Food and Agriculture Organization of the United Nations

LOW EMISSIONS DEVELOPMENT OF THE BEEF CATTLE SECTOR IN URUGUAY

Reducing enteric methane for food security and livelihoods

NEW ZEALAND AGRICULTURAL GREENHOUSE GAS Research Centre

CLIMATE & CLEAN AIR COALITION TO REDUCE SHORT-LIVED CLIMATE POLLUTANTS

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Executive summary

Uruguay's Intended Nationally Determined Contribution (INDC) sets its long-term climate change agenda. With its INDC, Uruguay has made a clear commitment to adopt a low-carbon growth agenda by setting ambitious targets that address both climate change mitigation and adaptation.

Uruguay has a unique greenhouse gas (GHG) emissions profile; the agriculture sector contributes about 75% to the country's total GHG emissions. Methane (CH_4) from enteric fermentation contributes more than half of the total agriculture sector emissions. Beef production is a key part of Uruguay's economy and a major source of export earnings. It also produces over half the country's GHG emissions. Considering the beef cattle sector's contribution to national emissions, Uruguay has set a specific target for the sector of reducing enteric CH_4 emission intensity per kilogram of beef live-weight by 33% in 2030 with domestic resources through the widespread application of improved practices and technologies[1].

This study is intended to contribute to the implementation of this climate change agenda. The study evaluates the potential for improving productivity while reducing enteric methane emission intensity from beef production in Uruguay. The overall objective of this study is to support Uruguay in identifying low-cost strategies to reduce enteric CH_4 emissions while contributing to Uruguay's short-and long-term social and economic development and increasing resilience to climate change.

Benefits of moving to a sustainable and low-carbon beef sector

Like many other economies in transition, Uruguay faces the dual challenge of promoting development and reducing GHG emissions. In its climate change agenda, Uruguay affirms that efforts to mitigate GHG emissions should not be at the cost of food security or add to the cost of development. At the same time, Uruguay recognizes that there are strong reasons to shift toward a low-carbon economy. In recognition of the need for future growth, Uruguay is one of the few countries that has adopted an emission intensity indicator. Reducing enteric CH_4 is critical in Uruguay, not only to address climate change but also to facilitate economic development, a key emphasis of the country's climate change agenda.

Moving towards a sustainable and low-carbon beef sector could benefit Uruguay in several ways:

- Cattle production remains is one of the most important economic sectors and important source of export earnings in Uruguay. Beef production is a very important sub-sector with about 42,500 beef producers managing about 11.5 million head of cattle. The Ministry of Livestock, Agriculture and Fisheries (MGAP), estimates the value of output from the beef cattle sector at almost US$ 2 billion, 4% of the national gross domestic product (GDP). In 2014, beef exports accounted for about 16% and 22% of the total value of Uruguayan exports and value of agricultural exports, respectively.
- With an economy highly dependent on agriculture, Uruguay is likely to suffer disproportionately from the impacts of climate change. Uruguay has a long traditional history of raising cattle on grasslands, with beef producers operating within a high degree of climatic variability, driven largely by periods of severe drought or flood therefore Uruguay has a strong interest in addressing climate change. In recent years, farmers have been affected by increased climatic variability, reflected in periods of excessive precipitation and flooding and more intensive and frequent drought. Severe

[1] Additional targets are also made for nitrous oxide emissions from manure: a reduction of N_2O emission intensity per kg of beef live-weight by 31%.

and repeated droughts and floods have had a strong negative impact on production, events, significant economic impacts, especially affecting the livelihoods of farmers. For example, the drought of 2008-09, the value of direct and indirect economic losses to the beef cattle sector were estimated between US$ 0.75 billion and US$ 1.0 billion.[2]

- Numerous "no-regret" interventions (interventions that have positive economic returns and can be undertaken irrespective of climate change considerations) can contribute substantially to farm incomes and economic development, an incentive for beef producers to adopt productivity-enhancing technologies.
- In addition to income generation and employment for rural communities, many of these measures bring additional environmental co-benefits, such as soil carbon sequestration, soil conservation, water quality, and ecosystem preservation, as well as income generation and employment for rural communities.
- Countries such as Uruguay that pursue low-carbon development are more likely to benefit from strategic and competitive advantages, such as the transfer of financial resources through the carbon market, new international financing instruments, and access to existing and emerging global markets for their low carbon products. Uruguay exports about 70% of its beef production, and its position in the global market has been enhanced by a number of factors such as it sanitary and disease status and national mandatory traceability system. In the future, lowering the emission intensity of beef may create additional competitive advantage for the Uruguayan beef sector.
- Considering the importance of the livestock enterprise to rural livelihoods and its potential role in poverty reduction, implementing a low-carbon development strategy for the beef sector through the adoption of performance-enhancing technologies is expected to significantly increase yields with net benefits in the short and medium term exceeding the costs associated with their adoption. There is evidence of a large productivity gap both within and between systems. Average productivity per hectare (kg live-weight/hectare) is lowest in cow-calf systems (83 kg live-weight/ha) and highest in fattening on improved pastures (341 kg live-weight/ha). Within the same system, the productivity gap is large; 141%, 116% and 128% for cow-calf and the two complete cycle systems, respectively. These performance-enhancing technologies would also increase farmers' resilience to climate variability and change.

Emissions and emission intensity from beef production systems in Uruguay

Cattle production in Uruguay can be categorized under three different production systems: (i) breeding systems, commonly referred to as cow-calf; (ii) complete cycle systems; and (iii) fattening systems[3].

The beef production cycle in Uruguay can be divided into breeding and rearing/growing and finishing activities. Farms can specialize in breeding of calves, finishing (fattening) or both (complete cycle farms).

This study found that in 2014, the beef cattle sector in Uruguay emitted 39.2 million tonnes carbon dioxide equivalent (CO_2 eq.). Within this, enteric methane represents about 56% of the total GHG emissions from beef production, equivalent to 21.8 million tonnes CO_2 eq. Emissions associated with deposition of manure on pasture contributes an additional 12 million tonnes CO_2 eq., 30% of the total GHG emissions.

The pasture-based systems (cow-calf and complete cycle systems) are responsible for 88% of the total GHG emissions associated with the production of beef. These two systems also account for 89% of the total enteric CH_4 emissions; 60% and 29% from cow-calf and complete cycle systems, respectively. Rearing and finishing on natural pastures, on improved pasture and finishing in feedlots contribute 6%, 3.5% and 1.8% of the enteric CH_4, respectively.

The results indicate that the emission intensity of beef in Uruguay is on average 33.1 Kg CO_2 eq./kg LW produced. The cow-calf and complete cycle 1 and

[2] World Bank (2013). NDVI Pasture index-based insurance for Livestock Producers in Uruguay.

[3] See section 3 for a detailed system description.

2 systems were found to have the highest emission intensities: 41, 35.3, and 24.8 Kg CO_2 eq./kg LW produced, respectively. The lowest carbon footprint is achieved for the fattening phase where animals are reared and finished on natural pastures (8.6 Kg CO_2 eq./kg LW) and reared and finished on improved pastures (7.9 Kg CO_2 eq./kg LW).

Options for improving productivity and enteric methane mitigation, by system

Improving animal productivity is one of the key pathways to reduce enteric CH_4 emissions per unit of product. Reducing enteric CH_4 via increasing productivity can have a monetary value; several activities that reduce methane emissions have low or negative economic cost when the value of the gains in output (in product) is considered.

Research in Uruguay and elsewhere has already identified several technologies that if comprehensively applied throughout the sector would make a rapid and important contribution to improving the technical performance and profitability of beef production while reducing GHG emissions. Improved practices and technologies such as better pasture management, strategic supplementary feeding, and substitution of high fiber forages, adequate animal health control, and genetic improvement of animals are some of the techniques that can improve livestock productivity and reduce emission intensity.

This assessment evaluated interventions for three main beef production systems: cow-calf, complete cycle and fattening beef productions systems. The following criteria were used to select interventions:

- Interventions had to have potential for improving productivity while at the same time reducing enteric CH_4 emissions per unit of output.
- Interventions had to be feasible in the short or medium term. Feasibility was first determined by sectoral experts and selected interventions had to have already been implemented or in use at least at farm level in Uruguay or in countries with similar conditions and production.

A team of national experts identified key areas to address low-productivity in beef systems including: (i) better management of existing forage resources by matching available forage resources to animal requirements; (ii) use of improved pastures through introduction of legumes, cultivation of forage crops; (iii) strategic feeding and supplementation to address the constraints of seasonality; (iv) genetic improvement and animal health interventions.

Significant gains in production reduction potential in emission intensity can be realized: 23% - 42% reduction in emission intensity and an 80% increase in beef production

Implementing the individual interventions that meet the criteria outlined for inclusion would reduce enteric CH_4 intensity by between 5.6% and 51.4% (CH_4/kg live weight), depending on the intervention and production system. These emissions reduction potentials can be considered conservative, in that the analysis did not assume any major changes in technology or change in production systems but focused on reducing the efficiency gap between producers in the same production system.

More significant reductions in emissions can be achieved through the combination of herd and health management, nutrition and feeding management strategies, and genetics. This study estimates a reduction potential of 23%-42% in emission intensity and an increase in production (expressed in live-weight terms) of 80% compared to the baseline situation.

Prioritization of interventions for enteric methane

From the analysis, it is clear that the assessed technologies not only yield mitigation benefits but also provide production benefits and higher benefit-cost ratio and additional unquantified benefits such as carbon sequestration benefits from better management of grazing land, reduced use of inputs such as fertilizer, etc. A preliminary ranking of interventions per production systems to identify those with high reduction potential, increased production and high economic return was undertaken to provide an indication of what is workable. For example, in cow-calf systems, increasing forage allowance, cross-breed-

ing (heterosis) and artificial insemination have been identified as main interventions. This initial prioritization will need further refrainment using additional criteria.

Elements of a low-carbon development strategy for the beef sector

Several high priority interventions in the beef sector have the potential to mitigate GHG emissions. These technologies have either already been developed or are being adopted by farmers, indicating that there is no lack of productivity-enhancing technologies.

The fact that many of these interventions have not already been adopted on large-scale suggests that there are barriers to implementation. To establish support for greater implementation there is a need to begin with measures that have positive economic returns for farmers while having positive social and environmental co-benefits.

Since, technologies are highly location specific, technology targeting in terms of ecological and socio-economic conditions of farmers is important in order to achieve maximum mitigation potential. To do this, there will be a need for local experimentation to gain experience on the ground and to better understand the role of policy and new investment mechanisms.

CHAPTER 1

A national commitment to low carbon development of the beef cattle sector

Uruguay demonstrated early commitment to action on climate change. Today, Uruguay remains strongly committed to voluntary action to reduce greenhouse gas (GHG) emissions. It is among the 160 countries that have submitted their Intended Nationally Determined Contributions (INDC) to the United Nations Framework Convention on Climate Change (UNFCCC). INDCs are the primary means by which governments can state what steps they will take in the context of their national priorities, circumstances and capabilities to address climate change.

Under the banner of the low-carbon growth, the government of Uruguay has shown political commitment by setting ambitious targets for climate mitigation and adaptation. In addition, in recognition of the need for future growth of its economy, Uruguay is one of the few countries that have adopted an emission intensity indicator.

Uruguay has a unique GHG emissions profile. The agriculture sector contributes about 75% to the country's total GHG emissions. Beef production accounts for 78% of domestic CH_4 emissions (largely due to enteric fermentation) and 61% of domestic N_2O emissions (due to manure deposited on pasture by grazing animals). In consideration of the beef cattle sector's contribution to national emissions, Uruguay has set-forth specific targets for the beef sector; these seek to reduce enteric CH_4 emission intensity per kilogram of beef live-weight by 33%-46% by 2030 through the application of improved technologies and practices (Table 1.1).

