Climate change mitigation initiatives in beef production systems in tropical countries

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Key messages

- Cattle production in tropical countries is based on the use of extensive grazing systems, which are inefficient systems and generate low levels of profitability. Cattle production, thus, has high emissions per unit of output.
- Globally, beef from beef cattle systems emits more greenhouse gases per unit of output than any other agricultural product.
- Particular mixes of grass and leguminous forage species can significantly reduce methane (CH\(_4\)) emissions from manure patches and digestion.
- Implementation of silvopastoral systems, restoring degraded pastures, and integration of improved pastures are promising mechanisms that can increase productivity and reduce emissions for beef cattle production in Colombia. These actions could also be adopted as national mitigation actions.

Introduction

In Colombia, livestock production is one of the principal economic activities; it makes a major contribution to the development of the agricultural sector, accounting for approximately 75% of the agricultural land surface (Zuluaga, 2013). Cattle production is based mainly on the use of extensive grazing systems, which are usually inefficient and generate low levels of profitability. Given current pasture management, climate concerns, and low soil fertility, beef cattle production has the highest greenhouse gas (GHG) emission intensity of all agricultural production activities in Colombia.

GHG emissions are mainly in the form of methane (CH\(_4\)), which is a product of enteric fermentation and mineralization of manure from grazing animals; carbon dioxide (CO\(_2\)), a product of land use change; and nitrous oxide (N\(_2\)O), which comes from the nitrification and denitrification processes of soil nitrogen.

Mitigating GHG production represents a challenge to agriculture around the world. Great efforts have been made to develop emission reduction strategies, for example through appropriate pasture management (grazing intensity) to improve the compositional quality of pastures, and through designing practices that improve the physical and chemical conditions of soil. Both are key factors in the sustainability of the agricultural systems.

Beef cattle production accounts for 41% of total emissions in Colombia, while specialized dairy production accounts for 29% of emissions (FAO, 2013). Figure 1 shows GHG emissions in CO\(_2\)eq from the different species that make up the livestock production chain.

![Figure 1: Global estimate of greenhouse gas emissions per species in Colombia. Source: FAO, 2013.](image_url)

What are the emissions per kilogram of beef and liter of milk?

In Latin America, emissions from beef cattle production systems range between 11.0 and 42.6 kg CO\(_2\)eq/kg of live weight (Becoña et al., 2014; Dick et al., 2015; Siqueira and Duru, 2016). This is higher than emissions from dairy production systems, which range between 0.5
and 13.5 kg CO$_2$eq/kg ECM (Bartl et al., 2011; De Leis et al., 2015).

According to FAO (2013), beef production generates close to 300 kg CO$_2$eq/kg protein, followed by meat production from smaller ruminants (165 kg CO$_2$ eq/kg protein) and milk from small ruminants (112 kg CO$_2$eq/kg protein). Cow’s milk and products from poultry and swine have lower average emission intensity, below 100 kg CO$_2$eq/kg protein.

**Developments in the analysis of livestock production systems in Colombia**

Studies conducted by the International Center for Tropical Agriculture (CIAT), the National University of Colombia, and the Ministry of Agriculture and Rural Development (MADR) in dual-purpose farms from the Colombian departments of Casanare and Atlántico show that CH$_4$ emissions from manure patches are higher in systems using degraded pastures than in production systems using improved pastures and scattered trees (231 mg CH$_4$ kg$^{-1}$ grazing manure$^{-1}$ and 56.13 mg CH$_4$ kg$^{-1}$ grazing manure$^{-1}$, respectively).

Soils in degraded pastures show low-to-medium fertility, giving rise to low-quality forages with high amounts of fiber, negatively affecting the degradability of plant material in the rumen and causing increases in nutrient excretion and enteric CH$_4$ emissions. The low quality of degraded and/or native pastures negatively affects the assimilation of the nitrogen supplied in the diet; thus, the losses of nitrogen through urine and dung are higher. Urine nitrogen values obtained in this study were close to 67.1g N m$^{-2}$ in animals fed on degraded pastures and 20.72g m$^{-2}$ in animals fed on Megathyrsus maximus, found in improved pastures, which suggests that diets from degraded pastures do not provide a proper balance of protein and energy and thus lead to higher nutrient excretion through urine and dung.

