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Research Paper

Impact of Cow Milk Production from Latin America on Greenhouse Gas Emissions

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ABSTRACT: *The lack of research from a Latin American perspective on greenhouse gas emissions (GHG) from cow milk production hinders the design of specific policies that will tackle the problems in this region. The present paper intends to fill in this gap by analyzing statistical information from FAOSTAT, with the aim to find the specific problems that contribute to GHG emissions from Latin America. The main objective of this paper is to review estimates of GHG emissions from dairy production from Latin America, so that more informed decisions in the face of climate change. Results show that milk production does not have such an important effect on GHG production than meat production. On the other hand, countries that import meat may consider the ecological footprint of their meat consumption, since it is an important contributor to GHG production.*
Keywords: *dairy production, methane, greenhouse gas, global warming, climate change*

I. INTRODUCTION

In the last 150 years, the concentration of greenhouse gases (GHG) has increased significantly. The most important greenhouse gases are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_20) [1]. Development of land for agriculture and agricultural production account for 25%, 65% and 90% of total anthropogenic emissions of these gases respectively [2].

Livestock accounts for and increasing quantity and a significant proportion of GHG gas emissions [3]. “Livestock’s Long Shadow” [4] reports that “livestock are responsible for much larger shares of some gases with far higher potential to warm the atmosphere. The sector emits 37% of anthropogenic CH_4 (with 23 times the global warming potential (GWP) of CO_2) most of that from enteric fermentation by ruminants.” After 10 years, a revision of these estimates is called for.

More recently, [3] claims that a life cycle analysis for quantifying emissions from livestock is not enough, since it fails to consider land use changes. Cederberg et al. [5] call for including carbon emissions from deforestation in the carbon footprint of Brazilian beef. In general, there is an effort to calculate better estimations to the impacts of livestock on GHG.

As for milk production, the most complete analysis is a study by Gerber et al. [6], which claims that in 2007, the dairy sector emitted around 1969 million tonnes of CO_2-eq, of which 67% were attributed to milk, 8% to meat from culled animals, and 25% to meat from fattened calves. These emissions contribute to about 4% of total anthropogenic GHG emissions [6]. Although this study has some disaggregated charts by continent, and the importance of the contribution of Central and South American countries is stated, the data does not include accurate numbers or disaggregation by country.

The lack of research from a Latin American perspective hinders the design of specific policies that will tackle the problems in this region. The present paper intends to fill in this gap by analyzing statistical information from FAOSTAT (http://www.fao.org/faostat/en/), with the aim to find the specific problems that contribute to GHG emissions from Latin America. The main objective of this paper is to review estimates of GHG emissions from dairy production from Latin America, so that more informed decisions in the face of climate change. The abovementioned objective is intended to be reached by answering the following questions:

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1. What is the contribution of dairy milk production on GHG emissions from Latin America?
2. What is the contribution of dairy milk production vs. meat production on GHG emissions from Latin America?
3. What policy recommendations can be made to Latin American governments and international agencies based on the answers to the three previous questions?

II. RESULTS

2.1 The contribution of milk production on GHG emissions

To place emissions of GHG from milk production in a wider context, an analysis of GHG production from agriculture was made. As can be seen in Table 1, enteric fermentation, manure management and manure left on pasture account for 60% of world GHG emissions and only enteric fermentation accounts for 39% of these emissions. These are specific to livestock production, but other items can be assigned to both plant and animal production, such as manure applied to soils. The main sources of N_20 include nitrogen fertilizers, animal manure and urine [1].

