distortions and will also contribute to accessing a larger pool of Climate Finance institutions able to provide credit lines.

Loans at farm and feed production level would still offer a straight-line amortization repayment schedule. For each of these cases, except zero-grazing units, the tenor will be increased by one to three years. The addition of a grace period was revealed to be necessary to keep the projects profitable, as the projects often do not provide returns during their implementation phases. The projects at milk processor levels required a more flexible repayment schedule to be able to absorb commercial interest rates. The most suitable repayment schedule is a balloon payment. During the life of the loan, processors will repay a smaller constant loan installment each year with a larger repayment in the last year of the loan. The first installments are smaller than they would be with a classic repayment schedule, so no grace period will be necessary.

Emission reduction estimates

A baseline survey provided a pilot data collection effort informing the MRV system development and allowing the refinement of the ex-ante assessment of the credit line's mitigation potential.

The objectives were: to verify and refine assumptions for the GHG mitigation potential assessment of on-farm investment packages and for commercial fodder production; to verify the Theory of Change that access to more affordable credit will increase adoption loans by farmers; and to feed the preparation of the design and development of the MRV system.

In total, 11 FPOs, 44 farmers and 5 commercial hay producers participated in the survey. Data on feeding practices, herd and manure management were collected to allow for a Tier 2 calculation of GHG emissions. Emissions calculated from the baseline survey represented current production without adoption of investments and improved dairy management practices.

In addition, 3 mitigation scenarios ("with project") were considered, reflecting investments on improved breeds, fodder, feeding practices, manure management (biogas digester), and disease prevention/treatment.

1. **With project (WP) scenario 1:** conservative level of adoption and improvement resulting in an increase of milk yield by 50%.
2. **With project (WP) scenario 2:** optimistic level of adoption and improvement resulting in an increase of milk yield by 100%. Given the low starting point in terms of milk yield, a 100% increase is optimistic but not unrealistic.
3. **With project (WP) scenario 3:** combines a 100% increase in milk yield with herd control (1 less dairy cow kept on-farm), to allow for maintaining production increase while reducing absolute emissions compared to the baseline

For each scenario, the GHG emission intensity (CO2e/kg FPCM) and emission reduction potential per farm were calculated using data from the baseline survey and scenario assumptions described above. The total absolute and relative (compared to same production levels achieved without emission intensity gains) emission reduction potential was determined for both semi-zero and zero-grazing production systems. The total mitigation potential of the credit line was then calculated using assumptions about the number of farms reached over 10 years and in the two production systems. Results at dairy farm level are summarized in Table 4 (see also Table 3).

Table 4. Emission reduction potential at farm and credit line level for three “with-project" scenarios

EMISSION REDUCTION AT FARM LEVEL (tonnes CO_2e per farm and year, using GS methodology)	BASELINE	WP-1	WP-2	WP-3
	Farm-level emission intensity (kg CO_2-eq/kg FPCM)			
Zero-grazing	1.21	0.9	0.81	0.81
Semi-grazing	1.22	1	0.85	0.85
	Credit line level emission reduction (t CO_2-eq)			
Emission intensity-based emission reductions (based on Gold Standard smallholder dairy methodology)	-	1,769,644	3,607,379	2,337,287
Absolute emission reductions	-	-1,109,547	-2,151,003	617,402

The baseline survey revealed that farmers mainly use their own resources (profits from milk sales, savings or income from employed family members) for investments, although a third of them had borrowed money for their operations, overwhelmingly from SACCOS. All farmers expressed interest in credit-line finance for investment finance, influenced by the lower interest rate, grace period, reduced collateral and longer repayment schedule. Similar sentiments were expressed by commercial hay producers.

Of the FPOs, all of them declare themselves to be interested in credit finance, both for operating costs and milk procurement, as well as investments in equipment.

Technical assistance

The scenario proposed for Kenya depends upon adequate technical assistance (TA) and capacity building for loan recipients. According to financial institutions surveyed in 2016, farmers need training in financial record keeping and dairy productivity and farm revenues to give them a verifiable track record in running a successful business and, thus, reasonable prospects to be able to repay a loan. The absence of this expertise resulted in loan applications’ being denied. Taking this loan-application experience into account, for the credit line, farmers require capacity building in improving feeding practices, breeding and herd management, financial literacy, how to use credit finance, and the importance of improved dairy practices for enhanced profitability and GHG reduction. Such training complements that directed towards increasing the efficient use of water resources, reducing application of harmful chemicals, and waste disposal. This training applies equally well to others along the dairy value chain.

In addition, farmers need to be aware of potential social and environmental risks from intensified production methods: increased poor-quality labor for women, threats to animal welfare and contamination of ground water and crops from bioslurry and/or mismanagement of biogas digesters. Any TA initiatives will need to take these risks into consideration.

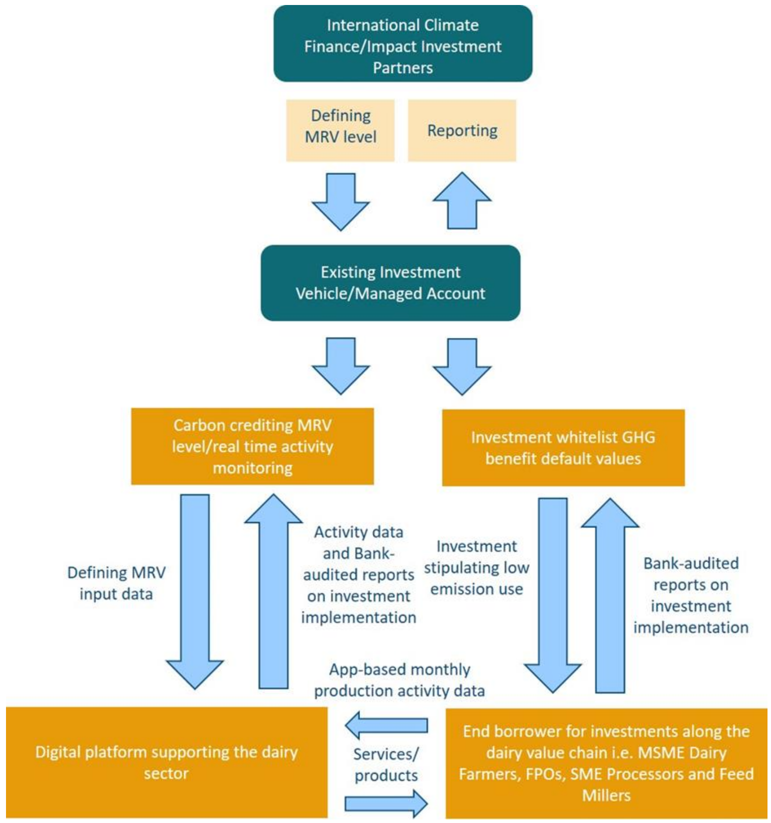
Alongside TA for farmers and others along the value chain, financial institutions will need assistance in building support at the executive level to ensure buy-in at the lower levels, in developing relevant tools and procedures to facilitate provision of the credit line to qualified applicants, and in strengthening climate-finance underwriting expertise. The overall aim of TA to FIs is the institutionalization of Climate Finance within them. The TA should thus be delivered in a phased manner to enable the financial institutions sufficient time to internalize the knowledge and capacity, while enabling the TA provider(s) to assess progress, incorporate lessons learned and adapt the TA measures over time. The proposal is to consider phased TA over a period of 18 – 24 months.

Measurement, Reporting and Verification

Measuring GHG emissions is crucial to demonstrate impact and justify the use of public Climate Finance. However, only limited guidance how to collect, analyze, report and verify emission reductions exists. Requirements by the Climate Finance provider should be the starting point for the MRV system. Furthermore, consistent reporting with Kenya's evolving climate action registry is required to recognize its NDC contribution. To ensure sustainability and contribute to the institutionalization of Climate Finance within the financial institutions, monitoring of GHG emission reductions and GHG efficiency gains should be done by the financial institution itself.

Different options for the MRV mechanism are considered: at investment level or using a digital platform and app-based activity data collection. In the former, information required to assess GHG emission reductions and GHG efficiency gains is provided by the loan recipient during the application process. The information supplied is verified either by the FI or by an outside consultant; the loan recipient will be encouraged to supply the information by a promised discount on the final repayment as a reward. In the latter, loan recipients are trained in the use of an app and required to upload data in specific intervals.

Figure 4. Depending on the selected options, different levels of data collection efforts will be required



In all options, the MRV system is IPCC-compliant and Tier2-based. It involves an alignment with the internal MIS systems of the FIs, and include the following steps:

1. Support of FI agriculture and sustainability strategy development;
2. Dairy portfolio diagnostics to establish an emissions baseline for the portfolio;
3. Assessment of banking requirements for FPOs;
4. Baseline development (Tier 2 level);
5. Preparation of an annual climate impact report for the dairy sector;
6. Development of Excel tool development and integration into existing MIS system, including the development of a guideline for sub-lending FIs and FPOs on how to use this tool;
7. Support climate reporting for (sub-lending) FIs.

An estimate of the costs associated with MRV system development is provided in Table 5. With a total cost of USD 693.000 and a total mitigation potential of 2.6-4.4 Mt CO_2-eq, the MRV costs would amount 0.16-0.27 USD/t CO_2-eq.

Table 5. Cost estimation of MRV system development in the two FIs

Activities	Budget Equity Bank	Budget Family Bank
Support of agriculture and climate finance strategy development	12,000	12,000
Comprehensive diagnostic (data gap analysis)	31,500	31,500
Baseline development (Tier 2 level)	58,500	58,500
Preparation of an annual climate impact report	31,500	31,500
Support climate reporting for FIs	21,000	21,000
Development of an Excel tool to be integrated into the existing MIS system	36,000	36,000
Tier 1 to Tier 2 development	36,000	36,000
Targeted capacity building support to FIs	40,500	40,500
M&E Officer within each FI (50%)	48,000	48,000
Travel costs incl. capacity building facilitation for both FIs	20,000	
TOTAL	**693,000**	

2.3. Conclusions and moving forward

The analyses carried out revealed the substantial technical and financial potential for a credit-line approach to financing GHG-reduction mitigation and adaptation on Kenyan dairy farms. The background information also confirmed the existence of a conducive context for schemes to go forward, especially with Kenyan financial institutions eager to develop their agriculture portfolio, and a growing global development of climate finance.