A second experiment was conducted by CIAT scientists in the department of Meta, in the eastern region of Colombia, to evaluate the association of grass and leguminous forage species. In this experiment, a lower amount of nitrogen was found in the urine of animals fed on Brachiaria humidicola associated with Arachis pintoi (3.9 g N kg$^{-1}$), compared to that of animals fed only on Brachiaria humidicola (4.55g N kg$^{-1}$). This difference suggests that including leguminous species (in this case Arachis pintoi) in the diet of grazing animals supplies the necessary amount of protein to tap the energy provided by the grass species (Brachiaria), resulting in a protein-energy balance that allows tissues to retain a higher amount of nitrogen and make more efficient use of it.

**Searching for alternatives to reduce greenhouse gas emissions**

Although Latin America is a region with a high level of GHG emissions from livestock production, nearly 1.3 gigatons CO$_2$ eq (FAO, 2013), it is also a very promising region for advancing mitigation strategies due to its location in the tropics, which offers the advantages of diversity of climate, animal breeds, soils, and forages.

Some of the forage associations tested thus far show potential for being able to increase the production of beef without increasing N$_2$O and enteric CH$_4$ emissions. Enteric CH$_4$ emissions can be reduced by 15% per kg of consumed dry matter when including Leucaena leucocephala and by 25% in diets based on Cynodon plectostachyus (Molina et al., 2016). Moreover, the association of grass and leguminous species included in trials carried out in the department of Meta (Figure 2) and at CIAT Headquarters (Figure 3) showed lower CH$_4$ emissions from manure patches and from the ruminal fermentation process. In the case of the trial in the department of Meta, animals that grazed on Brachiaria humidicola associated with Arachis pintoi showed a 93.5% reduction of CH$_4$ emissions from manure patches, compared to animals grazing on a monoculture. (Fig 2).
In addition to CH\(_4\) and N\(_2\)O emissions resulting from enteric fermentation and deposition of urine and dung, livestock production is responsible for a major portion of emissions caused by land use change. Forest areas (which serve as large carbon sinks) are affected by the search of tracts of land to increase grazing areas and, thus, the number of cattle. Land use change for livestock production usually involves logging, loss of biodiversity, decrease of carbon sequestration rates, soil degradation, and, eventually, degradation of pastures.

Different studies reveal that Intensive Silvopastoral Systems (ISPS) are a strategy to increase the carrying capacity of the soil without expanding the grazing areas; they have a positive effect on biodiversity. Murgueitio et al. (2016) found that ISPS can increase animal load compared to an extensive grazing system from 200 to 1200 kg ha\(^{-1}\) year\(^{-1}\). In another study conducted by CIAT, the association of Brachiaria brizantha with Canavalia brasiliensis and Leucaena diversifolia (2000 plants ha\(^{-1}\)) showed higher weight gains in kg ha \(-1\) year \(-1\) (Figure 4).

What are the major constraints to beef cattle production with fewer emissions?

The adoption of silvopastoral systems within cattle production systems has been very low, mainly due to the costs of implementation and the time required establishing systems. Smallholders have more limitations, both biophysical and financial, to making the necessary changes to protect the environment. In this context, the impact expected from adoption of silvopastoral systems in the livestock production system depends not only on dissemination strategies, but also on government and international entities’ abilities to facilitate funding mechanisms. Most organizations present in rural areas that would disseminate such technologies are foundations and/or non-governmental organizations; they provide funding through development or research projects to recover a few hectares, but neither their replication nor their maintenance is guaranteed over time, especially after such projects are completed. Likewise, government must ensure technical support throughout the period of establishment of silvopastoral systems, as well as for their maintenance, in order to avoid farmers abandoning the system. Similarly, farmers must have access to markets for their products so that their investments receive a guaranteed return.
References


This brief is specifically focused on the progress made by the LivestockPlus Project. The LivestockPlus Project works in Costa Rica and Colombia to support the design and implementation of the Livestock NAMA. It is hoped that the concepts presented will facilitate the active participation of policymakers, donors, the private sector, and other actors within the process, who contribute to the design of agricultural NAMAs worldwide. This brief is based on the evaluations and consultations with stakeholders conducted in October, 2015.

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