The adoption of improved technologies and practices to mitigate emissions provides opportunities for sustainable intensification consistent with food security and development goals, thus enhancing development with considerations of environmental, social, and economic issues. At the same time, it is important to recognize that Uruguay is likely to be significantly impacted by climate change and adaptation solutions are needed to reduce its vulnerability.

This report presents the findings and recommendations from an initial assessment of the beef cattle sector of Uruguay. It is undertaken as part of a project funded by Climate and Clean Air Coalition (CCAC), the New Zealand Government and Food and Agriculture Organization of the United Nations in collaboration with the Ministry of Livestock, Agriculture and Fisheries, Uruguay (MGAP) and experts and stakeholders from national institutions.

The primary focus of this assessment is to respond to the first part of this initiative; identification and prioritization of interventions to reduce enteric methane emission intensity from ruminant

Table 1.1: Uruguay's national mitigation targets for the beef sector

GHG	Sector	2030 Targets - % emission reduction targets from base year 1990	
		With domestic resources	With additional means of implementation
Methane	Beef production: accounts for 78% of CH_4 emissions	Reduce emissions intensity per kilo of beef (live-weight) by 33%	Reduce emissions intensity per kilo of beef (live-weight) by 46%
Nitrous oxide	Beef production: accounts for 61% of N_2O emissions	Reduce emissions intensity per kilo of beef (live-weight) by 31%	Reduce emissions intensity per kilo of beef (live-weight) by 41%

Source: http://www4.unfccc.int/submissions/INDC/

systems. To that end, this report examines Uruguay's beef cattle sector to assess the scale of enteric methane emissions, and identify cost-effective interventions through which methane can potentially be reduced. This analysis is meant to inform where reductions can be made and to systematically explore emission reduction opportunities with the objective of translating emission savings into benefits for producers.

CHAPTER 2

Objectives and approach

This study seeks to identify and evaluate low-cost options that Uruguay can implement in the short-to-medium term geared towards improving productivity in beef production systems, reducing enteric methane emissions and fostering economic development.

Three main methodological steps were employed in this study (Figure 2.1):

1) Definition of the baseline scenario. Including the selection and characterization of production system, estimation of GHG emissions and emission intensity, and identification of key drivers of low productivity and emission intensity.

2) Explore the mitigation potential. Identification of system specific interventions consistent with development objectives for improving productivity, addressing enteric methane emissions and assessment of the mitigation potential.

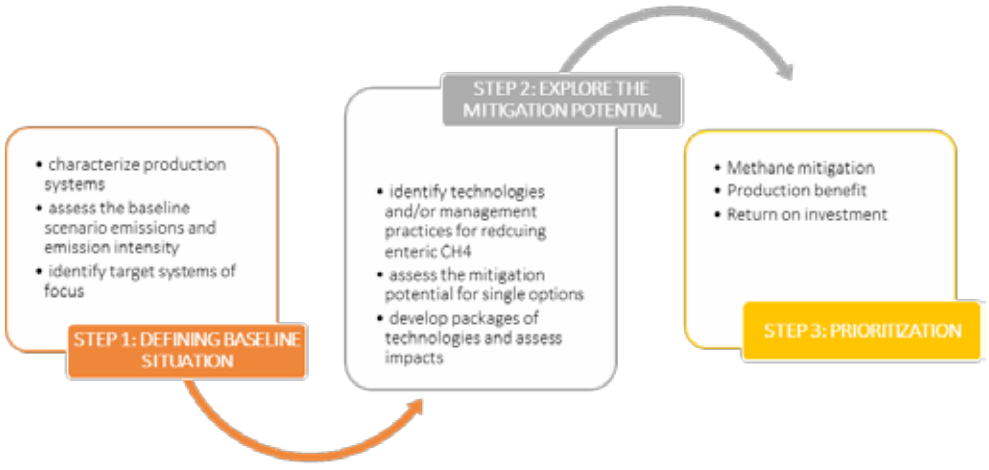
3) Prioritization of interventions. Prioritization of interventions is undertaken by drawing on modeling results and cost-benefit analysis. Three criteria - methane abatement, the impact on production and profitability for farmers - are used in the prioritization of interventions.

A key focus of this work is on interventions that reduce emission intensity while maintaining or increasing production such that climate change and productivity improvement can be pursued simultaneously (Box 1).

The analysis focuses on the beef cattle sector, a strategic sector of importance to Uruguay that was jointly identified in consultation with front-line government ministries e.g. ministry of livestock, environment, academia institutions, and public and private stakeholders.

The study undertakes biophysical modeling and scenario analysis using the Global Livestock Environmental Assessment Model (GLEAM) to provide a broad perspective of opportunities and the potential achievable goals in terms of productivity gains and emission intensity reduction in the beef sector (Box 2).

Figure 2.1: Process framework for the identification and prioritization of interventions to address enteric methane



Box 1: Absolute emissions versus emission intensity

The primary drivers of enteric methane emissions are feed intake, and fermentation characteristics of that feed in the rumen. In general, management practices that increase the proportion of feed used to produce meat or milk rather than maintain the animal, reduce the amount of methane per unit of animal product produced (emissions intensity).

Higher individual animal productivity generates more animal product and more methane per animal but as a smaller proportion of the feed consumed is used to maintain the animal, emissions intensity is reduced. The same amount of animal product can be produced with fewer methane emissions if producers keep fewer animals. More intensive production provides flexibility to control emissions and generally improves profitability. However, increasing feed intake per animal will always lead to an increase in total farm methane production unless the total number of animals is reduced. In low and medium income countries, the concept of emission intensity remains the most attractive mitigation route because it allows for the harnessing of synergies between food security and development objectives and climate change mitigation goal. Emissions intensity reductions will reduce absolute emissions below business-as-usual.

Box 2: Modelling GHG emissions from beef production systems in Uruguay

In this study, the Global Livestock Environmental Assessment Model (GLEAM; Gerber *et al*. 2013) is the main analytical tool used to assess the emissions and emission intensities in the baseline scenario and to assess the emission reduction potentials of selected interventions.

GLEAM is a spatial model of livestock production systems that represents the biophysical relationships between livestock populations (FAO, 2007, 2011a), production, and feed inputs (including the relative contribution of feed types—forages, crop residues, and concentrates—to animal diets) for each livestock species, country, and production system. The production parameters and data in GLEAM have been drawn from an exhaustive review of the literature and validated through consultation with experts during several joint projects and workshops. The relationships between GHG emissions and production have also been cross validated for ruminants across a range of regions and studies, and published reports on GLEAM have also been through rigorous peer review (Opio *et al*. 2013; Gerber *et al*. 2013). GLEAM works at a definition level of 1 km2, the spatially explicit GLEAM model framework allows the incorporation of heterogeneity in emissions, emission reductions and production responses.

The model was further developed to meet the needs of this study. The beef production systems in GLEAM were further refined to reflect the specificities of the beef systems in Uruguay and the database of production systems parameters was updated with more recent and system specific information and data on populations, performance parameters, feeding systems, manure management, etc. taken from national databases.

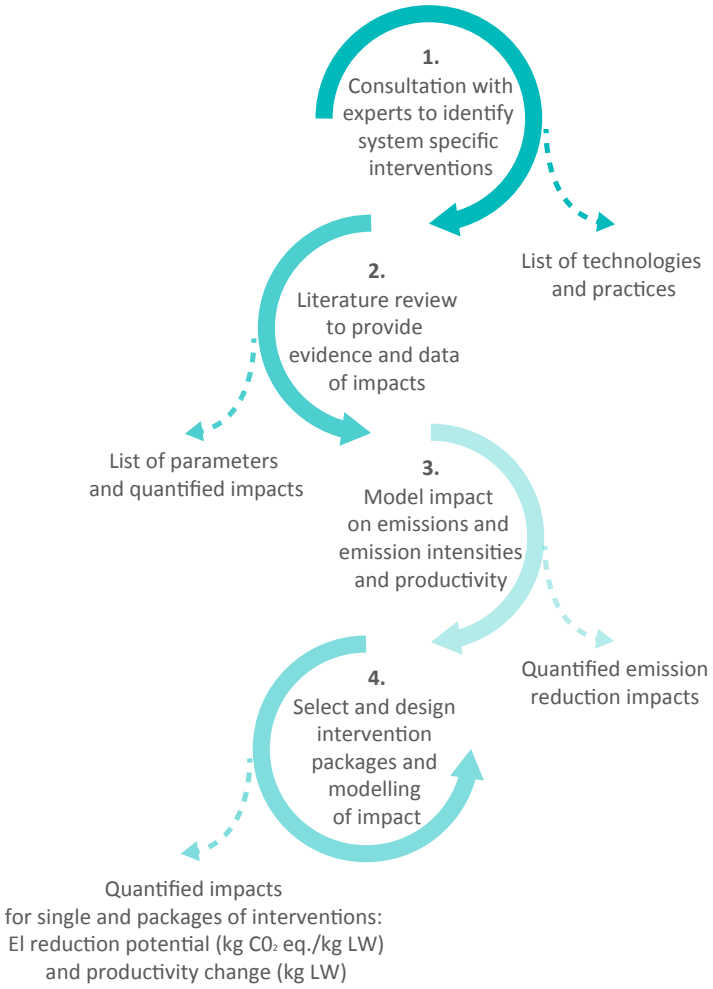
The GLEAM framework is used to characterize the baseline production and GHG emission output of the beef production systems. Emissions and emission intensities are reported as CO_2 eq. emissions, based on 100-year global warming potential (GWP100) conversions factors; methane = 34, nitrous oxide = 298.

The abatement potentials for each practice were calculated by estimating the changes from the baseline GHG emissions, following the application of each system specific intervention. To specify each abatement practice within GLEAM, it was necessary to incorporate additional data and information on the impacts associated with the application of the interventions. These data were obtained from a range of literature sources and databases as elaborated in the supplementary information.

The calculations are performed twice, first for the baseline scenario and then for the mitigation scenario. Emission intensity reductions and changes in productivity achieved can then be compared to those under baseline scenario.

Source: http://www.fao.org/gleam/en/

Figure 2.2: Process for exploring mitigation impacts



The scenario analysis uses the outputs of the bio-physical analysis combined with information taken from published literature, existing studies and expert knowledge on potential impacts of each intervention on herd performance and production to quantify the emission intensity reduction potential.

The range of options evaluated (referred to as "interventions") were selected by national sector experts based on their potential for methane emission intensity reductions, their impact on yield and their feasibility in terms of political, social, institutional, and other preconditions. The interventions identified are presented individually and with a subset evaluated as a 'package', in order to demonstrate to stakeholders how a combination of interventions would impact reduction potential and productivity gains. It also gives the ability to assess this flexibly within the framework of political conditions, available resources, and other considerations. Figure 2.2 presents the generic steps undertaken in the identification of interventions and assessment of their impacts on enteric methane emissions and production.

For purposes of prioritization of interventions, the assessment considered three aspects: the emission reduction potential, the production impacts and the profitability for farmers assessed by quantifying the return to farmers per dollar invested. The impacts on enteric methane emissions and production were assessed using the GLEAM model described above.

The cost-benefit analysis of selected interventions to assess the profitability for farmers were quantified using typical farm input and output costs provided by local experts and are presented as a ratio of the $ returned per $ invested. The purpose of the cost benefit analysis is to guide decisions on which interventions would be profitable for farmers.

CHAPTER 3

Overview of beef production in Uruguay

Cattle production in Uruguay is an important economic sector; the value of output from the sector is estimated at about US$ 2 billion – about 50% of the agricultural output (MGAP-OPYPA, 2016). In 2013, the beef sector contributed about 16% of total value of exports and 22% of total value of agricultural exports (MGAP, 2014).

