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Ambition Meets Reality: Achieving GHG Emission Reduction Targets in the Livestock Sector of Latin America

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Livestock production is a very relevant source of income and agricultural greenhouse gas (GHG) emissions in Colombia, Brazil, Argentina, Costa Rica, Uruguay, Mexico, and Peru. Several management and technological options with enteric methane mitigation potential have been evaluated and their scaling is anticipated to contribute toward achieving GHG emission reduction targets in the framework of the Paris Agreement. Yet, widespread adoption of promising mitigation options remains limited, raising questions as to whether envisaged emission reduction targets are achievable. Using findings from local studies, we explore the mitigation potentials of technologies and management practices currently proposed to mitigate enteric methane emissions from cattle production systems in the higher emitting countries of Latin America. We then discuss barriers for adopting innovations that significantly reduce cattle-based enteric methane emissions and the major shifts in policy and practice that are needed to raise national ambitions in the high emitting countries. Using the latest science and current thinking, we provide our perspective on an inclusive approach and re-imagine how the academic, research, business and public policy sectors can support and incentivize the changes needed to raise the level of ambition and achieve sustainable development goals (SDG), considering actions from the farm to the national scale.

Keywords: SDG targets, Paris agreement (COP 21), NDC, Latin America, enteric methane

INTRODUCTION

Cattle production is a pivotal source of income for Latin American countries, where a combination of large water reserves and vast natural resources create a conducive environment for animal husbandry. The importance of cattle production in the economic development of Colombia, Brazil, Argentina, Costa Rica, Uruguay, Mexico, and Peru is unambiguous. For instance, in Uruguay, about 11.3 million cattle utilize 13.3 million ha (Aguirre, 2018). Consequently, the cattle sector contributes 6% of national GDP and 28% of agricultural GDP (FAO UNDP, 2017). In Colombia, about 26.4 million cattle utilize ∼37 million ha (Federación Colombiana de Ganaderos (Fedegan), 2018). Additionally, cattle rearing contributes 1.4% of national GDP and 21.8% of agricultural GDP. In Costa Rica, the national herd comprises 1.5 million cattle raised on 1.04 million ha and contributes 1.8% of national GDP and 33% of agricultural GDP (OECD, 2017). In Argentina, the national herd comprises about 53.9 million cattle on 110 million ha. It contributes 3.04% of national GDP (Dirección Nacional de Sanidad Animal- Servicio Nacional de Sanidad y Calidad Agroalimentaria (DNSA-SENASA), 2019) and 38% of agricultural GDP (OECD, 2018a). In Brazil, the cattle sector contributes 6.8% of national GDP and 30% of agricultural GDP from a herd size of 214.8 million cattle raised on 168 million ha (FAOSTAT, 2017). Mexico's cattle herd of 33.5 million (Servicio de Información Agroalimentaria y Pesquera (SIAP), 2019), is distributed around half the national territory (197 million ha). It contributes 1.6% of national GDP and 43% of agricultural GDP (OECD, 2018b). In Peru, about 5.5 million cattle are raised on 18.7 million ha of land and contribute 3.1% of national GDP and 34% of agricultural GDP.

Despite its economic importance, the cattle sector is also a major source of GHG emissions, particularly as enteric methane emissions (**Table 1**). Reconciling the goals of benefiting from business and livelihood opportunities associated with cattle production while reducing GHG emissions associated with cattle production is a challenge that regional governments are grappling with. This is important considering national commitments in the Paris Agreement of the United Nations Framework Convention on Climate Change (UNFCCC) and the Sustainable Development Goals (SDGs). In this paper, we present our thoughts on whether achieving the desired reductions in enteric methane emissions is possible, and discuss the barriers and changes needed to advance toward achieving GHG emission reduction targets set under the Paris Agreement and potential contribution to the SDGs.

Previous studies have shown that emission reduction ambitions submitted under the Paris Agreement would lead to global GHG emission reductions of 52–58 $GtCO_2eq\ yr^{-1}$ by 2030. Unfortunately, this level of emission reductions will not limit global warming to 1.5°C (IPCC, 2018). Therefore, to raise the levels of ambition in terms of GHG emission reductions, more actions need to be considered by all economic sectors, including the cattle sector. The question then is whether, for the cattle sector in Latin America, ambition can be raised using

TABLE 1 | National areas dedicated to cattle production, GHG emissions and proportion of GHG emissions associated with cattle raising and GHG emission reduction in seven countries of Latin America.

