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Assessing the carbon footprint of beef cattle in Brazil: a case study with 22 farms in the State of Mato Grosso

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ABSTRACT

In order to meet the predicted growth in world population and increasing demand for food, the offer of animal products, especially in developing countries will also have to increase. Cattle-farming for beef production is one of the most important agricultural activities in Brazil. The country has the major commercial herd in the world and has achieved the position of leading beef exporter. The Brazilian beef sector has been under constant pressure from the international community to reduce the greenhouse gas (GHG) emissions and meet international sustainability standards. There are few studies regarding the GHG emissions associated with the Brazilian cattle production. The aim of this study was to evaluate the main sources of GHG in beef cattle production in the State of Mato Grosso, Brazil. We evaluated 22 farms distributed throughout the state in the year of 2011, accounting for approximately 60,000 ha of pasture area. The results indicated that the largest source of GHG in extensive beef production comes directly from the animals (89–98%). From these, 67–79% are from enteric fermentation, followed by manure decomposition (20–33%). Fuel combustion for farm operations, use of agricultural inputs and electricity consumption where other evaluated sources. The carbon footprints of the farms with herd size limited to 2000 head ranged from 4.8 to 8.2 kg of CO_2eq per kg of live weight gain. For the farms with more than 2000 head, the carbon footprints ranged from 5.0 to 7.2 kg of CO_2eq per kg of live weight gain. This study contributed to identify the main sources of GHG in the extensive cattle production and indicate mitigation priorities in Brazil.

1. Introduction

Food security represents one of the main challenges for humanity to achieve. Given the predicted world population growth from 7.2 billion today to 9.6 billion in 2050, the demand for animal products is expected to grow by more than 70% from the levels of 2010 (Garnett, 2008; Foley, 2011; Gerber et al., 2013). Providing different food products such as meat, milk and eggs, livestock contributes to around 12.9% of calories and 27.9% of protein consumed globally (FAO, 2011).

Cattle farming for beef production is one of the most important agricultural activities in Brazil. In the last five years, the country has occupied the position of leading beef exporter with 1.5 million tons CWE in 2013 (ABIEC, 2013). The Brazilian herd is the largest commercial herd in the world, with approximately 211 million heads occupying 170 million hectares of pasture (IBGE, 2012), leading to an average occupation rate of 1.23 head/ha.

Today the cattle industry in Brazil is concentrated in North and Center-West regions. The biggest cattle herd of the country is distributed between Mato Grosso do Sul and north of Mato Grosso. The latest is today Brazil's leading beef producer state with approximately 29 million heads, representing 13.6% of the total national herd (IBGE, 2012). Continuous grazing in large pasture extensions is the main beef production system, where the herd is

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maintained almost exclusively on pasture with low use of external inputs.

Over the last decades, agriculture and livestock production have been associated with many global environmental issues, such as deforestation, climate change, water pollution and biodiversity loss (Foley et al., 2005; Butler et al., 2007; Tilman et al., 2011). The Brazilian beef sector has been under constant pressure from the international community to reduce the GHG emissions and meet international sustainability standards (Ruviaro et al., 2015).

In Brazil, the agricultural sector is responsible for 30% of national greenhouse gas (GHG) emissions, with livestock production contributing with more than 60% of emissions (MCTI, 2013). From these, the majority is caused by cattle enteric fermentation (methane), followed by urine and manure decomposition (nitrous oxide).

Despite contributing with a significant share of global GHG emissions, the livestock sector can also deliver a significant share of the necessary mitigation alternatives (Gerber et al., 2013). In recent years, Brazil has taken a key role in the mitigation of GHG emissions from the livestock sector, promoting a number of efforts to reduce the environmental impacts of the activity.

One example is the Low Carbon Emission Agriculture Program (ABC Program in Portuguese) promoted by the Government of Brazil that will invest about R$ 200 billion by 2020 in activities intended to mitigate GHG emissions. Few goals of the ABC Program are the recovery of up to 15M ha of cultivated pasture and the enhancement of agricultural systems promoting the integration of crop–livestock–forest. In addition, the ABC Program will increase investments for manure treatment and biogas production, giving to farmers an alternative way to obtain electricity and to offset GHG emissions from livestock activity.