Uruguay is a traditional producer of beef, producing mostly grass-fed cattle, although a small proportion of the animals are finished on a grain-based diet. According to official statistics, in 2011, livestock production occupied 14.8 million hectares of the 16.4 million hectares of private land in Uruguay. Its beef cattle herd is composed of 10.8 million head (DICOSE, 2014). British breeds predominate; Hereford (70%), due to its beef traits and excellent adaptation to the environment followed by Aberdeen Angus (6%), crossbreeds of both breeds (13%) and other (11%). The number of animals slaughtered annually has stabilized around 2 - 2.1 million for the last seven years. Cattle farms in Uruguay are market-oriented; about 98% of marketed animals go to officially inspected facilities for processing. About 70 percent of the beef produced in Uruguay is exported; currently exporting 5% of world's total volume of traded beef (FAOSTAT, 2016).

Uruguay also has a well-developed animal health and veterinary services systems. It is one of the first developing countries in the world to develop and to implement a national computerized animal registration and traceability database as part of its livestock epidemic disease management and control systems.

Major production zones in Uruguay

Beef production in Uruguay is diverse and takes place across a wide array of economic, production, socio-demographic, geographic, and environmental circumstances —Such things as size of operation, production technologies and practices in use, climate conditions, soil fertility, and location-specific environmental factors vary considerably. This diversity can and will affect where and when farmers choose to adopt technologies and practices that improve productivity and mitigate enteric methane (and other GHG) emissions.

Agricultural production regions in Uruguay can be grouped into agro-ecological zones with different patterns in terms of natural resources and technology applied, among others. Based on these criteria and following the classification established by (Ferreira, 2001), the country can be divided into seven agro-ecological regions as shown in Figure 3.1. Beef cattle production is distributed throughout Uruguay across the 7 agro-ecological zones (Figure 3.2). Figure 3.2 shows the distribution of production systems and pasture resources in Uruguay. Almost 70% of the cattle herd and about 72 percent of the natural pasture resources are found in three zones: Basalto, Cristalino and Lomadas del Este and Areniscas.

Of the 51,800 farms in Uruguay, about 42,565 farms are cattle farms, managing 14.8 million hectares with 10.8 million bovine heads. Farm size and animal numbers per farm are not evenly distributed. There are 35,046 farms smaller than 500 ha, (82%), 4,000 (9%) between 500 and 1,000 ha and 3,519 farms (8%) larger than 1,000 ha (Figure 3.3). Beef herd sizes are highly skewed towards the smaller farms. Figure 3.3 shows that while small farms make up the majority of the farms they have a relatively small proportion of the total herd (about 30%). At the other extreme the 8% of the farms that are larger than 1,000 hectares own almost 50% of the beef cattle herd.

Classifying beef production activities in Uruguay

Cattle production in Uruguay takes place under three different production systems: (i) breeding systems, commonly referred to as cow-calf; (ii) complete cycle

Figure 3.1: Main eco-regions of Uruguay

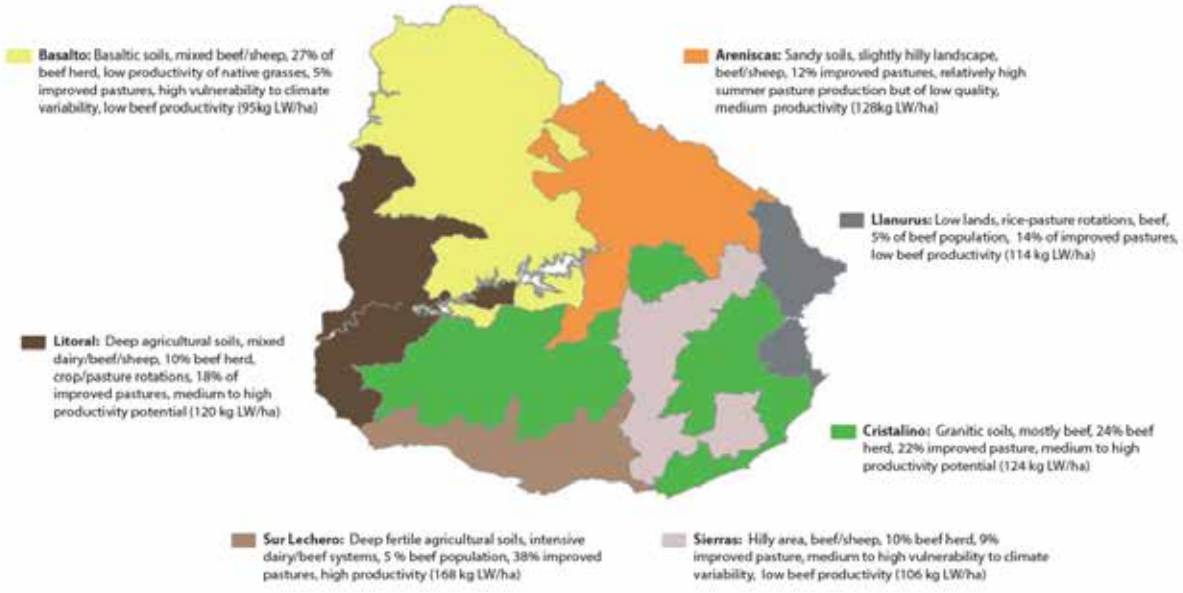
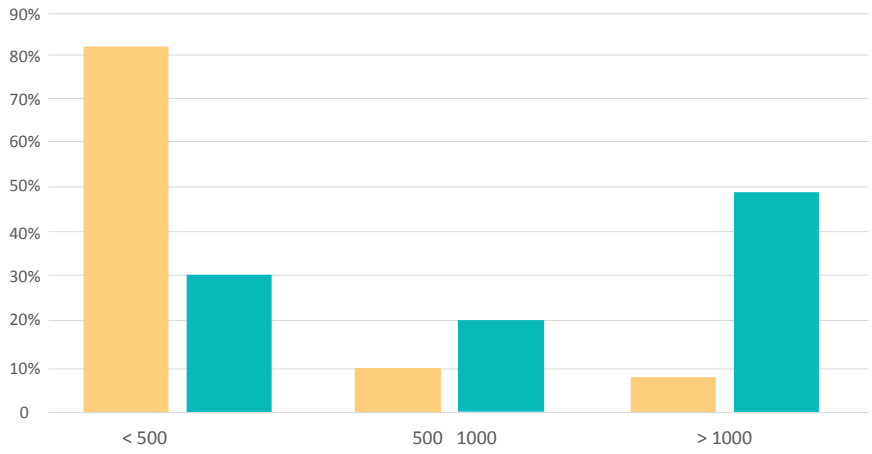


Figure 3.2: Distribution of beef cattle herd, production systems and pasture resources

	SHARE OF ANIMALS BY PRODUCTION SYSTEM					SHARE OF GRASSLAND		
	NUMBER OF CATTLE FARMS	NATIONAL CATTLE INVENTORY	BREEDING	COMPLETE CYCLE	FATTENING	TOTAL AREA	NATURAL GRASSLAND	OTHER GRASSLAND
	%					Million Ha	%	
BASALTO	6321 (15%)	27%	28	28	27	4.1	91	5
SIERRAS DEL E	4776 (11%)	10%	12	9	8	1.4	84	9
LLANURAS DEL E	1791 (4%)	5%	6	5	4	0.72	80	14
CRISTALINO Y LOMADAS	9903 (23%)	24%	24	22	28	3.3	68	22
ARENISCAS Y NE	6212 (15%)	18%	17	22	19	2.4	79	12
LITORAL	4505 (11%)	10%	9	10	17	1.7	52	18
SUR LECHERO	9057 (21%)	5%	4	4	10	0.72	48	38

Figure 3.3: Beef cattle herd size distribution by share of cattle and share of farms



Source: DICOSE, 2014

systems; and (iii) fattening systems. This assessment maintains the national characterization of production systems which is based on the MGAP-DIEA approach that classifies farms based on the steer to cow ratio[4]. The beef production cycle in Uruguay can be divided into breeding and rearing/growing and finishing activities. Farms can specialize in breeding of calves, finishing (fattening) or both (complete cycle farms). These activities are distributed throughout the national territory based on the land use capacity as shown in Map 3.1.

Breeding systems (cow-calf)

Beef production from breeding systems is the most widespread farm activity in Uruguay. Breeding farms have a widespread geographic distribution (Map 3.1) in contrast to the other beef cattle enterprises and make an important contribution to economic activity in diverse regions throughout the country. Approximately 23% of national beef production and a greater percentage of output value derives from beef breeding systems and therefore, this sector is a key income generator for the national economy.

The breeding activity includes the reproductive phase, producing calves as the main product that enters the meat production stages and culled cows. Breeding is by far the dominant activity in the supply chain, as around 37,000 of the 42,000 beef cattle farms are either dedicated to only breeding activities or a combination of both breeding and finishing (complete cycle production). Table 3.1 illustrates the national importance of these systems in terms of number of farms, number of beef cattle reared, land area occupied by these systems, proportion of smallholders[5] and the number of producers.

Complete cycle systems

In this system, the breeding phase occurs as described above with the difference that beef calves after weaning are reared and fattened for 26 to 35 months (Figure 3.4). During the rearing phase, the animals may receive supplements to improve growth performance and shorten slaughter age. Daily weight gain varies widely from about 300g/day for animals reared on natural grasslands to 1 kg/day for reared on cultivated pastures and supplemented.

[4] Farms classified as breeding when the steer-to-cow ratio is less than 0.2; complete cycle systems: when the steer-to-cow ratio is between 0.2 and 2 and fattening systems are classified as having a steer-to-cow ratio of more than 2. The complete cycle system was divided in 2 sub-groups: Complete cycle systems 1 (steer to cow ratio between 0.2 and 0.5) and mainly perform rearing and fattening of own calves. Complete cycle systems 2 (steer to cow ratio between 0.5 and 2) perform rearing and fattening of own and others calves.

[5] The Ministry of Livestock, Agriculture and Fisheries defines a smallholder as a farmer that complies with the following: (a) having no more than 2 permanent workers or its temporary equivalent; (b) farming no more than 500 ha; (c) the farm is the main source of income and workplace for the farmer; and (d) dwelling in the farm or in a village not further than 50km from the farm.