Table 1. World GHG emissions by item, 2014 (gigagrams of CO_2Eq)

Source	Total GHG	%	CH_4	%	N_2O	%
Enteric Fermentation	2,085,145	40	2,085,145	40		
Manure Management	351,813	7	204,962	4	146,850	3
Rice Cultivation	523,826	10	523,826	10		
Synthetic Fertilizers	659,762	13			659,762	13
Manure applied to Soils	191,826	4			191,826	4
Manure left on Pasture	845,645	16			845,645	16
Crop Residues	211,806	4			211,806	4
Cultivation of Organic Soils	132,815	3			132,815	3
Burning - Crop residues	29,747	1	21,513	0.4	8,233	0.2
Burning – Savanna	213,438	4	90,909	2	122,529	2
Total	**5,245,823**	**100**	**2,926,355**	**56**	**2,319,468**	**44**

Source: FAOSTAT (2016)

CH_4 is the largest contributor to total GHG emissions from dairy production [6]. If there is an interest in mitigating the CH_4 production from the dairy sector, segregating CH_4 production by region and country may aid in guiding policies towards this objective. Table 2 presents CH_4 production via enteric fermentation from by region. Enteric fermentation from dairy cattle in South America accounts for 21% of the World total, second only to Asia and the most important contribution in the American continent. Central America accounts for only 3%. This is because there are about 7 times more cattle in South America than in Central America.

Table 2. World enteric fermentation by region, 2014

Region	Total enteric fermentation (gigagrams of CO2Eq)	Percentage
Asia	793,176	38
South America	451,671	22
Africa	334,273	16
Europe	220,787	11
Northern America	135,798	7
Oceania	72,745	3
Central America	63,792	3
Caribbean	12,904	1
Total (World)	**2,085,145**	**100**

Source: FAOSTAT (2016)

The rumen is the most important source of CH_4 production, especially in cattle husbandry, but a substantial amount is also produced by cattle manure [1]. Enteric fermentation in ruminants (including small and large ruminants) accounts for 90% of the total emissions. Thus, monogastrics represent a small portion of emissions (see Table 3). In monogastrics, most CH_4 originates from manure [1]. Among ruminants, non-dairy cattle account for more than half of methane and CO_2-eq emissions (Table 3).

The location of ruminants by region will allow better policy design for mitigation of CH_4 production. As can be seen in Table 4a, South America is the second most important regions in terms of CH_4 emissions from domestic animals and for cattle, but most of these come from non-dairy cattle. Moreover, Cederberg et al. [5] claim that land use change due to deforestation for beef production in South America is the source of about 6% of global anthropogenic GHG emissions.

Table 3. World CH_4 emissions from enteric fermentation by type of animal, 2014 (gigagrams of CO_2Eq)

Type of animal	**Heads**	**Emission factor**	**Emissions (CH4) Enteric**	**Emissions (CO2eq) (Enteric)**
	(Thousands)	**(kg/head)**	**(gigagrams)**	**(gigagrams)**
Asses	44,126	10	441	9,266
Buffaloes	195,098	55	10,730	225,339
Camels	27,777	46	1,278	26,833
Cattle (dairy)	279,585	67.74	18,939	397,711
Cattle (non-dairy)	1202,559	44.53	53,555	1124,655
Goats	1006,786	5	5,034	105,713
Horses	58,914	18	1,060	22,269
Llamas	8,894	29.5	262	5,510
Mules	10,082	10	101	2,117
Sheep	1209,908	5.59	6,766	142,089
Swine (breeding)	98,665	1.14	113	2,364
Swine (market)	887,984	1.14	1,013	21,279
All Animals	**5030,378**	**20**	**99,293**	**2085,145**

Source: FAOSTAT (2016)

In terms of CH_4 emissions from dairy cattle, South American comes in fourth, after Asia, Europe and Africa. Even though Asia has a higher rate of CH_4 emissions, it produces less methane per animal (see Tables 4b and 4c).