Country	Statistics on the cattle production sector				References
	Land use (million ha)	National GHG emissions ($MtCO_2eq$)	Proportion of livestock-source to national GHG emissions	Emission reduction target	
Colombia	37	236.97	9.6%	20% below business as usual (BAU) scenario in 2030	IDEAM et al., 2018
Argentina	110.08	364.4	17%	Limit increase to 35% above 2010 levels by 2030	UNFCCC, 2016; Piquer-Rodríguez et al., 2018; Secretaría de Ambiente y Desarrollo Sustentable (SGAyDS), 2019
Costa Rica	1.04	11.25	19.4%	25% below 2012 levels in 2030	Chacón Navarro et al., 2015; Ministerio de Ambiente y Energía, 2015
Brazil	168	1,465.28	19.2%	Limit increase to 5% above 2010 levels by 2025	MCTIC, 2016; UNFCCC, 2016; ApexBrasil, 2018; MRE et al., 2019
Uruguay	13.3	32.36	72%	42% below BAU scenario by 2025	Instituto Nacional de Carnes (INAC), 2017; Ministerio de Ganadería, Agricultura y Pesca (MGAP), 2019; Ministerio de Vivienda, Ordenamiento Territorial y Medio Ambiente (MVOTMA), 2017; Sistema Nacional de Respuesta al Cambio Climático y Variabilidad (SNRCC), 2018
Mexico	197	534.61	13.2%	22% below BAU scenario by 2030	Instituto Nacional de Ecología y Cambio Climático (INECC), 2016; Servicio de Información Agroalimentaria y Pesquera (SIAP), 2019
Peru	18.7	169.71	6.3%	20% below 2010 levels in 2030	Instituto Nacional de Estadística e Informática (INEI), 2012; Ministerio del Ambiente (MINAM), 2016; Grupo de Trabajo Multisectorial de naturaleza temporal encargado de generar información técnica para orientar la implementación de las Contribuciones Nacionalmente Determinadas (GTM-NDC), 2018

TABLE 2 | Methane mitigation options tested in seven countries of Latin America.

Country	Region	Tested mitigation action	Potential methane emission reductions	References
Colombia	Valle del Cauca	Silvopasture	23.4% lower methane yields compared to traditional grazing systems	Molina et al., 2015
	Valle del Cauca	Improved pasture management	50.1% lower methane yields than those from degraded pastures	Gaviria Uribe et al., 2019
Argentina	Southeast Buenos Aires	Improvement of reproductive efficiency	Estimated methane emissions intensity of growing weaned calves decreased between 40 and 60% based on weaning percentages, distribution of calving and feed quality data	Ricci and Aello, 2018
	Southeast Buenos Aires	Grazing with supplements	26% lower emissions intensity of beef production than those without supplement	Ricci et al., 2018
Costa Rica	Atenas, Costa Rica	Improved forage quality	Steers fed with high quality hay during the summer months had 30% lower methane yield than those fed with low quality hay	Montenegro et al., 2016
Brazil	Rio Grande do Sul state	Grazing supplementation and crop diversification	Beef cattle fed with natural pasture plus cash crop soybean had 7 and 5% lower emissions intensities than those fed with natural pastures alone and with low supplementation, respectively	Pereira et al., 2018
Uruguay	Colonia, Uruguay	Improved grassland management	Beef cattle fed with high quality pasture had a 12% lower methane emission yield than those fed low quality pasture	Dini et al., 2018
Mexico	Yucatan Peninsula	Silvopasture	Including 40% of *Leucaena leucocephala* in a low quality grass diet decreased enteric methane emissions by 36% in cattle	Piñeiro-Vázquez et al., 2018
	Yucatan Peninsula	Silvopasture	Including 30% of ground pods of *Samanea saman* decreased enteric methane emissions from a low-quality grass-based diet by 51% in cattle	Valencia-Salazar et al., 2018
Peru	Central Andes	Improvement of forage quality	Lactating cows fed cultivated pastures during the rainy season had a 79% lower methane emission intensity than those on native pastures	Alvarado et al., 2019

current management and technological options. By focusing on key studies conducted in seven target Latin American countries, we observed that tested mitigation and technology options might have the potential to reduce absolute GHG emissions (g per day), emission yields [g per kg of dry matter intake (DMI)] or emission intensities [g per kg of live weight (LW) gain] from cattle systems (**Table 2**).

Most of the studies shown in **Table 2** demonstrate the possibility of reducing enteric methane emissions through dietary changes. However, because diet-based absolute enteric methane emission reductions have only been reported in a very limited number of studies, more options are likely to be identified with further research. In the meantime, improved herd management (e.g., to reduce the number of unproductive cattle) may be a more immediate approach to raise the level of ambition (Zhang et al., 2017). In addition, considering that other studies conducted in the region only report a reduction in emission intensities (see **Table 2**), increasing cattle numbers, as is normally the ambition at both individual farmer and national government levels, will increase incomes and definitively increase absolute emissions, unless feed options that can reduce absolute methane emissions can be identified and adopted at scale.