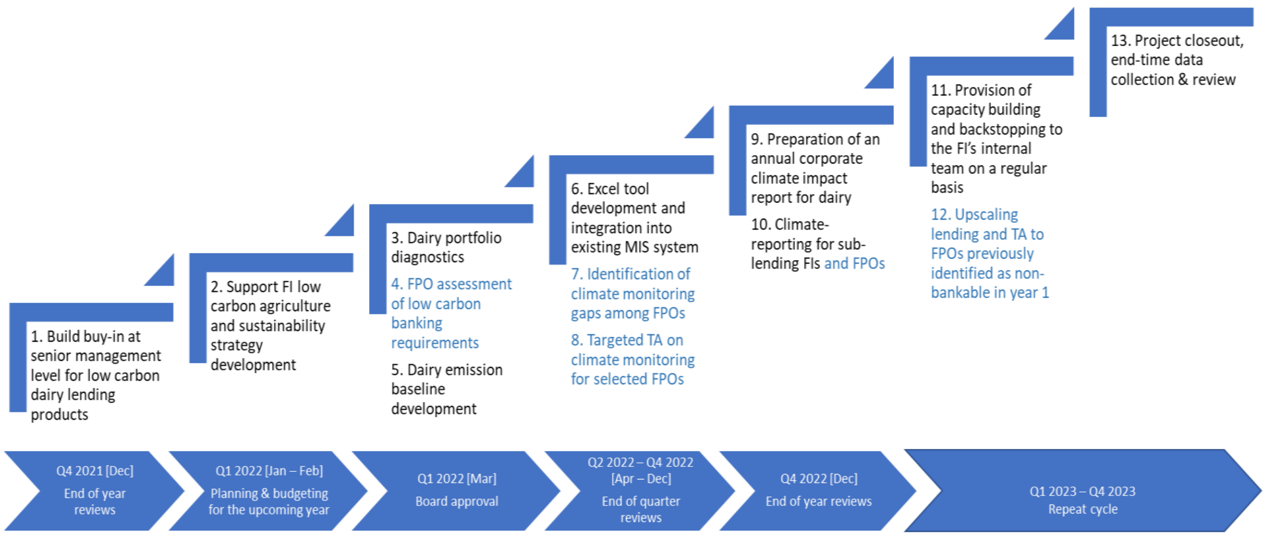
The role of training and TA is crucial for the implementation of the scheme, given the novelty of the approach and the absence of significant expertise in both the loan recipient group and the local financial institutions.

A collaboration with IFC Climate Finance Advisory would contribute to continuing the work, building on existing relationships between IFC and Tier1 banks in Kenya on Green Banking. Climate Smart Agriculture (CSA) is among the five themes along which banks can develop products as part of their climate lending.

Partners would involve IFC, WB (Kenya operational teams and global livestock/climate ASA team), local banks, and potentially an additional climate finance institution:

- WB-funded operations providing TA and grants to FPOs: “borrower-side de-risking”
- WB-funded ASA supporting the development of an MRV and content and technical expertise for TA
- IFC leads the dialogue with Local banks and accelerates their effort to engage in the agriculture/dairy space
- Potentially, a climate finance institution is associated to provide “bank-side de-risking”

Figure 5. Potential road map for setting up the credit line with mitigation condition for the dairy sector in Kenya.



3. Blueprint #2: Value-chain Finance in the Colombian Beef Sector

3.1. Background

The choice of the instrument of value chain finance

Value chain transformation requires the adoption of a set of practices by cattle ranchers, beef aggregators and processors, and regulators in equal measure. A specific financial obstacle related to the mitigation pathway of improving emission intensity of production and avoiding deforestation is the challenge of creating and transmitting effective price signals related to the protection of an asset (atmospheric methane concentrations, forest) and integrating this price into products consumed at the end of a complex global value chain far from the assets.

The interventions needed must change economic incentives for value chain actors to integrate externalities such that productivity improvements without expansion onto ecosystems become more attractive. Increasing transparency and accountability across value chains has the potential to transmit pricing signals and incentivize low carbon (or methane) modes of production. Demand from consumers for low carbon beef will encourage producers to join agreements or associations that promote collaboration toward sustainable beef.

Value chain finance has the potential to enable Climate Finance to impact entire value chains to achieve objectives such as reducing deforestation, lessening the emission intensity of production, as well as co-benefits including improved livelihoods and incomes, animal welfare and production quality that meets consumer demand for sustainable sources of animal protein.

Climate Finance flows best adapted to this blueprint come from local green banks or strategic investment funds which expect a certain level of profitability along with robust environmental impact. Philanthropic funds can enhance the return on investment by financing non-profitable aspects of the project. DFIs can provide additional funds and advisory services to ensure the success of the investment.

The approach is powerful because it offers a way to reach spatially spread-out farmers, establish traceability, and transmit price signals along the chain. These signals change incentives faced by all actors along the chain and can thus literally provoke a 'chain reaction' of transformation. Moreover, from a farmer's point of view, value chain finance can offer much needed improvements in access to finance to enable the uptake of new technologies and improved practices, another crucial element of this equation.

The Choice of Orinoquía and Hacienda San Jose (HSJ)

Colombia is a major beef producer (4th in Latin America and the Caribbean) and Orinoquía provides a unique case study where savannahs are the native vegetation, extensive beef production has existed historically but with a large potential for improvement. The region comprises almost 37 million hectares and is dominated by natural savannas and introduced pastures, used primarily for extensive cattle ranching. The region also has the largest potential for sustainable intensification of agricultural production as it remains vastly unexploited. In the last decade, there has been increasing interest in unexploited areas as it can be a source of food supply to national and international markets while improving livelihoods.

Figure 6. Key features of Hacienda San Jose's improved model of cattle ranching in Orinoquia

Improved fast growing breeds (top left), intensified forage production (top right), rotational grazing across (bottom right) and other improved grassland management such as more protein-rich grasses and improved drainage (bottom left).

Despite the region's low soil fertility conditions and prolonged dry seasons, it has been recognized as an agricultural pantry for its land management and high productivity, where at least 2.8 million hectares are suitable for livestock production. This presents a unique opportunity to foster sustainable cattle farming, while making a contribution to climate action.

Hacienda San Jose (HSJ) is a private company with a large farming operation including two productive operations (high quality cattle genetics and cow-calf production) and pursuing very high sustainability standards. It started operations in 2014 aiming at a sustainable intensification of the production system. The area of improved pastures went from 0 in 2014 to approximately 7,200 in 2021, covering more than 80% of the total 8,670 ha of the farm. To reduce the climate impact, the company changed some traditional management practices in the region: i) grassland productivity and beef production efficiency, ii) land-based carbon removal and iii) energy management.

Plan for investment

HSJ plans for investment are at two levels and timeframes:

Farm Expansion: The immediate intention is to expand HSJ's current operation by replicating it on a larger scale (with an additional 6,000 ha). HSJ was accompanied by IFC advisory services in this initiative during the preparation of the blueprint, resulting in an investment deal being closed with an impact investment fund, motivated in part by the operations' low-emission footprint.

Value Chain Expansion: HSJ aims to be the catalyst of a broader transformation of the Orinoquía beef value chain, by (i) providing genetic material and model farming practices; (ii) developing a framework for value chain restructuring covering all steps in the chain and promoting investment opportunities within the framework using several financial instruments. This process is also supported by IFC advisory services and could provide opportunities for IFC or World Bank investments.

3.2. Blueprint design

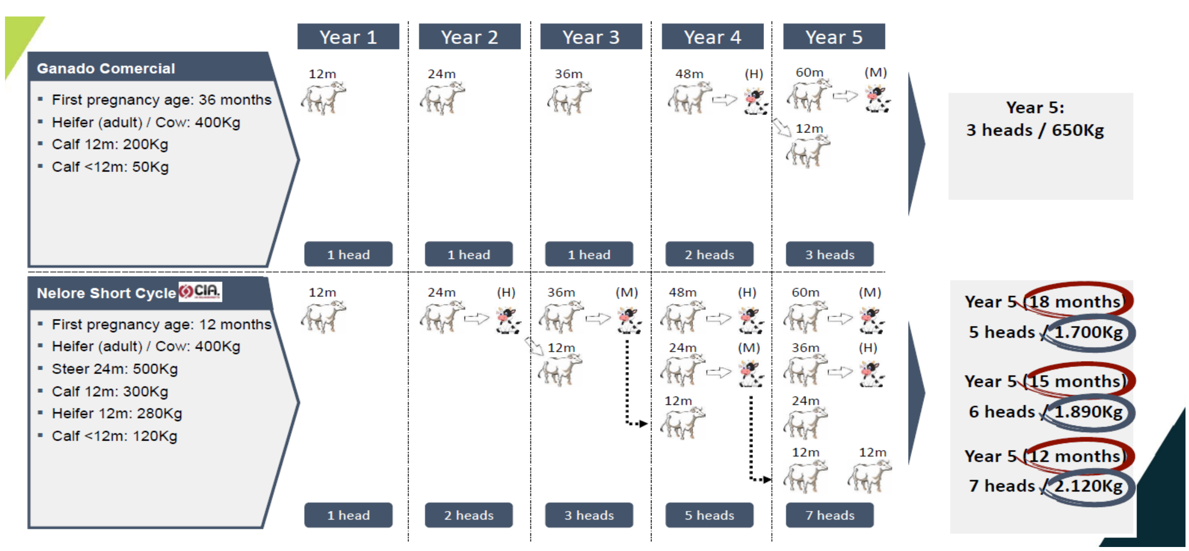
The objective of blueprint development is to evaluate the case for climate-motivated value chain finance investments by i) producing a consolidated assessment of HSJ's net carbon footprint, ii) identifying and quantifying mitigation opportunities and iii) drawing lessons for MRV systems supporting potential climate finance supported investments.

Establishing Business as Usual (BAU): average farm in the region

The BAU scenario reflects traditional beef production systems found in the Orinoquía region. It was based on detailed data collected by the International Centre for Tropical Agriculture (CIAT) on 38 farms. These were used to calculate an average farm that could be compared to HSJ. The main characteristics of this reference farm that influence its emission profile were the following:

- Use of the traditional Brahman breed, with a longer reproductive cycle and lower productivity (weight gain), compared to the short-cycle Nelore breed used by HSJ (Figure 7);
- Animals entirely fed with natural pastures (native savannahs), only complemented with mineral salts;
- Land use dominated by native savannahs having reached an equilibrium in terms of soil carbon stock changes (no sequestration).

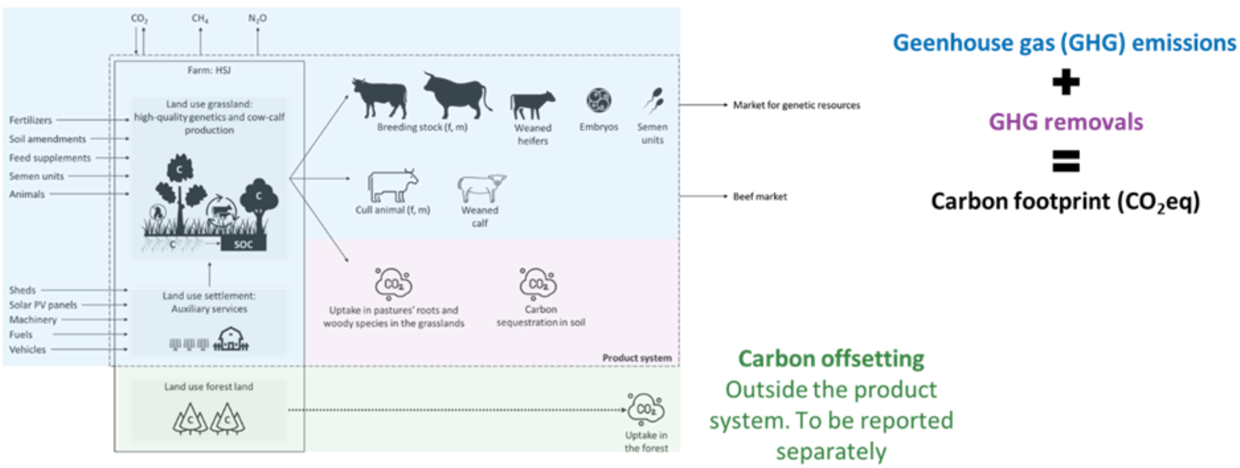
Figure 7. Breeding cycle over 5 years of the traditional Brahman breed (top row) compared to the Nelore short cycle (bottom row)



HSJ's current improved model of production

The current carbon footprint of HSJ was estimated using detailed methods and primary data collected directly within HSJ. On the emission side, a *Life Cycle Assessment* (LCA) was performed, accounting for all emissions from input production to feed cultivation and animal breeding. On the side of removals, direct field measurements were used and IPCC (2006, 2019) guidelines followed. Figure 8 provides an overview of emissions and removals accounted for in the net carbon footprint. Calculations were made for the period 2017-2023, to account for the operation's expansion strategy.