Table 4a. World CH_4 emissions from cattle enteric fermentation by region, 2014 (gigagrams of CO_2Eq)

Region	**Cattle dairy**	**Cattle non dairy**	**Total cattle**	**Total all animals**
Asia	133,543	295,535	429,078	793,176
Europe	86,217	102,352	188,568	220,787
Africa	71,879	153,551	225,429	334,273
South America	55,793	372,084	427,877	451,671
Northern America	26,911	100,988	127,899	135,798
Oceania	12,478	42,346	54,823	72,745
Central America	9,061	48,222	57,283	63,792
Caribbean	1,829	9,579	11,408	12,904
World	**397,711**	**1124,655**	**1522,366**	**2085,145**

Source: FAOSTAT (2016)

Table 4b. Heads (thousands) of cattle by type and region, 2014

Region	**Cattle dairy**	**Cattle non dairy**	**Total cattle**	**Total all animals**
Asia	106,845	391,703	498,549	2452,435
Africa	74,409	235,869	310,278	1104,611
Europe	37,615	85,097	122,711	462,038
South America	36,900	316,398	353,298	536,188
North America	10,012	90,735	100,747	201,035
Oceania	6,602	33,608	40,210	152,394
Central America	5,993	41,005	46,998	100,204
Caribbean	1,210	8,145	9,355	21,472
World	**279,585**	**1202,559**	**1482,144**	**5030,378**

Source: FAOSTAT (2016)

Table 4c. Implied emission factor by type of cattle and region, 2014 (kg CH4/head)

Region	Cattle dairy	Cattle non dairy	Total cattle	Total all animals
North America	128	53	60	32
Europe	109.15	57.3	73	23
Oceania	90	60	65	23
Central America	72	56	58	30
Caribbean	72	56	58	29
South America	72	56	58	40
Asia	59.5	35.9	41	15
Africa	46	31	35	14
World	**67.7**	**44.5**	**49**	**20**

Source: FAOSTAT (2016)

Since South America is the second region in terms of enteric fermentation, a disaggregation by country is called for. As can be seen in Table 5a, Brazil is by far the biggest producer of anthropogenic CH_4 in the South American region, for both dairy and non-dairy cattle. Brazil is the world´s second largest beef producer and the first in beef exports [5]. It is also, by far, the South American country with the most heads of cattle (Table 5b).

Table 5a. CH_4 emissions from enteric fermentation in South America by country, 2014 (gigagrams of CO2Eq)

Country	Cattle dairy	Cattle non dairy	Total cattle
Argentina	3,358	58,124	61,482
Bolivia	286	10,203	10,489
Brazil	34,802	222,648	257,450
Chile	1,538	2,332	3,870
Colombia	8,079	22,183	30,261
Ecuador	1,714	4,082	5,795
Falkland Islands	3	3	6
French Guiana	1	21	22
Guyana	58	88	146
Paraguay	368	16,725	17,093
Peru	1,206	5,622	6,828
Suriname	2	41	43
Uruguay	1,155	12,743	13,898
Venezuela	3,223	17,269	20,492
Total	**55,793**	**372,084**	**427,877**

Source: FAOSTAT (2016)

Table 5b. Heads (thousands) of cattle by type and country, 2014

Country	Cattle dairy	Cattle non dairy	Total cattle
Argentina	2,221	49,426	51,647
Bolivia	189	8,676	8,865
Brazil	23,017	189,327	212,344
Chile	1,017	1,983	3,000
Colombia	5,343	18,863	24,206
Ecuador	1,134	3,471	4,604
Falkland Islands	2	3	4
French Guiana	1	18	18
Guyana	38	75	113
Paraguay	243	14,222	14,466
Peru	798	4,781	5,578
Suriname	2	35	36
Uruguay	764	10,836	11,600
Venezuela	2,131	14,685	16,816
Total	**36,900**	**316,398**	**353,298**

Source: FAOSTAT (2016)

Brazil also produces more enteric fermentation per head of cattle than any other country in the region (See Table 6). Therefore, executing policies in Latin America without considering the particularities of Brazil may not be as effective as even a single-country policy within Brazil.