Table 3.1: Number of farms, cattle and land area – cow-calf and complete cycle systems

	Number and share
Number of farms	37, 000 (87%)
Head of cattle (million head)	9.2 (85%)
Number of smallholders	27,551 (75%)
Land area utilized (million hectares)	12.2 (83%)

Source: DICOSE, 2015

Table 3.2: Number of farms, cattle and land area – finishing systems

	Number and share
Number of farms	5,300 (12%)
Head of cattle (million head)	1.4 (13%)
Number of small-scale farms (< 500ha)	9,192 (81% of fattening farms)
Land area (million hectares)	2.4 (14%)

Source: DICOSE, 2015

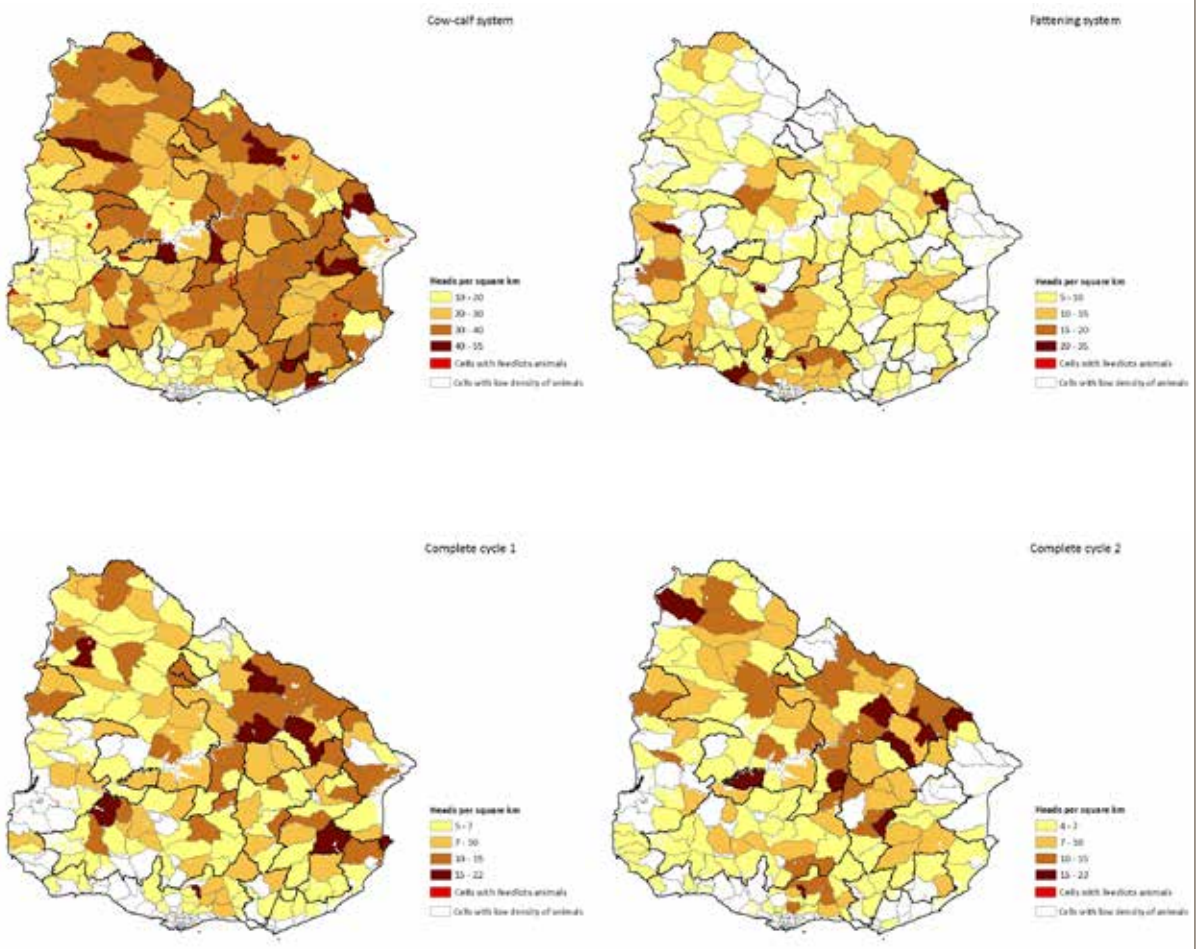
Fattening systems

This includes an initial rearing phase where animals are grown after weaning until they enter the final finishing stage. During the last few years, international meat prices and the opening up of new markets have triggered the intensification of fattening systems in order to improve animal performance and fulfill different market requirements. These intensive systems include a wide range of feeding strategies between pasture and concentrate utilization (Figure 3.5). In Uruguay, there are largely three beef fattening systems with contrasting diets, based on: grazed natural pastures, grazed-seeded pastures, and confined (feedlot), although combinations of these three systems also exist. Table 3.2 provides national statistics on number of farms, number of beef cattle reared, land area occupied by these systems, proportion of rural population engaged and the number of producers for farms engaged in fattening.

The finishing phase refers to the period between end-rearing and slaughter. Depending on the feed availability and quality, animals could be fattened from 3-4 months in feedlots to up to 16 months on natural pastures. Average slaughter weights can vary from 540 kg LW (in the case of steers) to 470 kg LW for females (cull cows and heifers) with average carcass yield being 49 to 53% for European breeds depending on the fattening system.

- Fattening on natural pastures has an average daily gain of 0.3 kg LW/day during the year, with variation considering climate conditions.
- Fattening on seeded pastures has an average daily gain between 0.6 to 1.0 kg LW/day depending on the type of pastures and season of the year. Pasture types may include natural pastures over-sown with legumes, cultivated pastures with different species (i.e. fescue, white clover, lotus) or annual grazing crops (i.e. ryegrass, oat).
- Fattening in feedlots is used mainly during late autumn to end of winter with fattening cattle destined to slaughter after 100 to 120 days. In feedlots, animals consume 10 to 15 kg of feed DM/head per day depending on the breed, size and age. Diets consist of 20 to 30% forage with

Map 3.1: Geographic distribution of cattle production systems (head per sq. km)



the remainder being maize grain, soybean meal and other energy and protein feed and byproducts. According to data from Sistema Nacional de Información Ganadera (SNIG), there are more than 100 registered feedlots. Many registered feedlots run only during the winter season. Current capacity is estimated at about 200,000 head, but in the recent past this capacity has never been reached. Feedlots are not to be compared with those, for example in the USA, since Uruguay's feedlots are for finishing animals (mostly steers) during the last 100-120 days before slaughter, without the use of growth promoters. Animals entering the feedlot are normally 2-year old grass-fed steers, weighing 350-380 kg that are sent to the processing plant weighing 525-540 kg.

Figure 3.4: Complete cycle beef production system

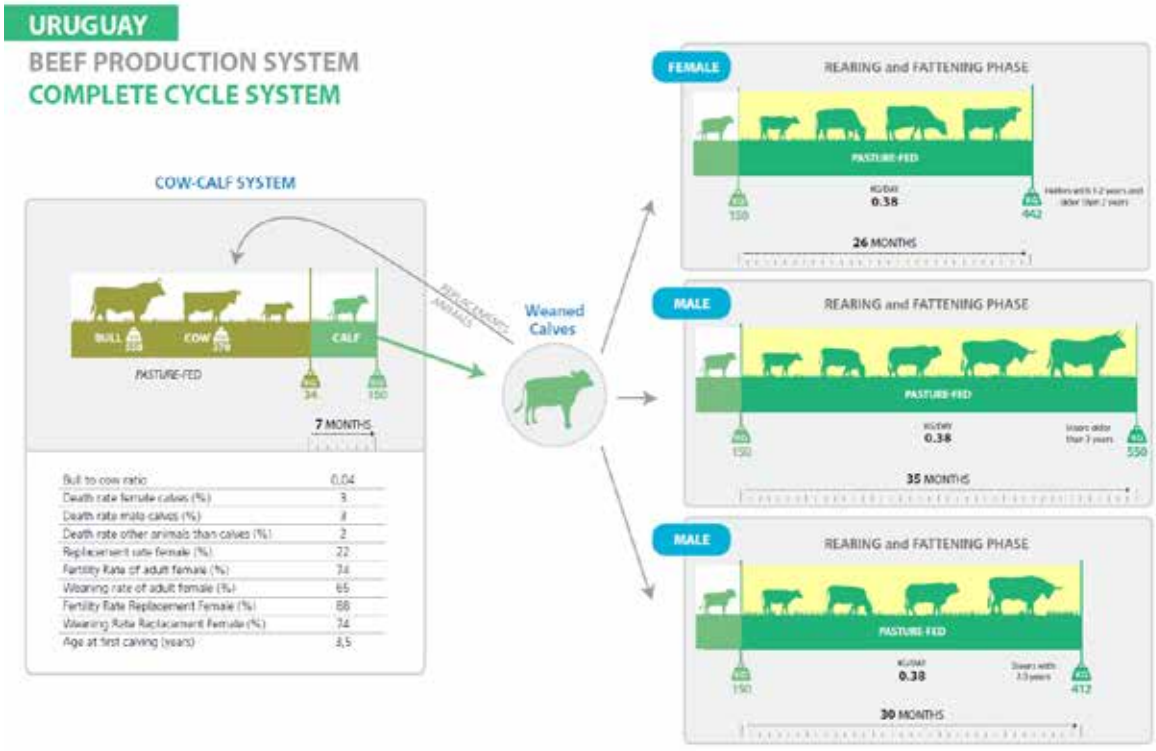
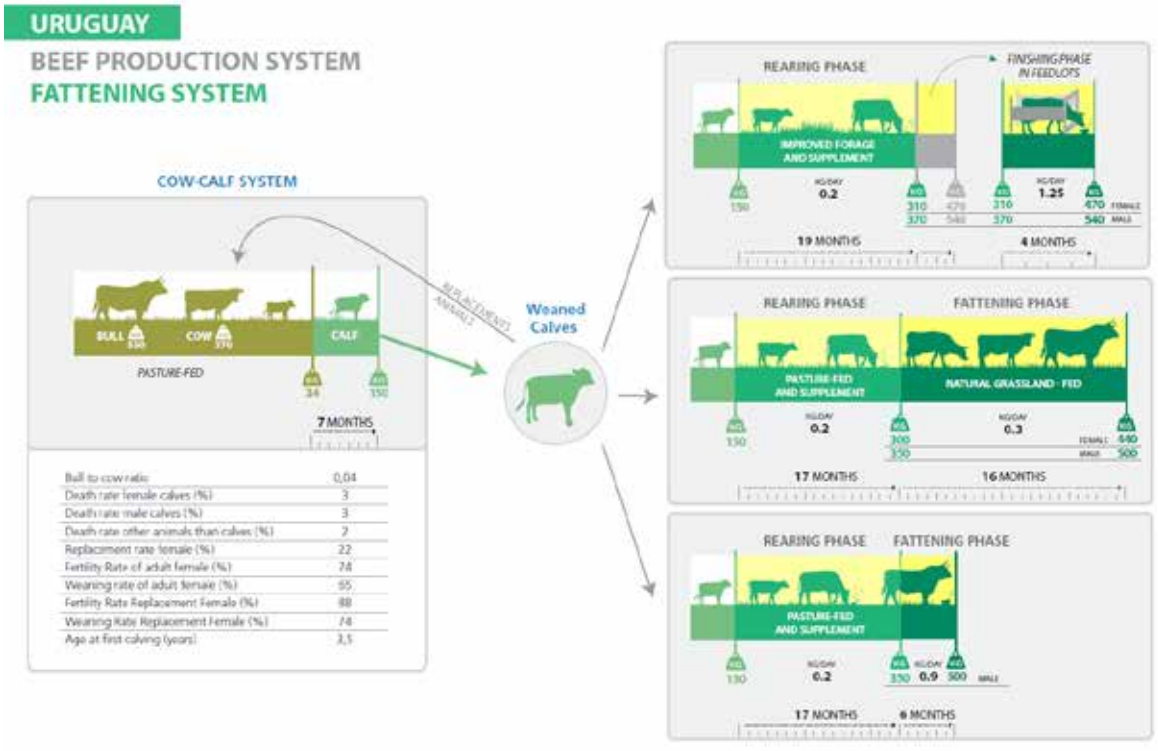