Numerous studies have evaluated the effects of various feed additives on methane emissions that might be of benefit to Latin American cattle producers. The use of plants containing condensed tannins has been shown to effectively reduce enteric methane emissions in cattle (e.g., Grainger et al., 2009; Piñeiro-Vázquez et al., 2018; Stewart et al., 2019), although the effect is dependent on the plant species used (Beauchemin et al., 2007) and care must be taken to prevent a reduction in diet digestibility and therefore animal productivity. However, offer potential to reduce enteric methane emissions in Latin American countries. Feeding fat and oils (e.g., Beauchemin and McGinn, 2006; Grainger and Beauchemin, 2011) offers potential to reduce enteric methane emissions and methane yields, but high concentrations of free fat (above about 6% of DMI) can have a detrimental effect on the rumen microbial population (Patra, 2013). Plant-derived essential oils have been shown to reduce methane emissions from ruminant livestock, but their mode of action is complex and poorly understood (Cobellis et al., 2016), and cost and availability limit their use. Feeding nitrate (Veneman et al., 2015) can lead to substantial reductions in methane emissions but is of limited practical value because of its potential toxic effects. Two recent novel feed additives, offered by private companies, are 3-NOP (Bovaer®, DSM Nutritional Products) and Mootral® (Mootral SA, Rolle, Switzerland) and are also of potential interest. Cattle supplemented with an average of 1.6 g 3-NOP/d enabled methane emissions reductions of between 23 and 33% (Kim et al., 2019; Van Wesemael et al., 2019). Similarly, inclusion of Mootral® in the diet at a rate of

3% of DMI showed a methane reduction of between 20 and 38% (Roque et al., 2019b). Additionally, the use of *Asparagopsis* spp., natural macroalgae used as a diet supplement, has demonstrated potential to reduce methane emissions; inclusion rates of 0.5% of DMI in dairy cow diets led to methane emission reductions of 26.4% without compromising milk yield or feed intake. Increasing the dietary inclusion rate to 1% of DMI resulted in reductions of 67.2% methane emissions (Roque et al., 2019a).

Plant breeding has long been used to improve the feeding value of forage crops and thus increase livestock productivity (Castor and Vogel, 1999). Until relatively recently, breeding targets have focused on plant yield and persistency, with nutritional value being mainly assessed as dry matter digestibility (Castor and Vogel, 1999). However, in the last 20 years or so breeding programs have started to consider other nutritional parameters that aim to reduce the environmental footprint of livestock production (Kingston-Smith et al., 2012). Tropical grass breeding is complicated by the apomictic reproduction of many of the commercially important forage species (Jank et al., 2011), although apomixis also offers a number of advantages for crop improvement (Miles, 2007). The use of improved forage species can contribute to a reduction in the environmental footprint of cattle production (Soteriades et al., 2018), but the development of forage species that can contribute to reduced emissions intensities does not automatically lead to their uptake by cattle producers.

Mitigation options such as the use of feed additives and improved forage germplasm offer an interesting way to reduce enteric methane emissions. Known responses allow for the inclusion of feed-based mitigation actions in national GHG inventories and also for setting up systems for monitoring, reporting and verifying (MRV) emission reductions. The national GHG inventories and MRV systems make it possible to connect mitigation actions with the quantification of progress in policy implementation.

SCALING CHALLENGES

Despite the availability of promising mitigation options (such as silvopastoral systems, improved pastures and feed additives) for the cattle sector in Latin America, their adoption by farmers is still limited by multiple factors (Ruiz et al., 2016; Bravo et al., 2018; Charry et al., 2018; Enciso et al., 2018). To achieve the required scale there is a need to ensure that farmers have access to inputs, capital and information. Formal grass and legume seed sale systems are underdeveloped in most Latin American countries limiting the purchase of planting material or the number of varieties available. Since the establishment of more sustainable technologies (i.e., silvopastoral systems) involves high initial costs, under capital scarce conditions formal credit systems become essential. However, in most Latin American countries, no specific credit options exist for such purposes, leaving many (and especially small- and medium-scale) producers with scarce financial resources and without opportunities for implementing mitigation options. A differentiation of meat and milk products derived from environmentally friendly production systems (e.g., Charry et al., 2019) or payments for ecosystem services could help in sourcing capital for investing in mitigation options, but efforts in that direction are still scarce and have yet to be proven as applicable at a large scale. Although the scientific community is generating valuable information on different mitigation options, it is not guaranteed that this information reaches the final users (cattle producers), especially if it is not being disseminated in a way that it is understandable to them. In addition, extension systems are weakly developed and technical assistance is scarce, coordination is usually weak among the service providers and different concepts of mitigation options being disseminated might confuse the policy makers, extension officers, and farmers. Currently, technical assistance often stops after selling an input (e.g., seeds) and does not include (post-) establishment support, leading in many cases to a wrong application of promising alternatives, negative experiences, disappointment, and a negative image of the technologies within and beyond farming communities.