Figure 8. Boundaries and emission categories for the calculation of the partial carbon footprint of HSJ according to ISO 14067:2018.



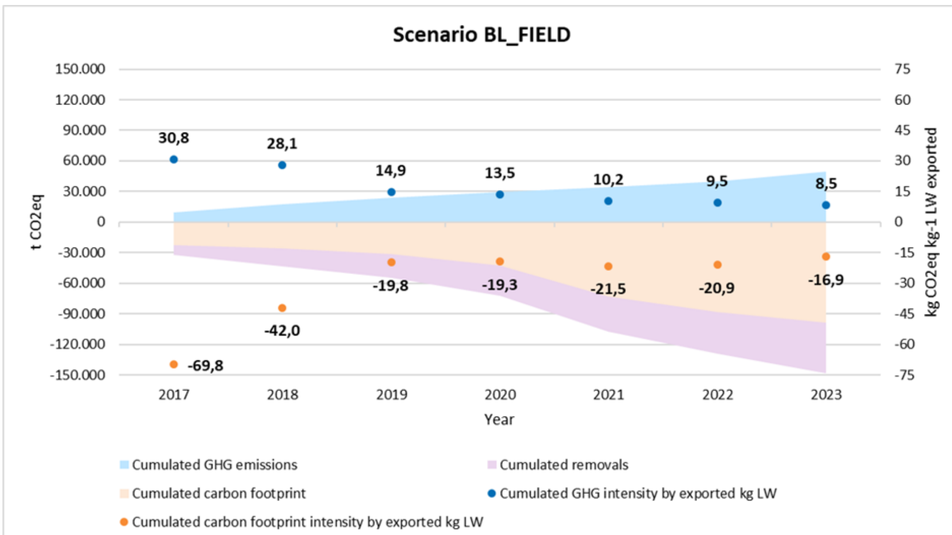
To perform the Life Cycle Assessment (LCA) of current HSJ emissions, data were collected directly at HSJ to characterize the herd structure and dynamics (number of animals by categories, ages at weaning, calving and culling), production (animal weights by categories), diet and land use. Importantly, the gross energy (GE) demand of animals was directly estimated based on known dry matter intake – an option provided by IPCC (2019) but more data-demanding and hence less frequently used than GE demand estimation based on energy requirements. In 2017-2023 accumulated emissions will have reached 49,700 t CO2-eq with the most important sources being enteric fermentation (64%), manure deposition (16%) and the production/import of feed supplements (8%). As HSJ set up its operation and gained productivity, emission intensity went from 30.8 to 10.2 kg CO2-eq/kg live weight, and is expected to amount to 8.5 kg CO2-eq/kg live weight when the operation reaches its full productive potential. By comparison, the BAU emission intensity of reference farms has been stable since 2017, at around 16.5 kg CO2-eq/kg live weight.

Soil Carbon Sequestration

A previous assessment of HSJ's carbon footprint had relied on IPCC default factors to estimate carbon sequestration potential, which was identified as the main source of uncertainty. Field measurements were thus used to estimate baseline SOC stock and sequestration rate. Soil was sampled in two nearby sites of HSJ presenting similar conditions: one in native savannah and one in improved pastures that had been implemented for 6.5 years (originally from native savannah). In total, 40 samples *per* site were collected, corresponding to different soil depths and replicates. Both types of grasslands had a baseline stock of more than 200 t C/ha, a value 40% higher than IPCC defaults for the corresponding region/pedo-climatic type. In improved pastures, the observed carbon accumulation was 13.6 t C/ha after 6.5 years, an amount of accumulation to be expected after 20 years according to IPCC default values. Accumulation is likely a consequence of higher biomass productivity and cattle waste deposition.

By combining the LCA of GHG emissions with the field measurements of SOC sequestration, the net carbon footprint of HSJ could be calculated. Results suggested a net negative carbon footprint (net removal) (Figure 9). The cumulative GHG emissions and C removals in the period 2017 to 2023 account for approximately 49,700 and 148,300 t CO_2-eq, respectively. The main factors explaining this result are twofold: (i) the underestimation of sequestration potential in IPCC default data compared to actual field data and (ii) the overestimation of gross energy intake using the IPCC Tier 2 equations based on energy requirements. Uncertainty remains regarding the evolution of the soil carbon accumulation rate going forward (i.e. between 6.5 and 20 years).

Figure 9. Cumulated carbon footprint of the BAU scenario of HSJ using data collected at farm level.



Improved mitigation scenario

A range of possible mitigation practices were considered to secure and strengthen the net climate benefit of the HSJ operations. Mitigation options were discussed with HSJ to ensure their applicability, agronomic and economic relevance. A set of practices was selected and their emission reduction potential explored for potential addition to the HSJ model:

Live fences - the most suitable tree species for implementation of this practice were identified using ecological models of species distribution (including under climate change scenarios). An intervention potential of approximately 51.04 linear km, which would result in a mitigation of approximately 126 t CO_2eq yr^{-1} (stored in trees) (plus 44.7 kg of CH_4 yr^{-1} from each animal raised on the intervened paddocks from improved grass digestibility). Therefore, the sequestration potential in trees is relatively low compared to sequestration as SOC in improved grassland. This is true in relative terms, with potentials of 2.5 t CO_2eq/y *per* linear km of trees vs. 7.3 t CO_2eq/y *per* ha of improved grassland (in the 0-20cm layer only). But more importantly, there is a big difference in absolute terms due to the large grassland area (leading to 12,670.2 t CO_2eq removed in 2020) vs. limited scope to establish live fences or silvopastoral systems (leading to the total value of 126 t CO2eq yr-1 stored in new trees). **Legumes** – legume species adapted to the local conditions could be planted separately or in combination with *Brachiaria humidicola* (grass species in improved pastures). This could contribute to higher carbon sequestration and lower emissions from animals (due to high digestibility). Preliminary assessments show a mitigation potential of 30% of enteric methane emissions in the most optimistic scenario.

Enhanced diet –feed additives specifically designed to reduce methane emissions are increasingly becoming available. An initial exploration of using the 3-NOP additive in the context of HSJ showed enteric methane emission reductions by up to 20% (which would amount to 933.5 t CO2eq in 2020). From the economic point of view, 3-NOP can be affordable, but the risk is reversibility of the mitigation benefits in the long term due to adaptation of the rumen micro biota.

Options and cost for MRV

The practices implemented by HSJ already generate large productivity gains and reductions in emission intensity compared to the BAU scenario, and direct field measurements show a large carbon sequestration potential in improved pastures converted from native savannahs, larger than what can be estimated with IPCC default factors.

Overall, the HSJ model shows a net positive climate contribution. The farm-level expansion could further strengthen this positive climate contribution by further extension – the main driver of the positive climate balance of the HSJ model. Other additional mitigation opportunities exist, through enhanced diets and live fences, such as trees and bushes. Enhanced diets could further improve the climate balance by reducing emissions. Live fences would improve the climate balance by increasing sequestration, although the sequestration potential in trees seem lower than in grassland soils (due to the relatively limited scope to plant new trees, from economic and production perspectives).

Results strengthen the evidence base regarding the climate benefits of HSJ's operations, show that strong alignment between economic and climate mitigation objectives for grass-fed beef production in certain contexts and build a strong case accessing climate finance.

The assessment also provides lessons for the development of MRV systems supporting potential climate investments. Most importantly, direct physical data collection combined with the use of advanced scientific methods (such as LCA) in determining the emission profile allowed to adequately determine the emission profile and yielded encouraging results, with a positive net carbon balance exceeding estimates derived from default IPCC values. More specifically:

- The LCA approach is very well adapted to value chain finance. In the case of HSJ, it was the key to accounting for emission sources that do not occur on-farm but are often associated with intensification: imported feed supplements not used in BAU farms but representing non-negligible emissions in the case of HSJ.
- Field measurements are essential for an accurate estimation of SOC sequestration – results can be very different from IPCC default values especially in relatively unique ecosystems and grassland improvement practices such as the context of HSJ.
- Field measurements of SOC need to be carefully planned: only about 30% of the total SOC stock were found in the top 0-20 cm soil layer, highlighting the importance of evaluating deeper soil layers in SOC assessments.

- Field measurements performed so far - 10 cores sampled per area - typically represent a "pre-sample". Such pre-sample is very useful to assess SOC variability and determine the larger sample size that would be required to comply with voluntary carbon market standards (e.g. for achieving a 10% uncertainty with a 90% confidence level).
- Field measurements of SOC will need to be combined with process-based modelling and repeated over time to reduce uncertainty related to the longer-term evolution of SOC sequestration rates.
- Innovation will be required to reduce the costs of LCA and direct SOC measurements to reach scale and deploy an MRV based on these elements for the purpose of generating carbon assets. This could be done by (i) prioritization and optimization of the sampling strategy to combine default data and several levels of sampling efforts, (ii) spreading MRV costs over a large amount of emission reductions, (iii) compiling data collected around the globe to update and improve the (spatial) differentiation of IPCC reference values.

Taking these elements into consideration, a very preliminary estimate of potential MRV costs is shown in Table 6. A period of 10 years was considered (2017-2026), during which 4.553 ha of improved pastures are implemented in 2017 and gradually increased to 7.500 ha in 2022 – for a total cost of 2.6 million USD. The net carbon removals during the same period would amount 198.657 t CO_2-eq, resulting in an MRV cost of 0.8-1.1 USD/t CO_2-eq. Assuming that 100 "satellite farms" could achieve the same carbon removals as the HSJ operation, MRV cost could be diluted and reach only 0.04-0.08 USD/t CO_2-eq. These economies of scale are achieved by three main factors: (i) fixed costs associated with the modelling framework/MRV system development are diluted, (ii) some data can be collected for a sample of farms rather than for all of them and (iii) the SOC sample size required to comply with voluntary carbon market standards (e.g. VCS VM0032) quickly plateaus as the project area increases.

Table 6. Preliminary cost estimate (in USD) of MRV (for livestock emissions and carbon sequestration in grasslands) for the HSJ operation vs. the same operation along with 100 satellite farms.