Figure 3.5: Beef fattening production system in Uruguay



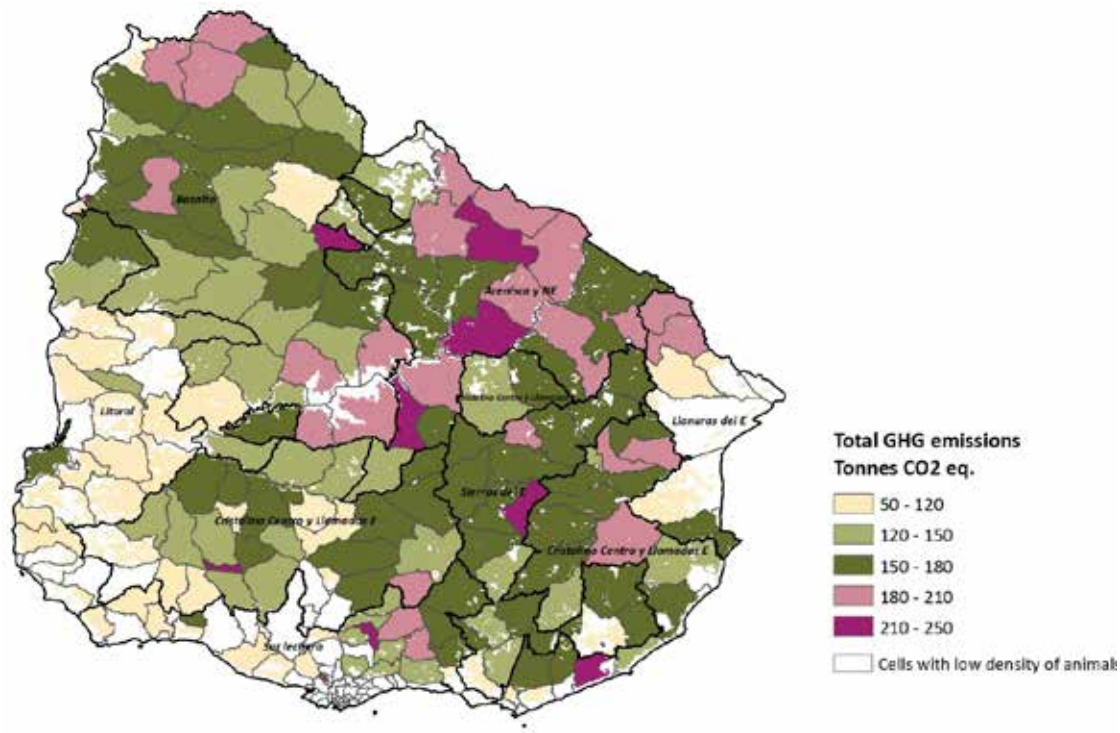
CHAPTER 4

Emissions and emission intensities from the beef cattle sector

The results presented here indicate that beef production in Uruguay is responsible for about 31.5 million tonnes CO_2 eq. in 2014, corresponding to 72% of total national GHG emissions from agriculture (GLEAM, 2016). These emissions are distributed throughout the entire country as shown in Map 4.1. Emissions are concentrated in those eco-regions where beef production is important such as Basalto, Areniscas and parts of Cristalino y Lomadas. Litoral, Sur Lechero and Llanurus, which are primarily dairy producing zones but also areas that specialize in fattening of cattle, have low absolute values.

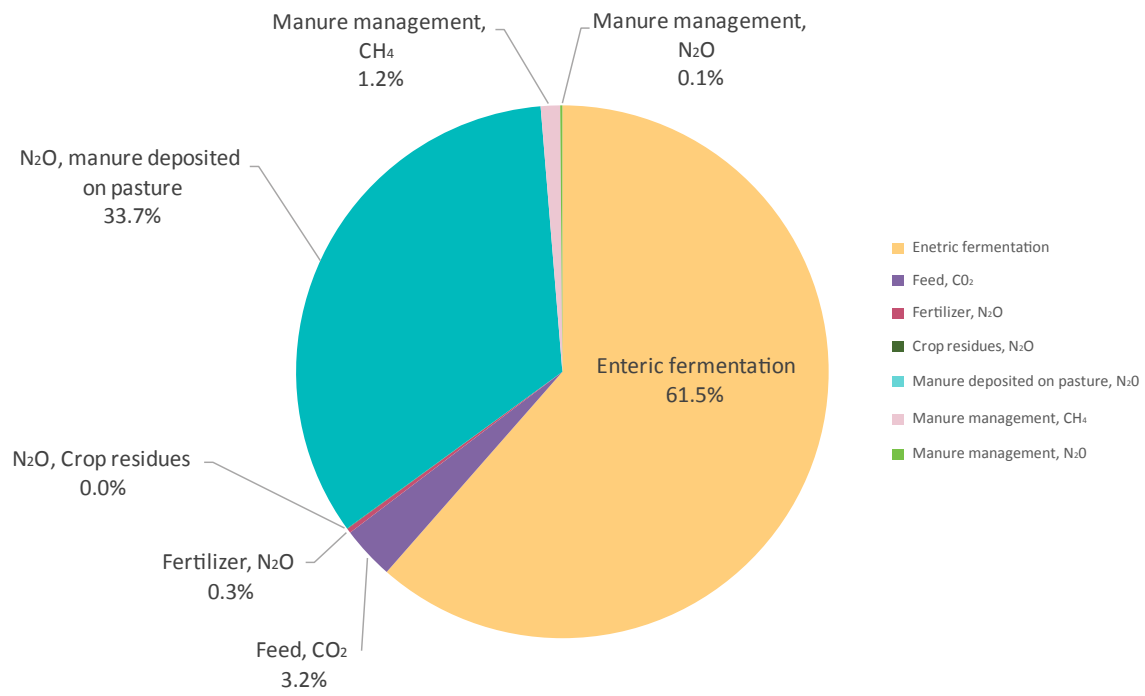
The GHG profile is dominated by methane: 63% (enteric fermentation and manure), followed by nitrous oxide (34%) and carbon dioxide from fossil fuels (3%) (Figure 4.1). The contribution of nitrous oxide and methane from manure management is negligible (0.1% and 1.2% of the total, respectively). N_2O and CO_2 emissions associated with feed production (crop residue decomposition, production and application of fertilizer and production of feed) amount to 3.5% of the total emissions.

Map 4.1: Total greenhouse gas emission from beef production



Source: GLEAM, 2016

Figure 4.1: Share of total emissions by emission source



Source: GLEAM, 2016

Production system contribution to the total GHG emissions

Figure 4.2 illustrates emissions in absolute terms disaggregated by beef production system and sources of emissions. The grass-based systems are responsible for a large share of total GHG emissions profile; cow-calf system contributes 60% of total emissions, while the complete cycle systems both contribute 14% each (Figure 4.2). The fattening phases on natural pastures, improved pastures and in feedlots each contribute 6%, 4% and 2%, respectively.

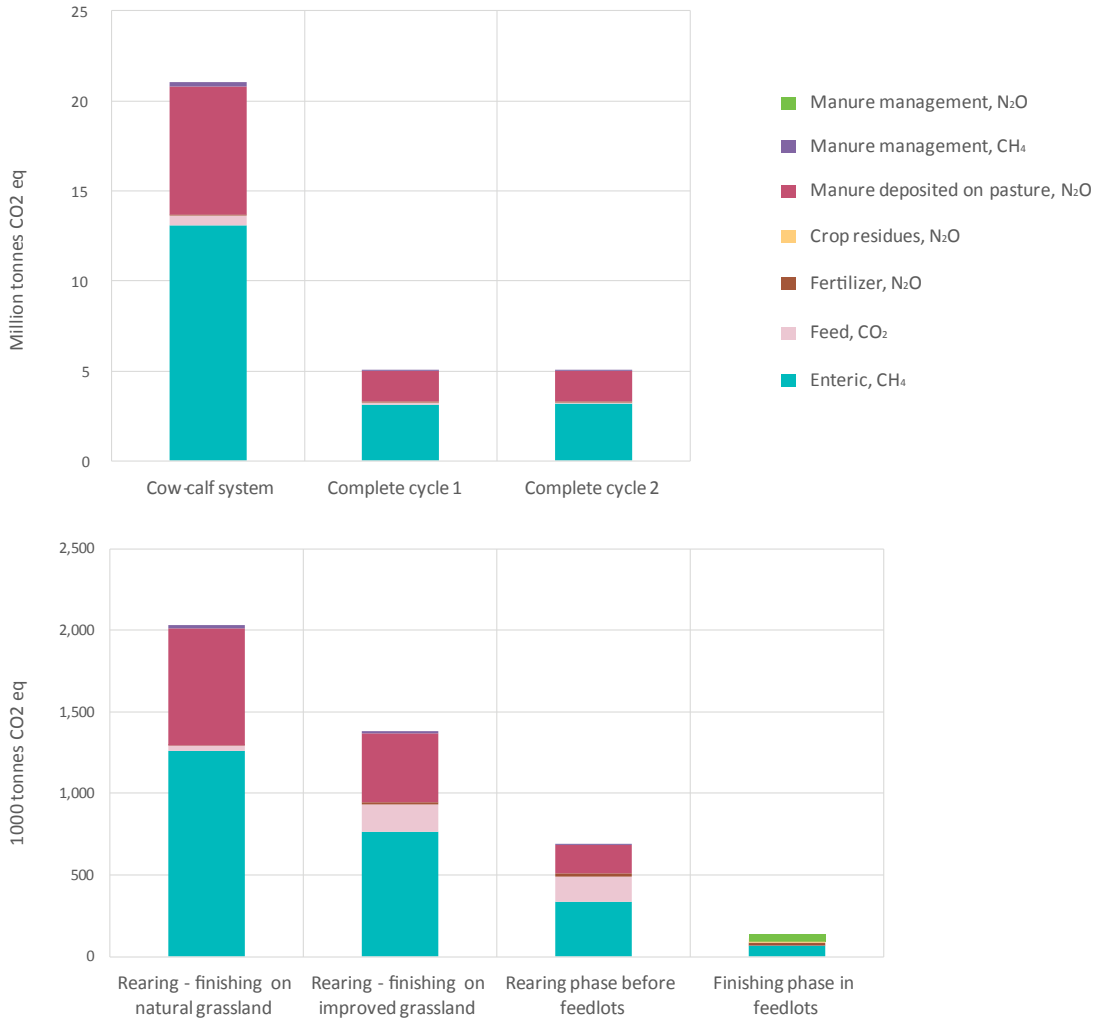
In relative terms, enteric fermentation makes the largest contribution to the total: average 61.5% (with a range of 49-63%) of emissions, followed by manure deposited on pasture, with an average of 33.7% (range, 28-47%) (Figure 4.3). Owing to the extensive nature of the systems, CO_2 emissions associated with feed production, fertilizer production and use, are generally insignificant. However, as production intensifies, the share of emissions from enteric methane reduces and there is a shift towards other emission sources.

Increased grain finishing led to most of the observed increase in fossil fuel energy demand for the herd as a result of external inputs for feed grain production and feedlot operations. Fossil fuel energy demand also increased in response to intensification of production on grazing land, observed from the increase in farm fertilizer and supplementary feed use in the finishing phase on improved grasslands.

Greenhouse gas emissions per kg of live-weight

Emission intensity per kg LW is lower as systems intensify, with the highest values for low-input cow-calf systems and the lowest in fattening in feedlots. On a product level, emissions were on average 41, 35.5 and 24.8 kg CO_2 eq./kg LW for cow-calf and complete cycle 1 and 2, respectively.