Table 6. Enteric fermentation by head of cattle in South America, by country, 2014

Country	Heads (Thousands)	%	Total enteric fermentation (gigagrams of CO2Eq)	Ent. Ferm. by head (Kg of CO2Eq)
Argentina	51,647	15	65,016	1259
Bolivia	8,865	3	14,180	1600
Brazil	212,344	60	265,069	1248
Chile	3,000	1	4,437	1479
Colombia	24,206	7	30,928	1278
Ecuador	4,604	1	6,055	1315
Falkland Islands	4	0	80	18,508
French Guiana	18	0	22	1216
Guyana	113	0	170	1501
Paraguay	14,466	4	17,307	1196
Peru	5,578	2	12,349	2214
Suriname	36	0	46	1268
Uruguay	11,600	3	14,922	1286
Venezuela	16,816	5	21,091	1254
Total	**353,298**	**100**	**451,671**	**1278**

Source: FAOSTAT (2016)

2.2 Milk vs meat production in Latin America

As was found in the previous section, meat production emits considerably more GHG than milk production. Nonetheless, an analysis of milk yield should also be made in order to fully understand the differences among regions. As can be seen in Table 7, North America as a region is more productive per animal in terms of milk production. Notwithstanding, milk yield in Asia is even lower than in Latin America.

Table 7. Milk production by region, 2013

Country	Milk animals	%	Production quantity (tonnes)	%	Milk yield (hg/An)
Africa	74,181,466	27	36,720,566	6	4950
Northern America	10,178,800	4	99,666,528	16	97916
Central America	5,903,989	2	14,687,010	2	24876
Caribbean	1,204,580	0	1,758,271	0	14597
South America	36,933,385	13	69,115,338	11	18714
Asia	105,874,328	38	177,475,135	28	16763
Europe	37,546,461	13	210,277,938	33	56005
Oceania	6,525,201	2	28,475,109	4	43639
Total (World)	278,348,210	100	638,175,895	100	22927

Source: FAOSTAT (2016)

Milk production yield can also be contrasted to meat production yield. Asia has more heads of non-dairy cattle, but South America produces at a higher yield than Asia (See Table 8). North America does not have a high number of heads for meat production, but its yield is considerably higher than in all other regions. Regardless of this, meat production (measured in tonnes) is highest in Latin America than in any other region (Table 8).

Table 8. Meat production by region, 2013

Country	Heads (Thousands)	%	Production (Tonnes)	Yield (hg/An)
Africa	36,104	12	5,907,271	1560
Northern Am.	35,253	12	12,754,389	3502
Central Am.	12,250	4	2,264,038	2020
Caribbean	1,325	0.4	238,226	1798
South Am.	69,370	23	15,617,999	2266
Asia	89,833	30	14,373,105	1564
Europe	40,614	14	10,140,072	2473
Oceania	12,210	4	2,901,429	2512
World	**296,959**	**100**	**64,196,529**	**2138**

Source: FAOSTAT (2016)

Since meat production in Latin America is high when compared to all other regions, it is important to consider whether this meat is consumed locally or exported. As can be seen in Table 9, meat from Latin America is exported more than in any other region, mostly in the form of boneless meat. Therefore, country policies aimed at local consumption of meat are not enough. It is important to consider consumption practices in importing countries. More research is needed in order to better understand meat exporting practices and to better address this issue.

Table 9. Meat imports and exports by region, 2013

Country	Meat (cattle)		Boneless meat	
	Exports	**Imports**	**Exports**	**Imports**
Africa	44,026	12,922	50,289	308,790
Northern Am.	73,326	143,708	908,818	819,330
Central Am.	11,117	47,664	184,006	184,271
Caribbean	2,951	186	136	23,551
South Am.	12,849	46,293	1,722,539	402,239
Asia	312,726	45,141	123,796	1,980,711
Europe	1,236,991	1,357,516	1,010,732	1,739,088
Oceania	3,699	123,666	1,409,538	24,174
World	**1,697,685**	**1,777,096**	**5,409,854**	**5,482,154**

Source: FAOSTAT (2016)

The specifics of each country can also be considered. Table 10 shows that Brazil is the South American country with the most amount of heads and meat production, but not in meat yield per animal. The vast majority (68%) of meat exports from South America come from Brazil. Another issue to be addressed is that non-dairy meat in Brazil is extensive. Cederberg et al. [5] believe that increased production in Latin America for export has been the main driver of pasture expansion and deforestation, and therefore should be included in carbon footprint calculations for beef exports.