Recently, Goldemberg et al. (2014) indicated that the technologies subsidized by the ABC Program would be enough to improve the carrying capacity expected for the livestock activity by 2020, while attending to the growing demand for food, fiber and energy, driving Brazil towards the consolidation of a low carbon emission economy.

However, there are few studies on the GHG intensity of extensive beef production in Brazil, especially with data collected directly from producers. Therefore, the main objective of this study was to evaluate the GHG emissions and main sources in the beef cattle production on a dataset of 22 extensive system farms in the State of Mato Grosso, Brazil.

2. Material and methods

The GHG emissions was estimated by multiplying annual (2011) activity data from 22 extensive beef cattle farms by specific emission factors provided by Intergovernmental Panel on Climate Change (IPCC) (IPCC, 2007). The chemical contributors to GHG emissions included carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4) related to agricultural practices, production and use of energy, animals and purchased products. The analysis is limited to environmental aspects, and not considers economic and social issues. All gases were expressed as CO_2e considering the global warming potential of each gas: CH_4, kg $\times$ 25 + N_2O, kg $\times$ 298 + CO_2, kg (IPCC, 2007).

2.1. System description

The study was carried out in the State of Mato Grosso, located in the Center West region of Brazil. We selected 22 extensive livestock farms, accounting for 78,950 head and 60,000 ha in 2011 (Fig. 1).

The farms were selected with the support of the largest cattle beef producer association in Mato Grosso. The set of 22 farms were subdivided into two groups (11 farms per group) according to herd size in 2011. Group 1 represents farms with herd size limited to 2000 head and Group 2 includes farms with more than 2000 head. Table 1 shows the location and the size of each farm in both groups.

The beef herd was comprised of non-dairy cows and bulls (both weighing more than 230 kg) and their progeny (young herd limited to 230 kg live weight) (MCT, 2010). Table 2 presents the herd composition of each farm in 2011 and the range of animal weight considered in this assessment.

GHG emissions were obtained over a 365 days period, which represents a typical year from a three-year beef cattle production system. Thus, the results presented in this study represent a typical cycle of animal production in the Center West region of Brazil. We assumed that calves are weaned at approximately 210 days and from this period onwards, the animal grazes on grass until the slaughter at the end of the third year (530 kg live weight, in average).

Additional inputs, in annual basis, included fertilizers (N, P and K), lime and pesticides applied to pasture, mineral salt for animal supplementation, fuel for agricultural practices and electricity (Table 3).

The extensive beef production system considered in this study also represents the traditional Brazilian pastoral system, where the animals are able to continuously graze on the natural pasture throughout the year with little mineral supplementation. Carcass yield was assumed to be 53% of total carcass weight.

2.2. System boundary and functional units

The system boundary was defined by the GHG emissions associated with beef cattle production in Brazilian farms from “cradle to farm-gate” (Fig. 2).

Direct GHG emissions included those GHG emissions associated with enteric fermentation, direct deposition of excreta by grazing animals, lime and fertilizer application and on-farm fuels consumption.

Indirect GHG emissions through on-farm included electricity use and fugitive N_2O production resulting from N-leached and ammonia (NH_3) volatilization of N-fertilizers. Upstream GHG emissions associated with the production and transport of fertilizers, lime, pesticides, mineral supplement and fuels were also included.

The functional unit chosen was 1.0 kg of live weight (LW) produced, which is the weight of the animal at the farm gate. Nevertheless, the average result was also expressed in carcass weight basis, in order to make comparisons with other studies.

2.3. Calculation of GHG emissions

The GHG emissions calculations were individually made for the 22 farms included in the study, considering the main emission sources and the input data reported by each producer. Equations and assumptions used for the estimation of emissions are summarized in Table 4.

2.3.1. GHG emissions related to cattle herd

We calculated enteric methane emissions according to the “2006 IPCC Guidelines for National Greenhouse Gas Inventories” (IPCC, 2006) equations and considered specific data on composition of cattle herd (non-dairy cows, bulls and young herd) as live weight and livestock units per year. Tier 2 protocols from IPCC guidelines were adjusted accordingly to MCT (2010) to calculate the enteric emissions due to the importance of methane emissions to the overall GHG emissions in beef cattle production.

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