Figure 4.2: Absolute emissions by production system and emission source



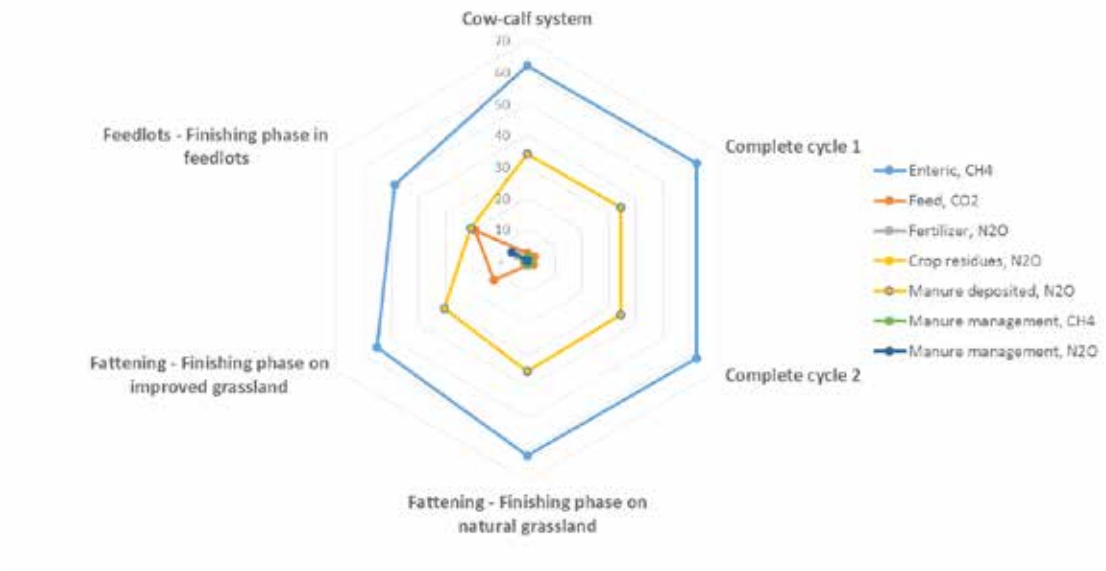
Source: GLEAM, 2016

These results suggest that pasture-finished beef from managed grazing systems as currently practiced in Uruguay is more greenhouse gas intensive than feed-lot-finished beef when viewed on an equal live-weight production basis but significantly lower than emission intensity of the breeding systems. The average GHG emissions per kg of LW in the fattening phase were: 8.6 and 7.9 kg CO_2 eq./kg LW for animals finished on natural pastures and improved pastures, respectively (Figure 4.4). Emission intensity of animal reared in feedlots is on average 10.5 kg CO_2 eq./kg; of which 84% is associated with the rearing phase and the rest with the finishing phase in feedlots.

Drivers of emissions and emission intensities

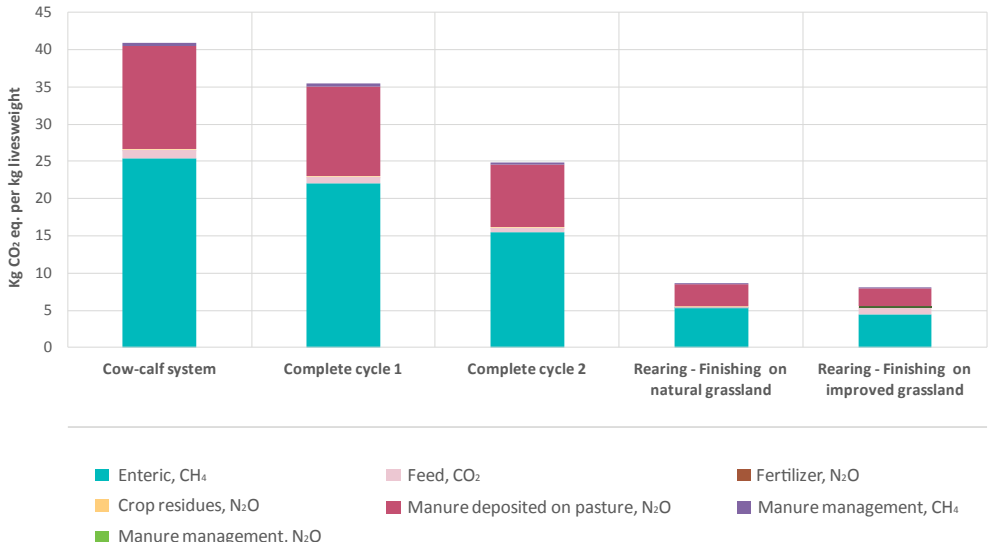
A number of herd management factors have been identified as influencing emission intensity from beef production at the animal and herd scale.

Figure 4.3: Share of emissions by source and production system



Source: GLEAM, 2016

Figure 4.4: Average emission intensity per kg live-weight, by system



Source: GLEAM, 2016

For breeding systems:

- Inadequate and poor nutrition i.e. the low supply of high quality pastures. Almost 90% percent of the diet is made up of native pastures that is of poor quality. This has a major influence on reproductive performance and the breeding overhead.
- Poor reproductive efficiency: Reproductive efficiency is key to the biological and economic sustainability of beef systems. Improvement in reproductive performance is a major efficiency goal of the beef industry. However, achieving this goal is hampered by a number of factors particularly feed availability and quality. Poor reproductive performance was manifested in a number of parameters such as low weaning rates, low fertility rates, delayed time to reach puberty and age at first calving. The improvement of reproductive efficiency has the potential to benefit the economic and environmental impacts of beef production through increasing the percent of cows that produce a calf each year. In Uruguay, the use of management tools to improve reproductive efficiency is highly variable, for example, only 33% of producers in breeding use pregnancy diagnosis.
- Large breeding overhead: Reproductive inefficiency of the herd also results in a large breeding overhead. In Uruguay, the breeding stock (cows, bulls and replacements) makes up a large proportion of the herd: 72%, 62% and 55% in cow-calf, complete cycle 1 and 2, respectively. Because heifers are consuming feed and producing GHG emissions before they reach calving age, advancing heifer development and lowering age-at-first calving can increase production efficiency and decrease the amount of GHG emissions per unit of beef. This study found the cow-calf system accounted for 60% of enteric methane emissions with 31% of the cow-calf emissions produced by breeding stock that do not immediately produce a calf (e.g. growing heifers).

For finishing systems:

- Long and inefficient rearing and finishing periods particularly for animals finished on natural pastures: An inadequate supply of low quality forage from poorly managed natural pastures lead to low growth rates of animals meaning that animals have to be retained longer to reach target weights. A reduction in beef finishing times by attaining high average daily gains can result in lower emissions per kg of beef product produced. High average daily gains are also compatible with high production efficiency and profitability. Achieving higher growth rates leads to a higher final weight at finishing and/or lower finishing age and means more beef and less emissions relative to the length of time the animal is on the farm producing emissions.

CHAPTER 5

Exploring the mitigation potential in beef production

The abatement technologies and practices assessed in this study were selected for their potential impact on enteric CH_4. Another important consideration taken into account during the selection of target interventions was the need to integrate mitigation with a number of key national objectives and developmental goals for the beef sector, such as its role in promoting food security, rural and overall economic development.

The mitigation options evaluated in this analysis were selected in a consultative process with national experts where those options identified as having the potential for large improvements in productivity were assessed alongside their potential to reduce on-farm greenhouse gas intensity while taking into account the feasibility of implementation. Box 3 summarizes the criteria used to identify interventions included in the analysis.

The interventions evaluated covered a broad range of areas including improved feeding practices, better herd health and management and the use of improved genetics. These comprised: increasing the forage/herbage allowance, inter-seeding natural pastures with legumes, sowing annual fodder crops and grass legume mixtures, strategic supplementation, controlled breeding (defining a mating season), artificial insemination, and crossbreeding (exploiting heterosis). Interventions were selected to address the known key drivers of low productivity and inefficiencies in production cycle. These are summarized in Table 5.1.

The strategies were not applied uniformly, but selected for each production system, animal category, and agro-ecological zone using evidence from modelling and field studies, expert judgement of their specific operating conditions and performance.

Quantitative summary of mitigation outcomes from the application of single interventions

The mitigation outcomes by system from the single interventions considered in this report are presented in Figures 5.1 and 5.2 for the potential reduction in both total GHG emissions and enteric methane emission intensities. Overall, the analysis shows that there is a high potential to reduce emission intensities; methane emission intensity (CH_4/kg LW) can be reduced by 5.6% to 51%, depending on the intervention and production system (Figure 5.2).

The implementation of a forage allowance concept as an option to improve on-farm management of existing forage resources results in a reduction in enteric CH_4 emission intensity of 17% in complete cycle systems and 21.6% in the cow-calf systems. While this intervention is considered by the national experts to be one of the key interventions for the grass-based systems, due to insufficient field evidence of the impacts, a conservative approach was assumed; the intervention was applied only to a sub-set of the animals in the herd, more specifically to adult cows.

Mitigation measures aimed at increasing forage quantity and quality for steers and heifers fattened on natural grasslands (inter-seeding natural pastures with legumes and sowing grass legumes and annual fodder crops) had a reduction potential of 5.4% - 21.3% and 45.5% - 51.4% (CH_4/kg LW), respectively. The interventions had the impact of shortening the rearing and finishing period as a result of higher daily weight gain with animals growing faster. Improving natural pastures by inter-seeding with legumes results in modest emission intensity reduction compared to the intervention on sowing grass

Box 3: Criteria for selection of interventions

Three principal criteria were used to identify interventions for analysis in the study; **the potential for improving production efficiency, feasibility of adoption by farmers and the potential to reduce enteric methane emission intensity.**

Improving production efficiency: A good strategy that farmers can implement to decrease methane emissions. Using this approach comprises the adoption of effective management of forage and other feed resources (e.g. supplementation, ration balancing), improved fertility and reproductive management of the herd, greater use of animals selected for improved production and better animal health management.

Reduction in enteric CH_4 emission intensity: Many measures that have the potential to increase productivity are associated with increased individual animal performance and this increased performance is generally associated with a higher level of absolute emissions (unless animal numbers are decreasing) but reduced emissions intensity. Some however can result in a decrease in both absolute enteric emissions and emissions intensity. For example, the inclusion of legume based forages in the diets is associated with higher digestibility and a faster rate of passage which results in less methane production (Figure below).

Feasibility of implementation: The third criterion is that the interventions had to be feasible in the short or medium term. For the purposes of selecting interventions, "feasibility" was first determined by sectoral experts in terms of their technical potential, production system and territorial applicability, and market development. The study also assumed reliance on existing and proven technologies. The selected interventions were discussed with a broader group of stakeholder to assess the social and institutional feasibility of adoption and up-scaling of interventions. Ensuring that this criterion was met required investigation of information on barriers that keep farmers from adopting these interventions at large scale. Other aspects taken into consideration with regard to feasibility included: location of interventions which should be informed by location of drivers/barriers; geophysical aspects, e.g. soil type; and potential to enhance other benefits, e.g. poverty reduction, biodiversity conservation, ecosystem services provision.

Impacts of inter-seeding legumes with natural pastures on absolute enteric CH_4 emissions and emission intensity, by system

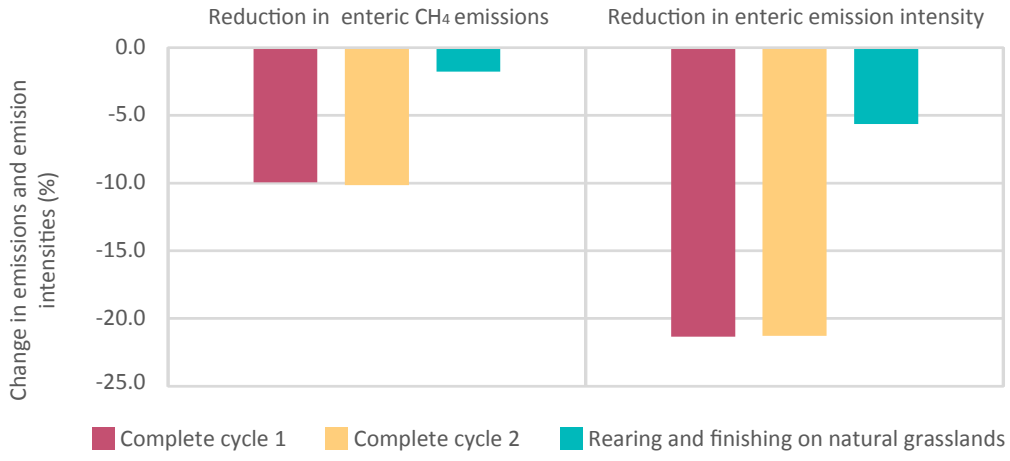


Table 5.1: Summary of selected intervention for Uruguay beef systems

Practice	Objective	Constraint addressed	Benefits
1. Increasing forage allowance	Improve management of forage resources by better matching available resources to animal requirements/herd nutrient demand	Beef production is dependent on native pastures with inadequate feed availability at critical times due to sub-optimal management	Improved animal and herd health Higher conception rates Improved weaning weights
2. Inter-seeding natural pastures with legumes	Increase forage supply especially during periods of low forage production and improved feed quality	Low quantity and quality of forage	Improved nutrition Improved growth rates Shorter finishing periods and/ or higher slaughter weights
3. Sowing annual fodder crops and grass legume mixtures			
4. Winter supplementation	Address energy and protein constraints during periods of low availability and quality	Addresses the lack of sufficient and quality feed resources (especially in winter). Sub-optimal pasture management.	Improved nutrition Improved cow condition Improved reproductive performance Higher conception rates Higher weaning weights Faster growth of replacement animals
5. Summer supplementation			
6. Early weaning and supplementation (flushing)	Improve reproductive performance of breeding animals	Low reproductive performance of breeding herd	
7. Controlled breeding	Synchronize pasture and supplement availability with the breeding cycle to better manage herd nutrition, cow-calf health, closely monitor breeding and calving	Low reproductive performance of breeding herd	Improved nutrition Improved conception rates Increased weaning weights
8. Artificial insemination using superior genetics	Genetic management to improve production and reproductive traits such as growth rate, carcass weight production	Poor genetics and low productivity	Improved conception rates, calf survival Increased weaning weights Increased final weights
9. Cross breeding (exploiting heterosis)			

legumes and annual fodder crops. These interventions exclude the region of Basalto from the analysis because of its agro-ecological unsuitability (shallow soils) for cultivation of legumes.