Table 10. Cattle meat production, imports and exports in South America, by country, 2013

Country	Heads (Thousands)	%	Yield (hg/An)	Meat production (Tonnes)	Cattle Meat (Tonnes)		Boneless meat (Tonnes)	
					Exp.	**Imp.**	**Exp.**	**Imp.**
Argentina	12,627,541	18	2235	2,821,700	4,106		124,986	128
Bolivia	1,122,234	2	1939	217,601	28		1,972	
Brazil	42,273,750	61	2326	9,832,874	10,253	4,558	1,174,280	37,434
Chile	791,143	1	2608	206,330	357	459	1,412	172,532
Colombia	4,292,248	6	2092	897,835	7,536		25,483	594
Ecuador	1,277,988	2	2038	260,454		9		60
Falkland Is.	600	0	2610	157				
French Gui.	2,370	0	1498	355				
Guyana	12,280	0	1839	2,258		6		
Paraguay	1,468,744	2	2544	373,648	1,500	28	180,000	1,257
Peru	1,299,887	2	1466	190,563	2	77	44	3,941
Suriname	9,179	0	1773	1,627		1		78
Uruguay	2,682,592	4	2016	540,811	22,511		214,322	846
Venezuela	1,509,869	2	2375	358,594		7,711		185,369
Total	**69,370,425**	**100**	**2264**	**15,704,808**			**1,722,539**	**402,239**

Source: FAOSTAT (2016)

2.3 Possible solutions

To cover and assess the wide array of options for reducing GHG emissions stemming from livestock would be beyond the limits of this paper, but this section will attempt at showing the variety of possible solutions and the logic behind them. Opportunities can include reducing emissions, enhancing removals and avoiding emissions [7]. Table 11 summarizes recommendations by different authors. On one end of the spectrum, Garnett [3] claims that cutting meat and dairy consumption is necessary to decrease animal production and therefore to reduce anthropogenic GHG emissions. Monteny et al. [1] propose complete manure removal from animal housing for biogas production. Another issue to consider is the cost-effectiveness of these options, where farm-level modelling could play a role [8]. Gerber et al. [9] emphasize that efforts should target both single practices with highest potential and also develop combinations of effective mitigation practices tailored for specific production systems that take into account the interaction between them.

Table 11. Mitigation strategies for GHG emissions from animal production

Recommendation	Reason	References
Reduce consumption of meat and dairy	Animal food products carry the greatest environmental burden	[3]
Measuring the carbon footprint	Avoid misleading information to policymakers and consumers	[5]
Changing animal diets	More efficient use of feed	[1]
Feed additives	Allows mitigation of CH_4 production via better digestion	[9]
Intensive silvopastoral systems	Maximizing the transformation of solar energy into biomass	[10,12]
Grazing management practices	Improving these practices can enhance carbon sequestration	[9]
Produce energy from manure	Optimal use of the energy in the food chain	[1]
Farm-level modelling	Development of cost-effective options	[8]

Another line of researchers recommend agroforestry and silvopastoral systems [10], the use of pastures with deeper penetrating roots, better integration of plant and animal production, the use of fodder trees, more efficient use of water, intensive pastoral systems, agricultural extension practices, and incentives to producers.
In terms of animal production, one aim is to optimize milk production per animal per day. This is because emissions of CH_4 are inversely proportional to milk production [11]. Nonetheless, there is a wide array of options available to policy makers and agricultural extensionists in Latin America for GHG emission reduction, including the ones reviewed in this section.

III. CONCLUSION

This study has two main conclusions. The first is that milk production does not have such an important effect on GHG production than meat production in Latin America. The second is that countries that import meat may consider the ecological footprint of their meat consumption.

As for milk production, the best way to deal with methane emissions is with more efficient production systems, that is, to produce more kg of milk per animal per day. Decreasing consumption of meat may be necessary to decrease GHG emissions stemming from animal production, but other practices may also be implemented. These may include silvopastoral systems and biogas production.

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