Absolute Environmental Sustainability of Milk Production in Brazil with a focus on climate change mitigation

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1. INTRODUCTION

Brazil is the fourth largest producer of bovine milk in worldwide (35 million tons in 2022) (FAOSTAT, 2023). Given the importance of the dairy sector, there is growing concern not only regarding the associated impact per unit of delivered product, but also with respect to the impacts in absolute terms (Hjalsted et al. 2021). This study aimed to assess the Absolute Environmental Sustainability Assessment (AESA) of climate change (CC) impacts for different dairy production systems in Brazil.

2. METHODS

An assessment was carried out in 2021 on 314 dairy farms in Brazil, encompassing: compost-bedded pack barns, free-stall, grazing, organic, and semi-confinement. All systems were approached from cradle-to-farm perspective, with the functional unit of 1kg of fat and protein correction milk (FPCM). Biological allocation was applied to address system multifunctionality using the OpenLCA v.1.11.3 software tool with background data extracted from the ecoinvent v. 3.9 cut-off database. Greenhouse gas emissions were estimated and calculated according to IPCC (2019) impact factors. The CC impact per kg FPCM of each production system was multiplied by the total annual production of kg FPCM milk for the respective farms. This allowed for the determination of the total annual impact of each milk production system. AESA approach (Hjalsted et al., 2021) was performed in two steps: 1) downscaling: share of Safe Operating Space (SOS) was reduced to the individual level (SoSOSi) through the principle of equal sharing per capita. Thus, the SoSOSi was the value of 0.52ton CO_2 eq/cap/year (Bjorn; Hauschild, 2015); and 2) upscaling: expansion of the SoSOSi value to the dairy farms. This calculation accounted for the share of the Brazilian dairy sector (SoSOSs) by employing the Gross Domestic Product (GDP) of national milk production as a proxy relative to the country's overall GDP. Thus, it was possible to calculate the SOS of the farms (SoSOSf) using the percentage representation of the production of the analyzed farms into the share of national milk production. Finally, Absolute Sustainability Ratio (ASR) was calculated by dividing the total current impact by the farms' share of SoSOSf.

3. RESULTS AND DISCUSSION

The Absolute Environmental Sustainability (ASE) was not achieved for any dairy production system (Table 1). This implies that the current impacts of the farms surpassed the SoSOSs threshold quota. Among the evaluated systems, the compost-bedded pack showed barn the lowest index (36.30), while the grazing (55.99) and organic (59.84) system registered the highest, representing 22% of difference. Organic systems have specific characteristics and can include both semi-confinement and grazing. A production system can only be deemed the ASE if the ASR is less than or equal to 1, ensuring that the total impact of the farms falls within the assigned SoSOS quota for farms. Hjalsted et al. (2021) also revealed a quota exceedance for the Indian and Danish dairy sector, when applied ASR with the principle of equal per capita. In addition, given that enteric fermentation is one of the main contributors to the impacts of CC, implementing actions to reduce the associated emissions can assist in their reduction and bring the evaluated systems closer to the SoSOSs quota. Thus, for the systems to achieve AS, the average CC impact across all production systems must be less than 0.022 kg CO_2 eq/kg FPCM emitted.

4. CONCLUSIONS

In this assessment, we specifically focused on the ASR for CC, considering the different types of production systems. The findings revealed that all evaluated systems surpass the SoSOSf share allocated for the farms. Therefore, it is crucial to underscore those methodological choices, such as selecting sharing principles, can affect in the results interpretation. Consequently, to mitigate uncertainties and enhance the robustness of future studies, it is recommended to broaden the scope of analyses, including exploring alternative sharing methods and incorporating more pertinent impact categories to the dairy sector.

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Table 1. Description of the results: climate change (CC) impact, total production of fat and protein corrected milk (FPCM) and absolute Sustainability Ratio (ASR)

Production System	Mean (kg CO_2 eq/kg FPCM)	Total Production (kg FPCM/year)	Total farm (kg CO_2 eq /kg FPCM/year)	ASR
Compost-bedded pack barns (n = 61)	$9.80x10^{-1}$	71028366.77	$5.43x10^{7}$	38.30
Free-stall (n = 10)	$1.09x10^{0}$	12221048.05	$1.05x10^{7}$	38.09
Organic (n = 20)	$1.70x10^{0}$	5534280.32	$7.44x10^{6}$	59.84
Grazing (n =58)	$1.80x10^{0}$	24299231.23	$3.06x10^{7}$	55.99
Semi-confinement (n = 165)	$1.33x10^{0}$	60443202.18	$7.07x10^{7}$	52.08

Table 2. Variable data used for calculating ASR.

Variable	value	Unit	Source
SOS/per capita (CC)	0.522	ton CO_2 eq/cap/year	Bjorn & Hauschild (2015)
Brazil's population	213317639.	people	FAOTAT (2023)
Brazil GDP 2021	9012141999300	R$	IBGE (2021) https://www.ibge.gov.br
Milk GDP (value production)	67987725000	R$	