Strategic supplementation, comprising interventions that address the constraint of feed deficits during periods of shortage result in a reduction of 9.6% - 34%. Supplementation achieves modest reductions in cow-calf system and this is explained by the small impact on production; with supplementation, production (kg LW) in cow-calf systems increases by only 5.8% and 1.6% (see Figure 5.1) for winter supplementation and summer supplementation, respectively. Supplementation however had a significant impact on enteric methane emissions in the complete cycle 2 system; enteric CH_4/kg LW are reduced by 34% and 26% for winter and summer supplementation interventions, respectively.

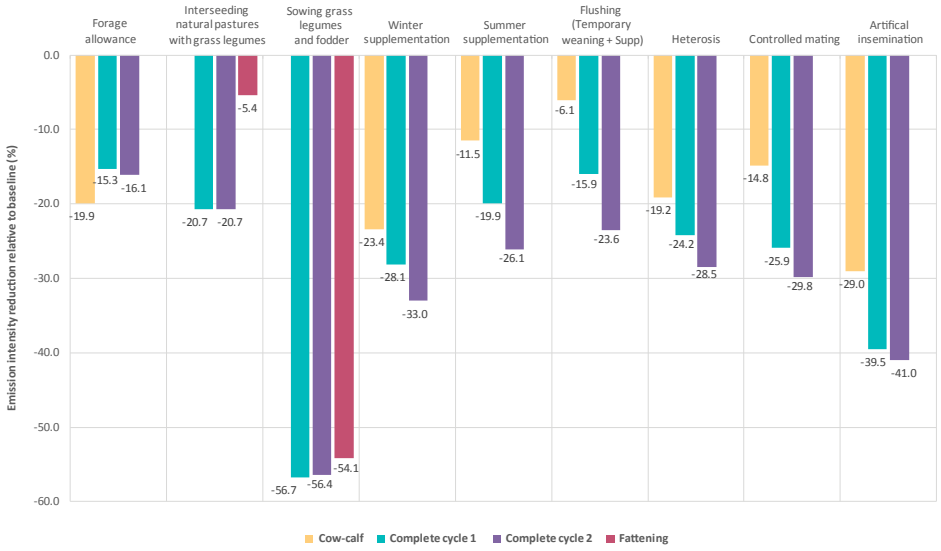
Flushing – the practice of increasing nutrient intake prior to breeding to increase reproductive performance coupled with temporary weaning for those animals rearing a calf results in abatement potential of 9.6% – 25.3%. In this study the practice was applied to only first calving cows (22 percent of the herd) for a limited period (20 days).

Artificial insemination, using semen from a reference bull whose progeny was expected to have higher weaning (+20 kg) and finishing weights (+36 kg), as well as increased weaning rates (from national average of 65% to 75%) results in reduction of 29% to 40% (CH_4/kg LW) (Figure 5.2). The impacts on emission intensity are achieved through the reduction in number of replacement breeding animals and improvements in reproductive performance of the herd.

Quantitative summary of mitigation and productivity outcomes from the application of mitigation packages (combined technologies)

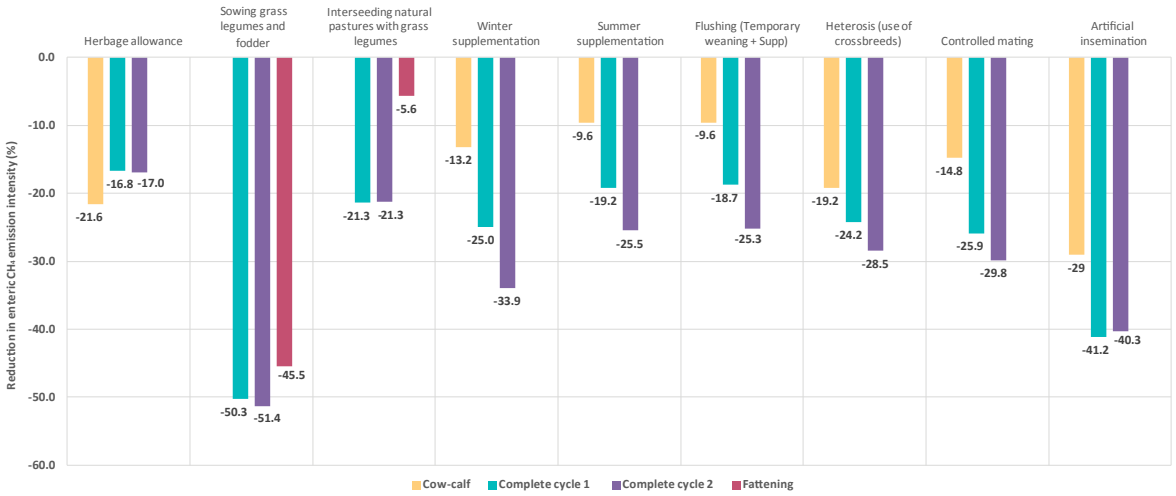
More significant reductions in emissions can be achieved in theory through the combination of herd and health management, nutrition and feeding management strategies, and genetics. However, the reality is that farmers are likely to combine tech-

Figure 5.1: GHG emission intensity reduction potential relative to baseline emission intensity for single intervention



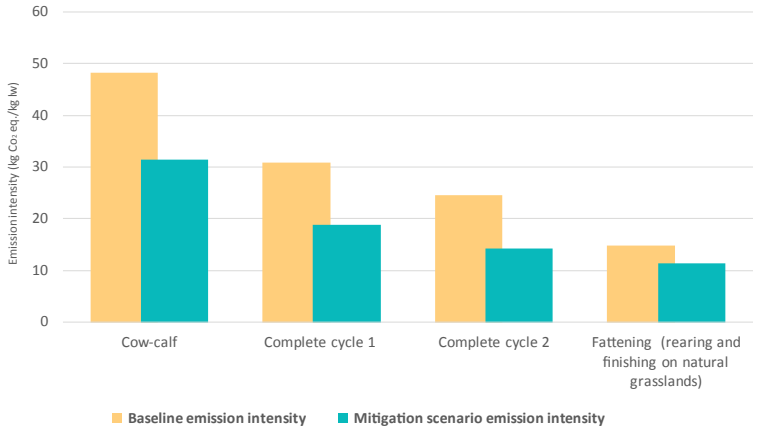
Source: GLEAM, 2016

Figure 5.2: Enteric CH_4 emission intensity reduction potential relative to baseline emission intensity for single intervention



Source: GLEAM, 2016

Figure 5.3: Package of emission intensity mitigation options (defined mating season, early weaning, winter supplementation, and inter-seeding natural pastures with legumes)



Source: GLEAM, 2016

nologies and will select the combination of technologies that will maximize a number objectives. To test this concept local experts were asked to devise a combination of interventions that they felt best optimized the achievement of multiple goals and was applicable across all systems. Applying a combination of interventions aimed at improving fertility and reproductive status of the herd (controlled mating and early weaning); improving feed quality and availability (winter supplementation and inter-seeding natural pastures with legumes) resulted in a reduction potential of 23%-42% in emission intensity relative to the baseline emission intensity (Figure 5.3).

CHAPTER 6

Prioritization of interventions to address enteric methane

Having identified and assessed the mitigation potential, the next step was to prioritize these technologies for wider dissemination and adoption. Prioritization should not only consider enteric methane mitigation potential but also the productivity benefits, income advantages to farmers and other co-benefits that are likely to provide additional incentives for farmers to adopt mitigation interventions. A key incentive to farmers for adoption is increased revenue and/or reduced costs. To better understand the implications for farmers, a cost benefit analysis was conducted to assess the profitability of each intervention. The benefit-cost ratio is the ratio between the present value of the benefit stream and the present value of the cost stream. It provides an indication of how much the benefits of an intervention exceed its costs.

The prioritization process

All individual practices were ranked for their ability to reduce enteric methane. Given that there is always uncertainty around any estimation of reduction potential we discarded any practice that would reduce emissions by <10%. This reduces the risk of promoting practices that have marginal or no enteric methane reduction benefit. The remaining practices were then assessed against their enteric methane reduction potential and two other criteria; productivity improvement and economic benefits (Figure 6.1). For ease of interpretation a 'coloured light' system was developed for assessing impact where red was 'high', blue 'medium' and yellow 'low'. As the impact of an individual practice varies by system, practices were prioritized separately for each system. The values associated with the high, medium and low clas-

Figure 6.1: Initial prioritization process of technical interventions

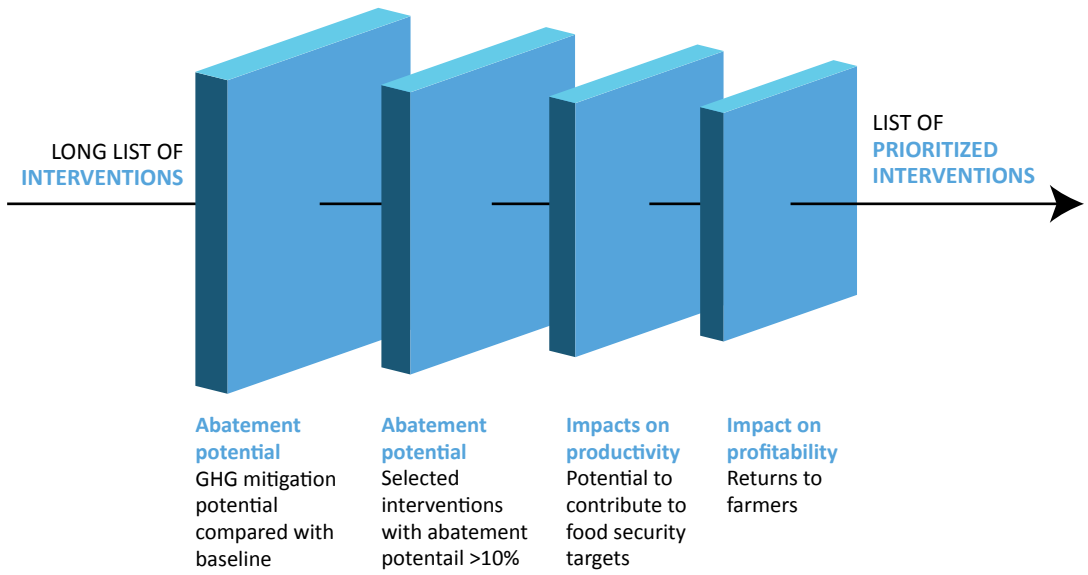


Table 6.1: Results from the prioritization of single interventions for beef production systems