	HSJ			HSJ+100 satellite farms		
	Unit cost	**Units**	**Total**	**Unit cost**	**Units**	**Total**
Emissions						
Establishment of LCA modelling framework	70000	1	70000	70000	1	70000
Extended data collection (years 1, 5, 10)	5000	3	15000	5000	30-75	150000-375000
Yearly data collection	500	7	3500	300	925-970	291000-277500
Data processing, QAQC, calculations	5000	10	50000	20000	10	200 000
Sequestration						
Soil sampling and analyses in reference area (once)	500	10-50	5000-25000	500	100-400	50000-200000
Soil sampling in improved area (years 1, 10)	500	20-100	10000-50000	500	200-800	100000-400000
Total			153 500-213 500			861 000-1 522 500

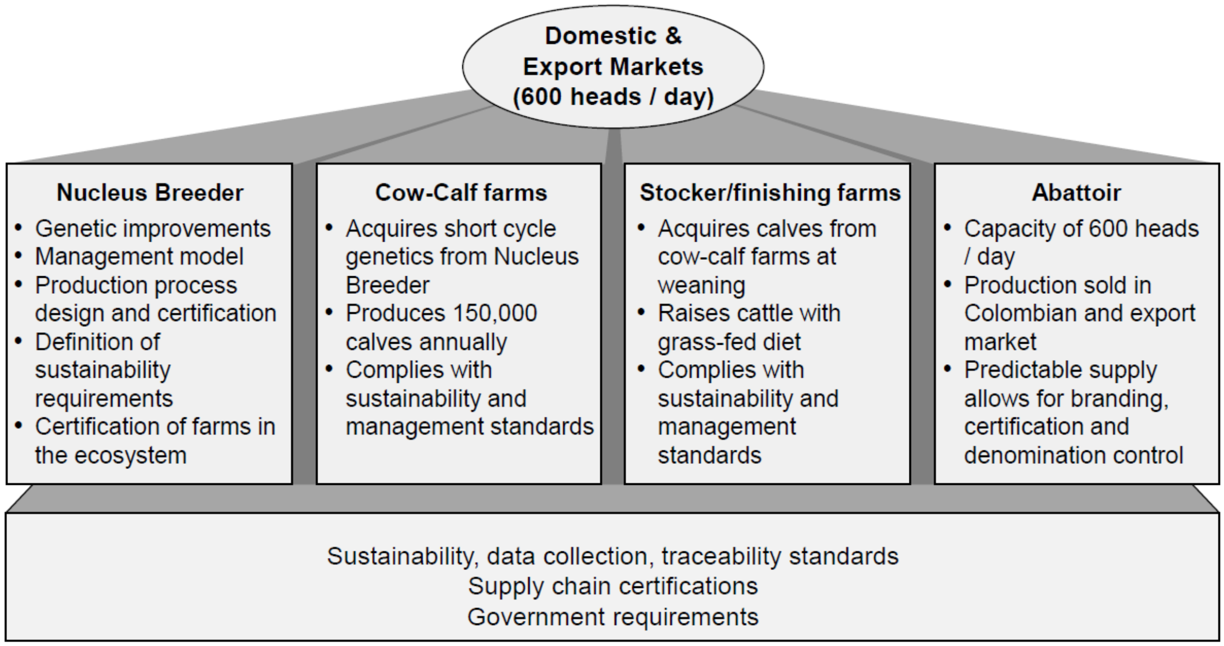
The scalability of the HSJ model inside and outside the Orinoquía region is limited by two factors: First, HSJ is a unique model in a relatively unique ecoregion, where grassland/savannah is the native vegetation and has a large potential for intensification and for almost fully meeting the animals' feed demand. Deforestation risks are more limited in this context than in many other Latin American production systems. Second, pasture improvement is very likely to have a positive climate contribution but its impact on other environmental aspects is more uncertain. Biodiversity in natural savannahs (native plant species and animal species using this habitat) may be negatively impacted by pasture improvement. Ecological studies will be necessary to quantify this impact. Land sparing could be a pathway to combine intensification with biodiversity conservation – by taking advantage of intensification to spare natural biodiversity habitats.

Assessment of the proposed broader value chain expansion

Orinoquía may offer the potential to develop a state-of-the-art beef value chain. in what would amount to a greenfield development. The current chain operates in a low-level equilibrium, with low investment, is poorly structured, has very low productivity and is uncompetitive. The proposed investment program would have the potential to transform the sector by modernizing, restructuring and expanding production using climate-smart practices and up-to-date processes to ensure traceability, food safety, social and environmental minimum standards. The proposed transformation of the Orinoquía beef value chain offers a fresh start (Figures 10 and 11).

Figure 10. Geographical dispersion of the Orinoquía value chain

Figure 11. The Orinoquía value chain with MRV application



Further investments in the value chain to enhance climate change mitigation and adaptation could have a ripple effect throughout the system, protecting forests, improving livelihoods and opening market opportunities, provided the finance was available to make the required investments and cover the risk factors.

Assessing whether an expansion of the value chain would generate emission reductions overall will require two steps:

1. Assessing the carbon footprint of the whole HSJ value chain. This would be done by expanding the LCA beyond calves and genetic material to all stages from breeding to slaughtering, with beef as the final product being beef meat and not only calves/genetic material anymore. If the net climate benefit at farm level was confirmed, and if it could be replicated in satellite cow-calf farms, it is likely that the net emission removals at this stage could compensate for emissions at later stages: fattening , slaughtering, and transport.
2. Building scenarios to explore how the reduced carbon footprint of the HSJ value chain would translate into an impact on total production and emissions of Colombian beef (consumed domestically and exported):
   - A BAU scenario could be derived from historical trends in beef production (for example, the cattle herd has been increasing in size at an average rate of 2.12% per annum in Orinoquía over the period 2008-2017) combined with the potential impact of beef demand.
   - A value chain expansion scenario, which will be needed to determine whether beef produced from the HSJ value chain would be additive, partly or fully substitutive to BAU beef production.

3.3. Conclusions and moving forward

The full LCA assessment of the farm expansion will be made available to HSJ and its investors. It provides a strong basis for attracting Climate Finance for further farm-level expansion going forward. In the event, additional technical support may be useful to define the methodology and technical specifications of an adequate MRV system.

Future work will be required to assess the climate emission impact of the value chain expansion The proposal remains at an early stage and further technical support may be required to identify the mitigation potential and to develop an MRV system.

Having contributed to blueprint development in recent months, the World Bank's programmatic ASA program *Developing Climate-Smart Agricultural Supply Chains* is well placed to continue providing support along the lines outlined above to help realize this blueprint's potential.

4. Supporting Activities

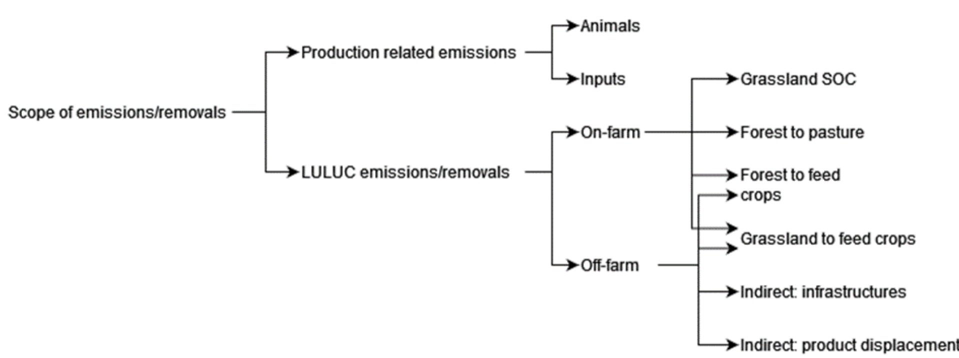
4.1. A conceptual framework for Measurement, Reporting and Verification

MRV is a common issue to all climate finance efforts, and very often one of the main bottlenecks due to complexity and cost. Needs are also diverse and MRV systems need to adapted. A conceptual framework was developed to look at interactions between livestock intensification, emissions and land use change, with a domain of application at *macro* scale (country, jurisdiction) but generic in terms of geographies and production systems. The conceptual framework lays the basic principles and key recommendations for the development of MRV systems for emissions and removals associated with livestock intensification, and it identifies options to improve cost effectiveness.

General recommendations include that MRV systems should be:

- compatible with national GHG inventories and NDCs;
- able to monitor GHG balance from landscapes
- based on a live cycle perspective, i.e. include pre-chain emissions, indirect land use change, leaching and displacement.

Figure 12. Main categories of emissions and removals



MRV systems should adopt a life cycle perspective, i.e. consider emissions at both animal production level and input production level (imported feed in particular). For these two levels, non-LUC-related emissions need to be considered, the main ones being enteric methane and manure management emissions at animal level, and fertilization and energy use at input production level. The same life cycle perspective should be adopted to for emissions and removals related to land use and land use change. In addition, those need to cover various land use change pathways (e.g., grassland remaining grassland, forest to grassland and to cropland), occurring both on-farm and off-farm, directly and indirectly (see also Annex 2, Figure A1 and A2).

Combining farm-level and national (regional) level MRV components

Climate finance interventions can be structured with farm-level and regional-level components, and the same will be true for the collection and aggregation of data feeding an MRV system (Annex 2, Figure A3). Certain farm-level data (e.g., on herd management, animal productivity, or diet) are key for an accurate estimation of direct livestock emissions. Emissions can then be extrapolated using regional to national level statistics on livestock population. Similarly, farm- or field-level measurements of carbon stocks in grasslands and forest can be combined with larger scale data on land use change from remote sensing or national inventories. Country scale imports and exports should also be used, since changes in feed and animal products imports and exports may cause indirect land use change.

Typologies to control data collection costs

Defining representative types of livestock farms or production systems will be a way to control MRV costs. Firstly, by defining a limited number of types and within each type by collecting data for the minimal sample to reach statistical representativeness. A typology consistent with national statistics will allow for upscaling from farm level data to regional or national results. Secondly, by defining simplification options within each type, i.e. less significant emission/removal categories for which default data can be used instead of collecting primary data. A third way to control cost is to ensure that data collected for MRV also serves other purposes. For example, technical advisory services, extension and production benchmarking programs, research projects, can effectively share data collection and analysis costs and benefits with GHG MRV systems.

Methods for indirect land use change to avoid leakages

A consequential LCA should be used to estimate indirect land use change caused by the project (e.g., deforestation for feed crop production, animal production displacement), as well as indirect production emissions change through changes in a country's imports and exports of animal feed and food products. If such indirect effects are through global markets, a global approach like the CarbonBenefit model can be used. This method only requires the estimation of national changes in production and default coefficients to determine indirect production displacement effects and associated land-use change emissions.

Monitoring a key source of emission: deforestation and forest carbon stocks

Given the large range of possible direct and indirect interactions between livestock farms, neighboring forests and remote forests (including savannahs, plantations and agroforests), livestock intensification projects will need to demonstrate the absence of negative impacts, and, if possible, the occurrence of positive impacts, on forest carbon. This requires monitoring of forest carbon in the vicinity of the monitored sample farms. Relating changes in forest carbon to changes in livestock will require coupled detection of forest cover dynamics and of animal density and mobility outside farms, into forests, savannahs and fallows with potential for secondary forests.

Tools to support MRV for the different emission/removal categories

Table 7 below provides an overview of the types of tools that can be used to measure the different categories of emissions and removals. Two levels of accuracy are also indicated. Annex 2 provides additional details on specific tools (Table A21 for emission calculators, Table A22 for Tier 2 models of SOC stock changes, and Box A1 for remote sensing tools).