In addition, new regulations aimed at formalizing the livestock sector (e.g., Decree 1500/2007 in Colombia; Díaz and Burkart, 2019) may be counterproductive (e.g., in Colombia, formal slaughtering facilities were shut down without providing alternatives, resulting in clandestine slaughtering), and can make mitigation options less attractive to producers since in an informal value chain few incentives exist to differentiate products and implement on-farm improvements. When looking at cultural and behavioral factors, many livestock producers in Latin America prefer traditional over more technical and sustainable production systems for reasons of simplicity and risk aversion. In order to overcome this barrier and to find entry points with those producers, the dissemination of information on the economic, social, and environmental benefits of mitigation options becomes even more critical. For both the dissemination of information and policy formulation, it is likewise important to understand how livestock producers make decisions, i.e., regarding the adoption of technologies and mitigation strategies, and how their decision-making process is influenced by e.g., trust (in the information provided or in its sources), risks, social networks and socio-cultural contexts. Although this is a growing field of research with interesting approaches (e.g., Robert et al., 2016; Singh et al., 2016), evidence has so far mainly been provided for agricultural (e.g., Stuart et al., 2014; de Sousa et al., 2018; Azadi et al., 2019; Gatto et al., 2019) and non-bovine livestock production (e.g., Jones et al., 2013; Ambrosius et al., 2019; Hidano et al., 2019), and only to a limited extent for (bovine) livestock production in Latin American countries (e.g., Martínez-García et al., 2013; Rossi Borges and Oude Lansink, 2016). This indicates a knowledge gap which needs to be addressed in order to assure a more widespread adoption of mitigation strategies. This brief description of scaling challenges suggests that even when the right management and technological options have been identified, there is a need to explore new and holistic mechanisms for effective communication and adoption at system level for achieving impact at a larger scale. Policymakers, in that regard, should aim to enact policies adapted to the underlying farmer decision-making context.

As described in the previous section, besides silvopastoral and improved pasture systems and management, other technologies such as feed additives can help to reduce methane emissions in livestock production. Although they seem to be promising alternatives for effectively reducing methane emissions, their suitability needs to be evaluated for the Latin American context (especially for open grazing systems). In beef-cattle grazing systems, it might be difficult to apply the required doses to animals in the field and ensure proper intake of the active compounds, since the animals move around freely while they are not being kept indoors. In dual-purpose and intensified milk production systems, the application seems to be easier. At a first glance, feed additives seem to be a less costly mitigation option than the implementation of e.g., silvopastoral systems but detailed cost-benefit analyses for the Latin American context, comparing feed additives with other mitigation options, would be needed for providing clear information for decision-making at the farm level. Measuring, reporting and verifying the reduction of enteric methane emissions and the definition of payments for ecosystem services is likely to be easier (i.e., imputation of methane emission reduction by effective intake of the additive) when using feed additives in a determined quantity, than under grazing conditions in a silvopastoral or improved pasture system where the animals move around freely and have different forage consumption patterns and preferences. This makes feed additives an interesting additional mitigation option that should be considered in future studies, as well as in the implementation of projects and public policies related to GHG mitigation in the Latin American livestock sector.

TARGETED POLICIES

Latin America has a significant opportunity to accelerate the transformation of its cattle sector through a wide implementation of novel technological options, such as the use of alternative feed options (Chirinda et al., 2017). However, such options require the decisive actions and support of governments at local and national levels and the engagement of both the private sector and all key local institutions (Serna et al., 2017). Currently, there are limited farm level climate change mitigation actions as farmers, as well as policy makers, have to manage potential trade-offs between climate change mitigation and socio-economic costs such as decreased food availability (Havlík et al., 2014). We contend that systemic and coordinated immediate science-based actions will contribute to the achievement of climate change goals. In addition, there is a need for robust and effective policies targeting both the demand and supply-side of cattle value chains (Scherer and Verburg, 2017).