Intervention	Herbage allowance	Sowing grass, legumes and fodder	Inter-seeding natural pastures with legumes	Winter supplementation	Summer supplementation	Flushing	Heterosis	Controlled mating	Artificial insemination
COW-CALF									
Methane reduction	●			●	●		●	●	●
Production increase	●			●	●		●	●	●
Econimic benefit	●			●	●		●	●	●
FATTENING ON NATURAL PASTURES									
Methane reduction		●							
Production increase		**							
Econimic benefit		$							
COMPLETE CYCLE 1									
Methane reduction	●	●	●	●	●	●	●	●	●
Production increase	●	**	●	●	●	●	●	●	●
Econimic benefit	●	●	●	●	●	●	●	●	●
COMPLETE CYCLE 2									
Methane reduction	●	●	●	●	●	●	●	●	●
Production increase	●	**	●	●	●	●	●	●	●
Econimic benefit	●	●	●	●	●	●	●	●	●

Assessment criteria:

Methane mitigation:	● Low: >10 <25	● Medium: >25 <50	● High: >50
Production increase:	● Low: <25	● Medium: >25 <50	● High: >50
Economic benefit:	● Low: <25	● Medium: >25 <50	● High: >50

** No change in production was achieved because output was kept constant. Reductions in enteric methane is achieved through shorter growth and fattening periods and better diets;

$ Impossible to quantify the economic impact due to lack of data on farm-level production costs for fattening operations.

sification system are shown at the bottom of Table 6.1. It must be emphasized that this system was developed as an aid to facilitate the identification of those practices with the highest potential both within and between practices and systems. It does not signal potential since even practices ranked 'low' against all three criteria reduced enteric methane emissions, increased output and returned a net financial benefit. The outcomes of the prioritization process are shown in Table 6.2.

Summary of prioritization of interventions

Comparison of individual interventions: The individual interventions assessed all resulted in increased production when compared across all systems; the largest productivity gains were recorded for increased herbage allowance, heterosis, controlled mating and artificial insemination. Sowing grass legumes and fodder was ranked high in the three systems in which it was deemed an appropriate inter-

Table 6.2: Prioritization results for the "package" intervention for beef production systems

Common intervention 'package'	Methane reduction	Production increase	Economic benefit
Cow calf			
Complete cycle 1			
Complete cycle 2			
Fattening on natural pastures			

Assessment criteria:

Methane mitigation:	Low: >10 <25	Medium: >25 <50	High: >50
Production increase:	Low: <25	Medium: >25 <50	High: >50
Economic benefit:	Low: <25	Medium: >25 <50	High: >50

vention. All of the individual interventions returned a positive benefit-cost ratio irrespective of system and, in general, those with the highest increase in production returned had the highest benefit: cost ratio. When assessed against the three criteria and across all systems, increased herbage allowance, sowing grass legumes and fodder, heterosis, controlled mating and artificial insemination are the practices that look to have the highest potential to balance decreases in enteric methane with increased food supply and returns on investment.

System level comparisons: The results from this study show that the impact of the modelled interventions was greater in the complete cycle 1 and 2 systems than in the cow-calf system. This was generally true for all assessment criteria and was particularly striking for economic benefit where a large proportion of the interventions were ranked 'high' in the complete cycle 2 systems.

Cow-calf systems produce approximately 60% of agricultural emissions and our results suggest that a focus on increased herbage allowance, heterosis and artificial insemination will provide the best balance between reducing enteric methane reductions, increasing product output and return on investment in these systems.

In cow-calf systems the productivity benefits are low for supplementation and controlled mating interventions and these are also associated with low financial returns. Artificial Insemination on the other hand has moderate impacts on emissions and productivity and lower economic benefits explained by the high costs of the intervention.

The complete cycle systems appear to have more flexibility with respect to implementing practices that have strong positive multiple benefits. Sowing grass legumes, controlled mating and artificial insemination all have the potential to bring about reductions in enteric methane emissions of between 25 and 50%, increase product output by >50% and return a benefit: cost ratio of >50%.

Prioritization of interventions for the fattening of steers was not possible because only one intervention – sowing grass legumes was selected by national experts as an applicable mitigation practice for fattening of steers in complete cycle production systems and the fattening of steers on pastures.

Intervention packages: The large number of possible intervention 'packages' ruled out a comprehensive comparison and prioritization of alternative 'packages'. Expert judgment was therefore used to define what was deemed the most appropriate common intervention 'package' to compare across the four systems. An assessment of this package, which comprised controlled mating, early weaning, winter supplementation and inter-seeding natural pastures with legumes, against the three assessment criteria is shown in Table 6.2. Compared with the individual interventions, enteric methane reduction was increased while production and economic benefits were maintained or increased.

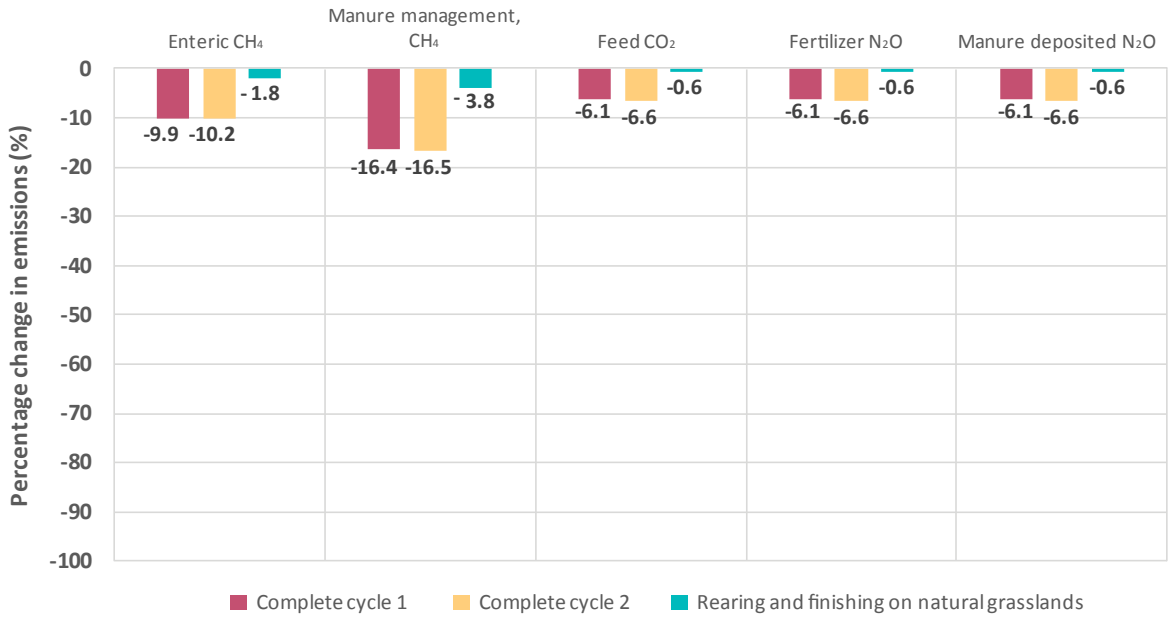
It is worth noting, in cow-calf and complete cycle 1 systems the combination of technologies has a positive impact on the reduction of enteric methane emissions, however the cost-benefit ratio even though positive was still low compared to other systems which points to the fact that cost of implementing such a combined mix of technologies is quite high in the cow-calf and complete cycle 1 systems compared to the benefits. The increase in production in cow-calf systems is also lower compared to other systems, this is largely explained by the fact that productivity of this system is determined by the number of calves weaned and if expressed in terms of number of calves weaned, the combined intervention results in an 41% increase in calves weaned compared to the baseline.

Insights on additional impacts from enteric methane mitigation actions

Many of the mitigation interventions targeted at reducing enteric methane emissions can also result in additional benefits (and trade-offs) for emissions, as well as have other environmental impacts. For example, inter-seeding natural pastures with legumes resulted in a decrease in emissions across all emission sources (Figure 6.2).

The benefits from inter-seeding pastures with legumes include increased forage production and quality, increased palatability and intake resulting in increased grazing capacity and animal gain. In addition to reducing enteric methane emissions, increasing forage supply reduces the requirements for other feed resources. Legume inter-seeding can increase soil nitrogen due to nitrogen fixation; this, in turn, increases soil fertility and decreases the need for synthetic inputs; emissions associated with nitrogen fertilizer production and use are reduced by 5% compared to the baseline. Inter-seeding of legumes on natural pastures also provides an opportunity to increase soil carbon sequestration, reducing erosion and improving water quality.

Figure 6.2: Impacts of improving natural pastures with legumes



Source: GLEAM, 2016

CHAPTER 7

Unlocking the potential of 'no regrets' opportunities

The analysis in the preceding sections indicates that there are significant opportunities for growth on a low carbon path for the beef sector and that low-cost (or no) opportunities exist across all production systems. Most notably, these include a range of efficiency enhancing measures such as improving nutrition, animal husbandry and herd health and genetics.

Why do these many low-cost opportunities remain untapped? The explanation lies in a variety of barriers that prevent the uptake of such opportunities. The following are the most commonly cited: lack of proper incentives for technology adoption, limited knowledge of farmers and environmental constraints (unsuitability), high cost of investment, etc.

It is important to note that the costs and benefits (and profitability) of the technology are only one part of the picture: adoption also depends on policy incentives, technical support, farmers' capacity, and other factors. Putting in place supportive policies and programs to overcome the market, regulatory and institutional barriers is essential for mitigation potential to be realized.

Drawing clear messages from the prioritization process around realized potential is challenging; some options could prove to be a better option at system level and may not work at farmer level where other criteria may be important. Consequently, there is a need to consider how these interventions behave on the ground. In particular, a better understanding of the barriers to adoption at the farm level is required. This information currently does not exist for the individual interventions assessed in this report. Artificial insemination is the best example of why this information is urgently needed. Based simply on its technical potential and strong benefit: cost returns it seems the prime example of a 'win-win' technology that should be adopted widely across the whole of the Uruguayan beef industry. Why isn't it being adopted? Developing an understanding of why individual technologies such as artificial insemination are not being adopted requires a much more intensive effort at the local and system scale than has been possible in this study. The current prioritization process however provides a guide to where these next efforts should be focused.

This study reveals that if enteric methane is to be used as a pathway for enhancing productivity and achieving emission reductions in Uruguay, the greatest win-win opportunities for achieving this goal lie in the breeding and complete cycle systems for the following reasons:

- Breeding and complete cycle systems account for 85 percent of the beef cattle herd, and provide livelihood support to more than half of smallholder beef producers;
- The breeding herd output is considerably less than it should be; this is confirmed by the wide productivity gaps in these systems. Furthermore, much of management practices do not optimize its potential; grassland management and other farm practices are often lagging, and farm profitability is low, and can be significantly improved;
- Emissions and emissions intensity are highest in these systems;
- Approximately, 89% of the enteric CH_4 emissions originate from cow-calf and complete cycle systems;
- Their reliance on the overgrazed natural resource base makes them most vulnerable to climate change hence interventions that improve natural grassland management can increase productivity and resilience at the same time targeting these systems are most likely to increase their adaptive capacity;
- Overall sustainability of the beef sector in Uruguay is closely linked to the breeding activities. The importance of cow-calf and complete cycle systems for the beef sector and for the economy as a whole lies in their specialization in breeding activities meaning that any negative impacts such as drought, disease, etc. will have multiplier effects in other systems such as the fattening systems and the industry as whole.

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