Table 7. Overview of types of tools to measure different categories of emissions and removals

	ENTRY-LEVEL ACCURACY	**HIGH-LEVEL ACCURACY**
a. Herd & manure management	Farm LCA calculator (farm sample)	On farm data verification (animal rearing, ag. Practices). Model uncertainties
a, b. Feed emissions	Farm LCA calculator (farm sample)	On farm data verification (pastures, crops, purchased feed etc.) Model uncertainties
b. Soil carbon	SOC balance (remote sensing, ag. practices, soil model)	Direct SOC sampling
c. Forest carbon	C balance from e.g. ForestWatch*	VHR, Gedi LIDAR remote sensing
b. Regional LCA/iLUC	Consequential LCA, e.g. CarbonBenefits* or Located LCA and vegetation change accounting	Tested CarbonBenefits or Located LCA and vegetation change accounting

Scientific developments are striving, especially in the domain of remote sensing and new methods will be available to bring MRV costs down in the near future. They will need to be combined with modelling approaches – for instance, to detect small changes in top soil organic carbon stocks (usually less than 0.5% per year). High resolution satellite images will be extremely useful to study livestock-forest interactions, as they will allow to spot individual trees or animals (Annex 2, Figure A4 and A5).

4.2. The Community of Purpose

The preparation of the, "*Opportunities for Climate Finance in the Livestock Sector*", report was accompanied by consultations with various Climate Finance and livestock sector experts and stakeholders. This gave way to a Climate Finance and Livestock Community of Purpose (CoP), which has thus proved to be an inspired development.

The CoP is a space for knowledge exchange, learning, collaboration, and peer support to mainstream climate change in the livestock sector, to increase capacity and effectiveness to access Climate Finance and to explore investment opportunities. Among other communities in the climate and sustainable development fields, this is the only one dedicated to climate finance and livestock.

Since Dec 2020, seven events have been held: overcoming Climate Finance barriers for sustainable livestock value chains; transparency and traceability; Climate Finance opportunities in the sector; sustainable feed sourcing and deforestation in Latin America; MRV; and the last, in December 2021, a reflection of lessons and best practice. A special event informed stakeholders of initial findings and to gather inputs for the further development of Blueprint 1 on credit line development conditional on mitigation action in the Kenya dairy sector.

These gatherings typically last two hours, with a format designed to encourage dialogue and the creation linkages between its members. Each event commenced with the creation of an online newsletter to talk about relevant events such as the recent Food Systems Summit or COP26, or news such as the launch of the Global Methane Pledge. Participants were also encouraged to promote their most current initiative, study or publication. A keynote presentation circling the gathering's theme provided depth, focus and direction to the small and participatory group work that followed.

The CoP has attracted over 220 stakeholders from four continents (Africa, North and South America, Europe), with over 45 participants per gathering. Key organizations that have participated frequently include FAO, UNEP, RuMeth International, Samawati Capital, UNIQUE Land Use *GmbH*, Marfrig, and Minerva Foods, among others. Research institutions from, for example, the CGIAR system, financial institutions such as IFC, Rabobank, EcoBusiness Fund, and networks such as Solidaridad and Global Roundtable on Sustainable Beef were also regular attendees.

5. Lessons learned

Climate Finance[8] is not a homogenous, nor even a generally agreed concept, with a large diversity in the type of sources, instruments, and providers: very different transactions take place between a range of public and private stakeholders, with wide-ranging levels of stringency in the monitoring of climate outcomes. These can include the generation of emission reduction credits under independent market methodologies, with detailed accounting of mitigation outcomes, to virtually no accounting at all. There are also very contrasting levels of return sought by investors: from grant financing (zero practical returns) to commercial loans with or without concessional rates of interest.

The overview report produced for this project identified bottlenecks and opportunities for expanding Climate Finance for the livestock sector. The two most promising options, dairy in Kenya and beef in Colombia, confirmed that financially viable mitigation options exist. The report also sketched cost-effective MRV approaches, despite revealing obstacles to implementation.

5.1. On Climate Finance readiness to work with livestock sector

Despite the evidence – including that produced under this project – that investments in the livestock sector can be viable and profitable, it remains relatively unattractive for climate-finance investors, especially with regards to the beef sub-sector.

The sector is growing and has correspondingly increasing financing needs. This is reflected in the growing livestock portfolio within the World Bank. However, sustainability-impact-driven investment in livestock is rare. The sector has a "bad name", both because of its contribution to climate change, a lack of understanding of its capacity to contribute to mitigation and because of other issues such as those relating to ethics, nutrition and health. The beef sub-sector is particularly disadvantaged by its high-emission profile and generally negative image among climate investors. These elements add to the relative high risks in the sector as well to the costs related to serving relatively small and dispersed projects.

Soil Carbon (sequestration) presents a potentially compelling story, given the co-benefits that it offers (resilience to climate change impacts, water retention, protection of biodiversity). The issues of permanence and MRV standards, however, could raise concerns of "green washing": falsely claiming that

[8] The United Nations Framework Convention on Climate Change (UNFCCC) Standing Committee on Finance defines climate change finance as: "…finance that aims at reducing emissions, and enhancing sinks of greenhouse gases and aims at reducing vulnerability of, and maintaining and increasing the resilience of, human and ecological systems to negative climate change impacts."

an act or innovation has environmental benefits or advantages. Hence the "greening" of the livestock sector must be verifiable and transparent, if climate finance is to be attracted to it.

Private banks remain unenthusiastic about issuing concessional loans offering virtually no options to reduce interest rates for the livestock sector. While interest rate reductions do not seem feasible, either because of the general interest rate environment, or the cost of capital, or the perceived risk of the investment – banks do however seem willing to provide flexible terms on loans in other ways, which could potentially bridge the financing gap to some extent. For example, increasing the tenor of the loan reduces the repayment that needs to be made each year and so effectively makes the loan easier to service. Finding such solutions that are workable given the constraints of the financiers and the needs of the borrowers is a promising area for future work to focus on.

Another limitation is the very limited readiness on the part of private banks to allocate resources to monitoring and verification activities of climate finance transactions, which are essential to validate and verify the contribution of the activity to climate-change mitigation. First, MRV expenses can be significant and hamper the financial viability of credit lines. Second, for private banks, the rationale for incurring such an expense is unclear. This will be the case unless the results are to be monetized in some form (e.g., through carbon markets – in which case the credits may belong to the project or farm owner and not the bank), or required for some form of reporting or regulatory compliance.

Business-to-business transactions offer another option for climate financing to enter the livestock sector where green sourcing can be part of the business plan and important to the image of the company. Such is the case, for example with the coffee-shop giant, Starbucks. The company has partnered with the Nature Conservancy, a global environmental non-profit organization that operates in 75 countries and territories, to invest in in a regenerative, lower-emission dairy industry. The advantage for the livestock sector in working with such companies is that they are *already* engaged in the sector.

The landscape of Agriculture, Forestry and Land-Use (AFOLU) finance is shifting and new instruments are becoming available. Emission Reductions Purchase Agreements, or ERPAs, a legally binding contract that allow one party to deliver verified carbon credits to another, can also help developing countries build a track record of generating and selling carbon credits or applying them to their own emission reductions targets. The World Bank's Climate Change Fund Management Unit (SCCFM) uses ERPAs to support programs that preserve forests, reduce the use of dirty fuels, and increase the uptake of renewable energy. They can equally be used to offer financial incentives to investors in the livestock sector, since they reduce costs to the end-user of an innovation – such as a biodigester – because of the carbon credits earned by the supplier.

The project revealed that there is a strong need for awareness raising and technical assistance to financial institutions, both to identify profitable areas for investment in the sector and to assess and develop investments in a sector with which they may be unfamiliar and to carry out monitoring of the use and progress of their investments.

5.2.On livestock sector readiness to access Climate Finance

The livestock sector already faces the challenge of attracting finance to the livestock value chain in developing countries and this is compounded by the difficulty of obtaining Climate Finance. Moreover, there is a continued lack of awareness of the severity of the climate challenge in large parts of beef industry, itself. This means the sector – and, especially, the beef sub-sector – might be missing out on becoming part of the solution.

The beef sector gets much bad press: "Is beef the new coal?", and the market – sensitive to accusations of lagging behind on climate – is reluctant to be seen supporting an industry that presents a major threat to the environment. Hence, organizations like IFC are discouraged from closing deals on beef because of negative perceptions of the environmental impact and particularly the impact of beef supply chains on biodiversity. The reaction of the industry is defensive, rather than comprehensive, with initiatives to reduce the perception of emissions intensity and climate pollution, or corporate social responsibility (CSR) initiatives aiming to show action, instead of aiming to take advantage of the sector's mitigation potential as a business opportunity to attract Climate Finance. The example of Hacienda San Jose (HSJ) supported under blueprint #2 in Colombia has a business opportunity to generate climate assets and fully become part of solution.

Despite demonstrable bankable mitigation investments, particularly in dairy and renewable energy from biomass, for example, the current financing options are ill-suited to large-scale adoption. Capacity issues among potential financing recipients including the inability to prepare applications, insufficient or inappropriate collaterals, and limited profitability prospects under the current lending conditions can limit potential borrowers' confidence in obtaining Climate Finance. There is clearly a need for TA to improve the ability of lenders and borrowers to improve the design, implementation, and management of mitigation options.

The lack of awareness about Climate Finance options, the stakeholders involved and their requirements are further constraints on climate borrowing in the livestock sector. This is especially true, given the frequent impossibility of generating absolute emissions reduction: in most Low- and Middle-income countries emission-intensity reduction is slower than the rate of production growth. Reversing this relationship would mean interventions to limit expansion/consumption and actors along the value chain are reluctant to consider such an option, an attitude that limits the credibility of the sector's commitment to mitigation. This limits their self-perception as partners in mitigation and, therefore, their perceived likelihood of receiving climate financing.

5.3.On measurement, reporting and verification

While some progress has been made, major obstacles remain. Indirect effects, related to feed production when land-use changes take place possibly very far from the point of consumption on livestock farms and related to rebound effects on the market involving competitiveness and substitution issues are still difficult and costly to capture. There are, hence, potential leakage issues. A further issue is the permanence of SOC. As for other land use sectors, an important challenge to the MRV and accounting of SOC in livestock-driven land use is the risk of reversal. Carbon sequestered in soils and vegetation can be released to the atmosphere if practice are reversed. These issues lead to credibility concerns regarding the mitigation options of the sector and will need to be adequately addressed by further MRV development work.

There have been improvements in some significant areas. Evaluating soil-carbon sequestration is becoming more accurate but is still based on a continued need for local samples, which is costly and time-consuming. Other options, such as satellite monitoring and measurement, have been deemed promising, although more research and development is needed to refine and operationalize such methods and make them operational. Some jurisdiction-based programs (e.g. the BioCarbon Fund) have developed methods that financially reward emission intensity reductions under specific conditions. These include compensating overall absolute emission reductions from all sectors in the jurisdiction, demonstrated implementation of programs to reduce livestock emissions intensity, and reducing pace of growth of absolute emissions from livestock compared to historical trends.

5.4. On the Community of Purpose

Whie community participation can be increased to include more climate and environmental finance and public sector professionals, the meetings revealed a core group of stakeholders who are passionate about the livestock sector and eager to find ways to make it less carbon-intensive and more productive.

It is important, however, to find ways of capitalizing and sustaining enthusiasm. This can be done through responsiveness to stakeholder needs and requests, ensuring that themes are relevant, solutions-oriented, less focused on barriers, and ideally, mutually beneficial.