Although policies are key (e.g., national low carbon development plans and Nationally Appropriate Mitigation Actions), cattle producers need to play their part to transform the sector into an active contributor of GHG emissions reduction in the region. By combining policies that facilitate short-term efficiency gains with solution-oriented mindsets amongst researchers, livestock stakeholders and farmers, we may be able to leverage significant changes for the Latin American cattle sector. Challenges remain regarding widespread adoption of proven technologies due to barriers to implementation such as cultural issues, access to finance, lack of private investment, and traditional mind-sets that are often misaligned to current realities. There is an important opportunity to bring behavioral and social sciences to work together in addressing such challenges in order to acquire an in-depth understanding of crucial factors that prevent the adoption of low emissions technologies (e.g., Jones et al., 2013; Martínez-García et al., 2013; Stuart et al., 2014; Rossi Borges and Oude Lansink, 2016; de Sousa et al., 2018; Azadi et al., 2019; Gatto et al., 2019).

Clear public policies focused on GHG mitigation in cattle production systems are pivotal for the success of national mitigation actions. It may be possible to enforce several mitigation actions at the farm level, but public or private farmer support services are crucial for supporting the implementation of new technologies. Moreover, acknowledging that countries are committed to contribute to the Paris Agreement and the SDGs is crucial (Kanter et al., 2016). A sustainable cattle production would contribute to various SDGs such as: (i) Climate Action (SDG 13) limiting GHG emissions; (ii) Life on Land (SDG 15) reducing deforestation, and (iii) Zero Hunger (SDG 2) through the increase in productivity and income of cattle producers. However, as indicated above, an increase in cattle production through increased animal numbers would result in increased absolute methane emissions unless efficiency of production is also increased. Policy development, therefore, must take into account ways of improving cattle productivity that lead to reduced emissions intensities, for example using better diets to increase growth rates and increase stocking densities to allow less land to be used for a certain level of productivity. Better fed animals are faster growing, healthier, and produce lower GHG emissions per kg of beef or milk produced.

KNOWLEDGE AND EXPERIENCE SHARING

To achieve the set ambitions, existing knowledge, experiences, and expertise should be continuously harnessed to build technical and research capacities in the region. Concurrently, to reduce experimental costs, there is a need to promote south-south knowledge exchange as well as sharing of analytical infrastructure (Rosenstock et al., 2016). This, together with increased research and development funding, will ensure that more promising options for reducing enteric methane are discovered, identified, tested and promoted (Gerber et al., 2013). This is important as it appears that both a lack of understanding of technical and management options to reduce GHG emissions, scaling mechanisms and financing are challenges that generally limit progress toward ambitious climate change mitigation targets (Brown et al., 2008). Yet, through knowledge and experience sharing, countries can learn from each other and thus jointly progress. Such exchanges should also include lessons learned and experiences that could provide insights on institutional mechanisms that can enable change at different scales and by different stakeholders.

CONCLUDING REMARKS

Considering cattle only as a large source of GHG emissions would be an incomplete assessment. Their contribution to food production and rural economies are just two of the other dimensions that need to be considered. However, it is also undeniable that cattle is a major contributor to GHG emissions from the AFOLU sector for most Latin American countries and it would be practically impossible to achieve national emission reduction targets without considering significant reductions from the cattle sector of Latin America. A range of technologies and agronomic practices exist to improve farm level efficiency. A real challenge is to increase productivity without also increasing methane emissions. From our perspective, achieving the desired reductions in enteric methane emissions is feasible but there is a need to consider a set of high leverage actions to increase access and adoption of novel technological options and incentivize behavioral change.

DATA AVAILABILITY STATEMENT

All datasets generated for this study are included in the article/supplementary material.

AUTHOR CONTRIBUTIONS

JA was responsible for guiding the entire process of drafting and analyzing national goals, as well as completing the next steps of research in the area of GHG mitigation in livestock production. AR was in charge of collecting information sent from all countries, summarizing, analyzing, and ordering it in the paper, as well as collaborating in the search for additional information. AL and DM-B were in charge of guiding the meaning that the perspective paper would have from the political-administrative point of view. JK-V, PR, CG, WO, MC, AB, and CT were the researchers in charge of collecting information on livestock production, greenhouse gas emissions, mitigation goals, and mitigation strategies of the countries of Mexico, Argentina, Peru, Uruguay, Costa Rica, Brazil, and Colombia, respectively. SB was responsible for carrying out the socioeconomic analysis and contributing to the perspectives that GHG mitigation research should have in Latin America. JM was responsible for giving a logical order to the brief, as well as providing tools for presenting the results of the review. NC was responsible for consolidating national mitigation objectives in all countries and generating a logical order in presenting the results of the review.

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The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.