Considering the variety of stakeholder groups in this community, the CoP could also be an interface linking critical actors, to co-develop and test ideas and outputs.

6. Conclusions and next steps

The 26th United Nations Conference of the Parties (COP26) revealed increasing interest in Climate Finance as a response to the threat produced by climate change. However, the percentage of total Climate Finance flowing to agriculture declined between 2000 and two decades later, from some 45% to barely a quarter. Of that, less than 2% went to the livestock sector.[9] There are reasons for optimism, nonetheless.

The special session at COP26 that brought bankers, insurers and investors from the private sector together to underwrite commitments to net zero demonstrated how private finance can help fund private sector initiatives and USD billions committed to climate investment through public channels into USD trillions of total climate investment. With the right approach, at least some of this "new" finance can be directed towards the livestock sector, and that strategy can be based on the findings of this project.

The same applies to the major pledge at COP26 to reduce methane emissions by 30% by 2030. Cutting methane pollution was identified as the fastest way to slow global warming and as central to the transition to cleaner, safer, and healthier energy systems. In addition to cuts in emissions in the oil & gas sector, nations also committed to emissions reductions in agriculture, and a major part of these emissions come from the livestock sector. Also, the reaffirmed commitment to keep average warming within 1.5°C will require a contribution from all sectors, including livestock. Hence, there is a new and tangible incentive to invest in emissions reductions in the sector that should liberate Climate Finance on that front, alone. Despite that, there were no new announcements of new major commitments or Climate Finance deals on mitigation in agriculture more broadly and certainly none directly aimed at the livestock value chain. Specifically, there was no tangible progress on the Koronivia Work Program for Agriculture, the dedicated UNFCCC forum to discuss agriculture issues.

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[9] FAO. Climate finance in the agriculture and land use sector – global and regional trends between 2000 and 2018. https://www.fao.org/3/cb6056en/cb6056en.pdf

6.1. Relevance of this work

Livestock, as the undisputed major contributor to climate change within the AFOLU space, offers the most substantial mitigation options in the agricultural space (others are rice cultivation, soil-carbon loss, and fertilizers), especially when considering land-use change impacts in addition to enteric fermentation and other production-related emissions. This project has established that the problem of attracting Climate Finance to the livestock sector is bi-directional: the reluctance of climate financiers to consider livestock as a viable investment destination, and the reluctance of actors in the sector to seek and accept Climate Finance.

A major part of solving this mismatch lies in the design of climate-finance offers, including practical, relatively inexpensive, accurate and proven MRV procedures. The case needs to be made for investments in the livestock sector that can be proved to have verifiable mitigation or adaptation effects. This project has demonstrated some of the ways forward for resolving some of these issues by drawing up blueprints in two pilot countries.

For Kenya, there is room to build on the evidence of incentives and TA to engage with local financial institutions and extend credit lines to farmers for climate-friendly modifications to their practices. At the same time, TA for farmers can be augmented to equip them better to understand the triple advantages of investing in climate-smart husbandry: mitigation, adaptation and human security through improved productivity. Calculations suggest that one possible pathway towards securing viable climate-finance options for farmers is through collaboration with IFC in the context of their support to local banks engagement in climate smart financing.

In Colombia, the World Bank's Advisory Services and Analytics (ASA)[10] are working with the Government to continue the work on the sustainability of supply chains in Orinoquía. Hacienda San José is using findings of this work to promote the climate dimension of their proposed expansion on the basis of climate investors. Meanwhile, the IFC is continuing to evaluate options for Climate Finance to the livestock sector in the country.

The Community of Purpose offers the opportunity to exchange experience, build stakeholder alignment and exchange practical options and solutions to climate finance implementation. Better integration of climate mitigation objectives in livestock operations supported by the WBG and others would benefit from collaboration with World Bank Group Climate Finance initiatives and programs (such as the CERF). Consultations with members of the CoP can ensure solutions are adapted to different needs and situations and are cost-effective, especially developed using digital tools and solutions. The CoP can help support MRV development and TA operations on the ground and assist with fine-tuning based on the experience of participants.

6.2. Next steps

This work has clarified obstacles and identified opportunities for the livestock sector's readiness to access climate finance. It has also contributed to building momentum and to designing practical implementation solutions and mechanisms.

[10] Developing climate smart agricultural supply chains: opportunities, challenges, and emerging lessons - P173540

Four strategic directions are being explored to continue this work:

(1) To deliver proof of concept for the livestock sector as a recipient of climate finance by utilizing the growing range of climate finance-related initiatives at WBG: (a) the growing number of Emissions Reduction Purchase Agreement (ERPAs) under the climate funds, (b) the forthcoming Climate Emissions Reduction Facility (CERF), (c) IFC green and sustainability loans, and (d) opportunities to access carbon markets (both voluntary carbon markets and markets under Article 6). As the current phase has demonstrated, these undertakings could benefit from expertise in livestock-specific MRV, support to the contextualization of mitigation investments in the sector for climate financiers and technical assistance in the implementation of interventions targeting the sub-sector. Activities would thus focus on these two areas.

(2) There is a need to address the question of consumption and growth of the sector more systematically by assessing how climate finance could more directly influence consumption patterns, with a view to reducing emissions from the broader animal protein sector.

(3) Developing a global communications and outreach strategy around climate-change mitigation in the livestock sector, defining its role in the transition to net zero in World Bank client countries.

(4) Extending support to three elements of the current phase:

a. Continued collaboration with IFC and national banks in Kenya for the operationalization of the credit line with mitigation conditionality in the dairy sector
b. Continued collaboration with IFC and HSJ in the assessment of climate benefits and the contribution to structuring of value chain expansion design in Orinoquia
c. The Community of Purpose should be supported as a unique venue for the exchange of information and solutions towards achieving the effective readiness of all livestock sector actors to access climate finance – and *vice versa*. The Bank would liaise with a UN or CGIAR partner for the co-facilitation of the CoP event.

Annex 1. Kenya Dairy credit line – Results of financial analysis for mitigation investments/projects

A financial analysis was performed to assess the financial viability of the mitigation projects. The sensitivity analysis evaluated the impact of modifying loans terms – interest rates, tenor and grace period - on the cash flow statements of each project. It helped evaluate the conditions that would allow projects to absorb market interest rates. The analysis tested how these parameters impact the debt-service coverage ratio (DSCR), the number of years when the cash balance of the project is negative and impact on the yearly debt service.

The results shows that the finance of the projects benefits more from increasing the loan tenors and grace periods than reducing the interest rates. The recommended loan terms are summarized in table A1. The recommended interest rates are close to the market rates. However, the team recommends modifying the repayment schedules to better match the profitability profile of the projects.

Table A1. Current market loan terms and proposed loan terms per mitigation project

PROJECT	LOAN AMOUNT (US$)	MARKET LOAN TERMS	RECOMMENDED LOAN TERMS
Biogas	1,166	Tenor: 2 years Interest rate: 20-30%	Straight-Line Amortization Tenor: 4 years Interest rate: 20% Grace period: 3 months
Zero-grazing unit	2,430	Tenor: 4 years Interest rate: 14%	Straight-Line Amortization Tenor: 4 years Interest rate: 13.95% Grace period: 1 year
Dairy cow	1,458	Tenor: 3 years Interest rate: 20-30%	Straight-Line Amortization Tenor: 4 years Interest rate: 20% Grace period: 1 year
Hay production	33,048	Tenor: 1 year Interest rate: 14-18%%	Straight-Line Amortization Tenor: 4 years Interest rate: 14% Grace period: 6 months
Hay storage and marketing	77,760	Tenor: 4-5 years Interest rate: 20%	Straight-Line Amortization Tenor: 6 years Interest rate: 20% Grace period: 6 months
Milk chilling	27,216	Tenor: 6 years Interest rate: 12-14% Grace period: 3 months	Balloon Payment Tenor: 6 years Interest rate: 12% Constant annual payment: US$2,000
Milk pasteurization	58,320	Tenor: 6 years Interest rate: 12-14% Grace period: 3 months	Balloon Payment Tenor: 6 years Interest rate: 12% Constant annual payment: US$6,000

The following sections present the result of the financial analysis for each project.

Biogas units

The sensitivity analysis for the biogas project (Table A4) shows that the project can absorb market interest rates (20%) if the tenor is increased from 2 to 4 years and a 3-months grace period is added. Table A2 and A3 provides additional details on the financial viability of the project with the recommended loan terms.

Table A2. Summary of financial analysis results for biogas projects

Capex (US$)	**1,166**
Average annual costs (US$/year)	165
Average annual revenues (US$/year)	690
Interest rate (%)	20%
Tenor (Years)	4
Grace period (Years)	0.25
Project IRR (%)	45%
Average DSCR (Ratio)	2.73
NPV (US$)	920.42
Payback period (Years)	2.22
Average profit margin (%)	76%

Table A3. Cash flow summary for biogas project

Year	0	1	2	3	4	5
Net Cash from Operations	-	525	525	525	525	525
Net Cash from investing activities	(1,166)	-	-	-	-	-
Net Cash from Financing Activities	1,166	(437)	(583)	(583)	(583)	(146)
Change in Cash Balance	-	87	(59)	(59)	(59)	379
Cumulative Cash Balance	-	87	29	(30)	(88)	291

Table A4. Sensitivity analysis

Tested interest rate	16%	18%	20%	22%	24%
Impact on the average DSCR (ratio)	2.88	2.80	2.73	2.67	2.60
Impact in number of years when cash balance <0 (years)	-	-	-	-	-
Impact on the average annual debt service (US$)	336	349	362	374	387
Tested tenor	**2**	**3**	**4**	**5**	**6**
Impact on the average DSCR (ratio)	2.25	2.50	2.73	2.94	3.14
Impact in number of years when cash balance <0 (years)	3	3	-	-	-
Impact on the average annual debt service (US$)	525	423	362	321	292
Tested grace period		**0.00**	**0.25**	**0.50**	**0.75**
Impact on the average DSCR (ratio)		1.23	2.73	2.01	1.81
Impact on number of years when the cash balance <0 (years)		1	-	-	-

Zero-grazing unit

The results of the financial analysis show that zero-grazing units projects can absorb tenor and market rates (4 years and 14% interest rates) if a 1-year grace period is added. Table A2 and A3 provides additional details on the financial viability of the project with the recommended loan terms.

Table A5. Summary of financial analysis for zero-grazing units

Capex (US$)	**2,430**
Average annual costs (US$/year)	2,546
Average annual revenues (US$/year)	3,594
Interest rate (%)	13.95%
Tenor (Years)	4
Grace period (Years)	1.00
Project IRR (%)	31.12%
Average DSCR (Ratio)	1.36
NPV (US$)	585.93
Payback period (Years)	3.53
Average profit margin (%)	29%

Table A6. Cash-flow statement for zero-grazing units

Year	0	1	2	3	4	5
Net Cash from Operations	-	(67)	1,014	1,005	997	988
Net Cash from Investing Activities	(2,430)	-	-	-	-	-
Net Cash from Financing Activities	2,430	-	(946)	(862)	(777)	(692)
Change in Cash Balance	-	(67)	67	144	220	296
Cumulative Cash Balance	-	(67)	0	144	364	660

Table A7. Sensitivity analysis for zero-grazing units

Tested interest rate	**10%**	**12%**	**14%**	**16%**	**18%**
Impact on the average DSCR (ratio)	1.46	1.41	1.36	1.32	1.28
Impact in number of years when cash balance <0 (years)	1	1	1	2	3
Impact on the average annual debt service (US$)	744	771	798	826	853
Tested tenor	**2**	**3**	**4**	**5**	**6**
Impact on the average DSCR (ratio)	0.75	1.07	1.36	1.69	2.00
Impact in number of years when cash balance <0 (years)	4	4	1	1	1
Impact on the average annual debt service (US$)	1,444	1,013	798	669	583
Tested grace period	**0.5**	**0.75**	**1.00**		
Impact on the average DSCR (ratio)	1.78	1.48	1.36		
Impact on number of years when the cash balance <0 (years)	4	4	1		

Improved dairy cow project

The study shows that the dairy cow projects can carry a 20% interest rate – which is the market rate level – if the tenor is increased from 3 to 4 years and a 1-year grace period is added. Table A1 and A9 provides more information about the financials of the project, while table A10 display the results of the sensitivity analysis.

Table A8. Summary of financial analysis for dairy cow projects

Capex (US$)	**1,458**
Average annual costs (US$/year)	2,383
Average annual revenues (US$/year)	4,694
Interest rate (%)	20%
Tenor (Years)	4
Grace period (Years)	1.00
Project IRR (%)	63.0%
Average DSCR (Ratio)	3.65
NPV (US$)	585.93
Payback period (Years)	2.06
Average profit margin (%)	49%

Table A9. Cash flow statement for dairy cow projects

Year	**0**	**1**	**2**	**3**	**4**	**5**
Net Cash from Operations	-	(387)	1,730	1,722	1,715	1,734
Net Cash from Investing Activities	(1,458)	-	-	-	-	-
Net Cash from Financing Activities	1,458	-	(656)	(583)	(510)	(437)
Change in Cash Balance	-	(387)	1,073	1,139	1,205	1,296
Cumulative Cash Balance	-	(387)	687	1,826	3,030	4,327

Table A10. Sensitivity analysis for dairy cow project

Tested interest rate	**16%**	**18%**	**20%**	**22%**	**24%**
Impact on the average DSCR (ratio)	3.86	3.75	3.64	3.54	3.45
Impact in number of years when cash balance <0 (years)	1	1	1	1	1
Impact on the average annual debt service (US$)	496	513	529	546	562
Tested tenor	2	3	4	5	6
Impact on the average DSCR (ratio)	2.04	2.88	3.64	2.26	2.90
Impact in number of years when cash balance <0 (years)	1	1	1	1	1
Impact on the average annual debt service (US$)	927	662	529	502	440
Tested grace period	0.5	0.75	1.00		
Impact on the average DSCR (ratio)	4.69	3.82	3.64		
Impact on number of years when the cash balance <0 (years)	1	1	1		

Hay production

The investment is consequent compared to the initial revenues of the project, although the project is highly profitable. Commercial banks propose a 1-year tenor which cannot be sustainable with such a principal to repay. We recommend increasing the tenor to 4 years with the addition of a 6-months grace period and to keep a market rate of 14%, in line with market offer.

Table A11. Summary of financial analysis for hay production projects

Capex (US$)	**33,048**
Average annual costs (US$/year)	16,574
Average annual revenues (US$/year)	29,597
Interest rate (%)	14.00%
Tenor (Years)	4
Grace period (Years)	0.50
Project IRR (%)	29%
Average DSCR (Ratio)	2.12
NPV (US$)	5,933.22
Payback period (Years)	3.43
Average profit margin (%)	44%

Table A12. Cash flow statement for hay production projects

Year	**0**	**1**	**2**	**3**	**4**	**5**
Net Cash from Operations	-	12,137	10,382	10,035	9,688	9,804
Net Cash from Investing Activities	(33,048)	-	-	-	-	-
Net Cash from Financing Activities	33,048	(8,758)	(12,310)	(11,154)	(9,997)	(4,709)
Change in Cash Balance	-	3,380	(1,928)	(1,119)	(309)	5,094
Cumulative Cash Balance	-	3,380	1,451	332	23	5,118

Table A13. Sensitivity analysis for hay production projects

Tested interest rate	**10%**	**12%**	**14%**	**16%**	**18%**
Impact on the average DSCR (ratio)	2.27	2.19	2.12	2.06	2.00
Impact in number of years when cash balance <0 (years)	-	-	-	2	3
Impact on the average annual debt service (US$)	7,998	8,275	8,553	8,830	9,108
Tested tenor	**2**	**3**	**4**	**5**	**6**
Impact on the average DSCR (ratio)	1.65	1.87	2.12	2.35	2.57
Impact in number of years when cash balance <0 (years)	4	3	-	-	-
Impact on the average annual debt service (US$)	13,175	10,286	8,553	7,397	6,572
Tested grace period	**0**	**0.25**	**0.50**	**0.75**	**1.00**
Impact on the average DSCR (ratio)	1.26	2.75	2.12	2.06	1.23
Impact on number of years when the cash balance <0 (years)	4	3	-	-	-

Hay storage and marketing

Similarly, hay storage and marketing can cope with market interest rates (20%) if the tenor is increased from 4-5 years to 6 years and a 6-month grace period is added to the loan terms.

Table A14. Summary of financial analysis for hay storage and marketing projects

Capex (US$)	**77,760**
Average annual costs (US$/year)	155,546
Average annual revenues (US$/year)	184,680
Interest rate (%)	20.00%
Tenor (Years)	6
Grace period (Years)	0.50
Project IRR (%)	27%
Average DSCR (Ratio)	2.20
NPV (US$)	21,218.79
Payback period (Years)	3.75
Average profit margin (%)	16%

Table A15. Cash flow statement for hay storage and marketing projects

Year	0	1	2	3	4	5	6	7
Net Cash from Operations	-	25,428	25,039	24,261	23,484	23,795	23,017	22,239
Net Cash from Investing Activities	(77,760)	-	-	-	-	-	-	-
Net Cash from Financing Activities	77,760	(22,032)	(27,216)	(24,624)	(22,032)	(19,440)	(16,848)	(7,776)
Change in Cash Balance	-	3,396	(2,177)	(363)	1,452	4,355	6,169	14,463
Cumulative Cash Balance	-	3,396	1,218	855	2,307	6,661	12,830	27,294

Table A16. Sensitivity analysis for hay storage and marketing projects

Tested interest rate	**16%**	**18%**	**20%**	**22%**	**24%**
Impact on the average DSCR (ratio)	2.33	2.26	2.20	2.14	2.08
Impact in number of years when cash balance <0 (years)	-	-	-	3	4
Impact on the average annual debt service (US$)	16,085	16,707	17,329	17,951	18,574
Tested tenor	**4**	**5**	**6**	**7**	**8**
Impact on the average DSCR (ratio)	1.81	2.01	2.20	2.37	2.54
Impact in number of years when cash balance <0 (years)	4	4	-	-	-
Impact on the average annual debt service (US$)	22,084	19,310	17,329	15,844	14,688
Tested grace period	**0**	**0.25**	**0.50**	**0.75**	**1.00**
Impact on the average DSCR (ratio)	1.52	2.85	2.20	2.01	1.54
Impact on number of years when the cash balance <0 (years)	4	2	-	-	-

Milk chilling

The profits from the project increase every year but do not allow the repayment of a straight-line amortization loan. The project has a high potential to become highly profitable, but the first years of the project face limited revenues and relatively high costs. We recommend a balloon repayment schedule that would better match the profitability profile of the project. We recommend a fixed repayment of $2,000 during the first 6 years of the project and a final repayment of $39,988 the seventh year. With such repayment schedule, the recommended terms match the market rates and tenors of 12% and 7 years.

Table A17. Summary of financial analysis for milk chilling projects

Capex (US$)	**27,216**
Average annual costs (US$/year)	68,810
Average annual revenues (US$/year)	
Interest rate (%)	12%
Tenor (Years)	7
Grace period (Years)	0.00
Project IRR (%)	43.56%
Average DSCR (Ratio)	4.82
NPV (US$)	9,339
Payback period (Years)	5.38
Payback period (Years)	58%

Table A18. Cash flow statement for milk chilling projects

Year	0	1	2	3	4	5	6	7
Net Cash from Operations	-	4,874	1,822	3,736	5,891	8,786	12,839	21,744
Net Cash from Investing Activities	(27,216)	-	-	-	-	-	-	-
Net Cash from Financing Activities	27,216	(2,000)	(2,000)	(2,000)	(2,000)	(2,000)	(2,000)	(39,988)
Change in Cash Balance	-	2,874	(178)	1,736	3,891	6,786	10,839	(18,244)
Cumulative Cash Balance	-	2,874	2,696	4,432	8,323	15,109	25,948	7,704

Milk pasteurization

As for the milk chilling project, milk pasteurization investments face an issue low profitability in the first years of the loan repayment. We also recommend a balloon repayment schedule with a constant annual repayment of $6,000 the first 5 years of the project and a final payment of $66,442. The interest rate and the tenor of 162% and 6 years are those currently offered by commercial banks.

Table A19. Summary of financial analysis for milk pasteurization projects

Capex	**58,320**
Average annual costs	442,589
Average annual revenues	651,346
Interest rate	12%
Tenor	6
Grace period	0.00
Project IRR	44.03%
Average DSCR	2.07
NPV	59,378.46
Payback period	5.15
Average profit margin	32%

Table A20. Cash for statement for milk pasteurization projects

Year	0	1	2	3	4	5	6
Net Cash from Operations	-	6,071	7,123	10,798	15,682	22,027	31,542
Net Cash from Investing Activities	(58,320)	-	-	-	-	-	-
Net Cash from Financing Activities	58,320	(6,000)	(6,000)	(6,000)	(6,000)	(6,000)	(66,422)
Change in Cash Balance	-	71	1,123	4,798	9,682	16,027	(34,880)
Cumulative Cash Balance	-	71	1,194	5,992	15,674	31,701	(3,179)

Annex 2. Additional figures on MRV conceptual framework

Figure A1. Overview of the emissions and removals associated with livestock intensification: direct/indirect emissions and removals, direct/indirect land use change.

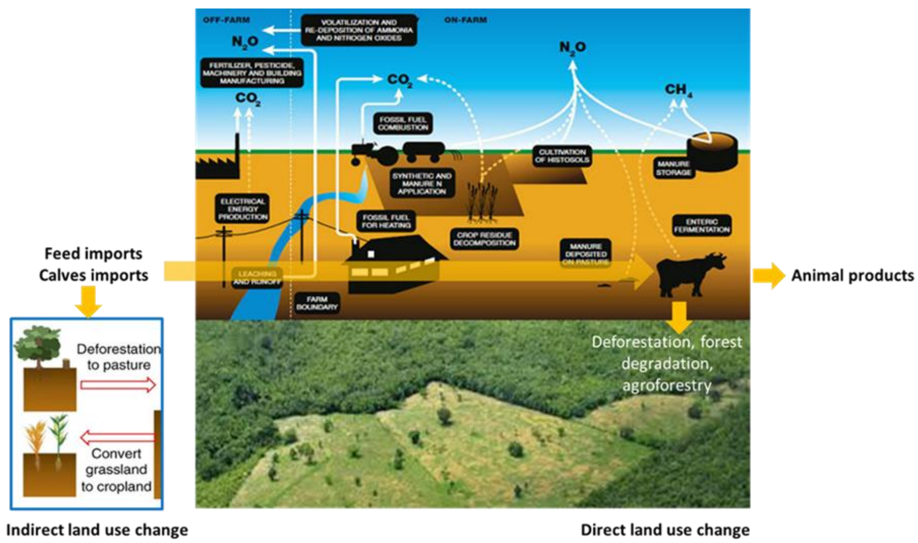

Figure A2. Summary of direct and indirect interactions between livestock and forests.

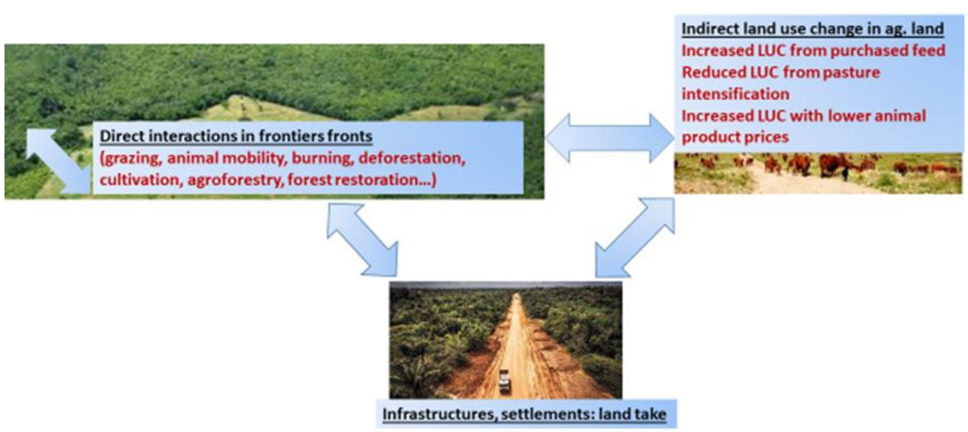

Figure A3. A climate finance project for the Brazilian Amazon discussed within a Brazil case and structured by interventions at both farm level and regional level, also addressing pressures on remote forests.

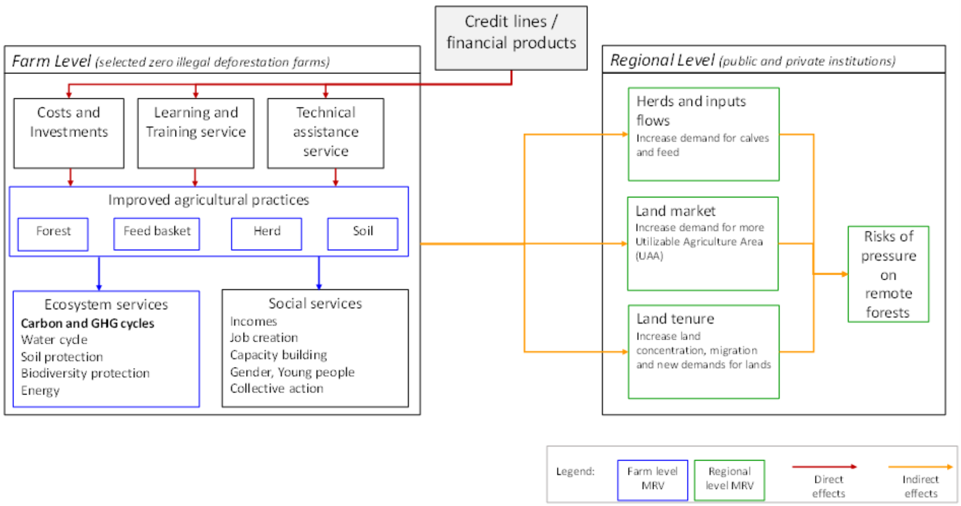

Table A21. Calculators classified according their main objective and geographical zone (Colomb et al., 2012).

OBJECTIVE OF THE USER		**CALCULATORS AND GEOGRAPHICAL ZONE OF APPLICATION**
Raising awareness		Carbon Calculator for New Zealand Agriculture and Horticulture (NZ), Cplan v0 (UK); Farming Enterprise GHG Calculator(AUS); US cropland GHG calculator (USA).
Reporting	Landscape tools	ALU (World); Climagri (FR), FullCam (AUS)
	Farm tools	Diaterre(FR); CALM (UK); CFF Carbon Calculator (UK);IFSC (USA)
Project evaluation	Focus on carbon credit schemes	Farmgas (AUS), Carbon Farming tool (NZ);Forest tools : TARAM (world), CO2 fix (world)
	Not focused on carbon credit schemes:	GLEAM-i (World);EX-ACT (World);US AID FCC (Developing countries), CBP (World), Holos(CAN), CAR livestock tools(USA)
Market and product-oriented tools		Cool farm tool (World); Diaterre (FR), LCA tools and associated database (SimaPro, ecoinvent, LCA food etc: mainly data for developed countries.)

AUS: Australia; CAN: Canada; FR: France, NZ: New Zealand; UK: United Kingdom; USA: United States of America; FullCam: calculator used by Australia for its national accounting. Only evaluates carbon fluxes, not N_2O or CH_4. High accuracy level obtained coupling extensive dataset and bio-physical process models.

Table A22. Examples of models used in National GHG Inventories to estimate Carbon dioxide emissions and removals from the cropland remaining cropland soils component (Tier 3 method).

Country	Model		Reference
Australia	The Full Carbon Accounting Model (FullCAM)	Estimates emissions from soil through a process involving all on-site carbon pools (living biomass, dead organic matter and soil) on a pixel by pixel (25m x 25m) level.	(Richards, 2001)
Canada	CENTURY	process model used for estimating CO2 emissions and removals as influenced by management activities, based on the National Soil Database of the Canadian Soil Information System	(W J Parton, Schimel, Cole, & Ojima, 1987; W J Parton, Stewart, & Cole, 1988)
Denmark	C-TOOL	3-pooled dynamic soil model parameterised and validated against long-term field experiments (100-150 years) conducted in Denmark, UK (Rothamsted) and Sweden and is “State-of-the-art”.	(Arezoo Taghizadeh-Toosi et al., 2014)
Finland	Yasso07 soil carbon model	The parameterisation of Yasso07 used in cropland was the one reported in (Tuomi, Rasinmäki, Repo, Vanhala, & Liski, 2011)	(Palosuo, Heikkinen, & Regina, 2015)
Japan	Soil Carbon RothC model	In order to apply the model to Japanese agricultural conditions, the model was tested against long-term experimental data sets in Japanese agricultural lands (Shirato & Taniyama, 2003)	(Coleman & Jenkinson, 1987)
Sweden	Soil Carbon model ICBM-region	Calculate annual C balance of the soil based on national agricultural crop yield and manure statistics, and uses allometric functions to estimate the annual C inputs to soil from crop residues	(Andrén & Kätterer, 2001)
Switzerland	Soil Carbon RothC model	The implementation of RothC in the Swiss GHG inventory is described in detail in (Wüst-Galley, Keel, & Leifeld, 2019)	(Coleman et al., 1997)
United Kingdom	CARBINE Soil Carbon Accounting model (CARBINE-SCA)	Simplified version of the ECOSSE model (J. Smith et al., 2010), coupled with a litter decomposition model derived from the ForClim-D model (Liski, Perruchoud, & Karjalainen, 2002; Perruchoud, Joos, Fischlin, Hajdas, & Bonani, 1999).	(Matthews et al., 2014)
United States	DAYCENT biogeochemical model	Utilizes the soil C modelling framework developed in the Century model (Metherell, Harding, Cole, & Parton, 1993; W J Parton, Ojima, Schimel, & Cole,	(Del Grosso & Parton, 2011; Del Grosso et al., 2001; W J Parton,

	1994; W J Parton et al., 1987, 1988), but has been refined to simulate dynamics at a daily time-step.	Hartman, Ojima, & Schimel, 1998)

Box A1. Tools for remote sensing of forests.

Forest cover change can be retrieved from online tools such as GlobalForestWatch (https://www.globalforestwatch.org), or from national projects (e.g. INPE in Brazil), showing in near real time and at high spatial resolution (30 to 100 m) deforestation and forest fires. These products can also be used to compare past and recent trends in these factors, including climate trends.

In order to convert from an area change to a carbon stock change, the carbon density of forest cover is also estimated, based on the colocation of aboveground live woody biomass density values with annual tree cover loss data. All of the aboveground carbon is considered to be "committed" emissions to the atmosphere upon clearing. Emissions are "gross" rather than "net" estimates, meaning that information about the fate of land after clearing, and its associated carbon value, is not incorporated. Further improvements should consider how to estimate changes in soil carbon after LUC (e.g. following IPCC guidelines) and how to account for residual woody biomass after deforestation.

However, small-scale forest disturbance (less than 50 m) caused by livestock, or by selective logging activities, would not be detected with these tools especially since the vegetation regrowth is often recovered very fast (within a few months). Moreover, many observations are too noisy to be used due to atmospheric issues (for instance smoke and aerosol effects can be intense during fires) and cloud coverage.

High spatial resolution images with a high temporal frequency (daily or weekly) are therefore very useful, especially for hot spots of livestock-forest interactions. In the future, it is very likely more innovative methods will rely on frequent (daily or weekly) and high resolution (3 to 10 m) sensors in the optical (Sentinel 2 and Planet Lab) and microwave domains (Sentinel 1) which can be analyzed with machine learning methods (in particular Deep Learning). A breakthrough can be noted through the use of very high spatial (3 m) and temporal (1 week) resolution data from the Planet Lab constellation of about 100 satellites (https://www.planet.com/). The breakthrough of these very high spatial resolution (VHR) images is that they offer the possibility to see almost all (not too small) trees and to access directly to their features (size of crown, location, etc.). Moreover, Deep Learning fits well to the analysis of these huge data sets, with relatively low optical quality (for instance because of a lack of atmospheric corrections).

Automated grazing cattle detection from modern high-resolution satellite sensors is achievable, but further work is needed for a large-scale deployment, especially by using different revisits of the same geolocation in order to distinguish cattle from static objects that resemble cattle, like bushes, rocks, and patches of sand. However, satellite detection of cattle is hardly possible when grazing occurs under tree cover (or in very tall grasses), or when the sky is cloudy or obscured by smoke. It is also not applicable with small ruminants (requiring UAV, unmanned aerial imagery). Deployment of such methods in hot spots for cattle-forest interactions, is likely to require tasked-based images with covered regions chosen on customer demand. Therefore, it will require investments.

Figure A4. Counting cows from Brazilian ranches through satellite images with 40cm or better resolution (after pansharpening), and with less than 20% cloud coverage. Left: Typical image with cattle. Center left: Crowded ranch.. Center right: There is likely a white cow in the middle, while the rest of the white blobs appear due to lack of vegetation. Image ©2020 Maxar Technologies. From: Laradji et al. (2020). Counting Cows: Tracking Illegal Cattle Ranching From High-Resolution Satellite Imagery. arXiv preprint arXiv:2011.07369.

Figure A5. High resolution remote sensing of forest-livestock interactions in Mato Grosso, combining synthetic aperture radar and optical images (www.globeo.net).