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Toward Environmentally Optimal Cattle Systems in Rwanda: A Comparative Analysis with Emphasis on Brachiaria-Based BNI Pastures

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Abstract

Livestock systems in Rwanda face pressure to intensify amid growing environmental, economic, and climate-related demands. Zero-grazing (cut-and-carry) modelshave been promoted for their perceived efficiency and methane mitigation potential, but these assumptions often rely on idealized view of productivity and fail to take into account full-system costs, including labor, land use, and reproductive inefficiencies. This paper compares four cattle rearing systems; extensive, semi-intensive, zero-grazing, and Brachiaria-based pasture systems enhanced by Biological Nitrification Inhibition (BNI) using environmental, productivity, and economic indicators. Annualized milk yield, labor burden, land use efficiency, and GHG emissions are evaluated using field data, national policy estimates, and published studies. Results reveal that zero-grazing systems produce an average of 540–600 liters of milk per cow per year, despite intensive feeding and year-round labor. In contrast, SACPP's BNI-enhanced pasture system averages ~2,700 liters per cow per year, with minimal external inputs and lower environmental burden. Both systems support ~5 cows per hectare annually, but the Brachiaria pasture achieves this without tillage, erosion, or feed transport costs. Metrics like GWP★ are used to assess methane's true impact, showing that systems with stable herd sizes may be climate-neutral or cooling over time. We recommend incorporating annual yield, labor return, and land-use efficiency as standard metrics for livestock evaluation. BNI-enhanced grazing systems offer a credible, regenerative path forward for Rwanda balancing productivity with climate resilience, soil health, and farmer viability.

Keywords: *Livestock, Methane, GWP★, Brachiaria, BNI, Rwanda, Pasture systems, Zero-grazing, Sustainability*

1.0 Introduction

Ruminant livestock are a cornerstone of rural livelihoods in Rwanda and also a growing concern in Rwanda's climate and land use planning. Rwanda's agricultural strategies have ranged from zero-grazing policies to feed subsidies. Additionally the strategy has leaned heavily on intensification, largely through programs by outside entities and the Rwanda Governments Girinka program among other related livestock development efforts. These shifts have been driven by the need to increase productivity, reduce land degradation, and align with international climate commitments.

Yet the environmental impact of cattle rearing is far from uniform. Extensive grazing systems, semi-intensive approaches, and stall-fed cut-and-carry systems each interact differently with Rwanda's soils, vegetation, water resources, and atmospheric emissions. Metrics like greenhouse gas emissions per animal or per liter of milk are often used to compare these systems, but they rarely capture the full ecological picture particularly in a landscape as topographically and agronomically diverse as Rwanda.

This paper investigates the environmental performance of four cattle rearing systems, with special attention to a lesser-studied but promising approach: pastures based on Brachiaria species exhibiting Biological Nitrification Inhibition (BNI). By basing information from published literature, national policy documents, and preliminary data from SACPP Farm Services in Ngoma District, this study aims to identify the most environmentally beneficial livestock management strategies in the Rwandan context.

2.0 Overview of Cattle Rearing Systems in Rwanda

2.1 Extensive Grazing: Still practiced in parts of Eastern Province and rural pockets elsewhere, extensive grazing involves open land use, herd mobility, and low external input. It often takes place on communal or marginal land. While it is sometimes portrayed as environmentally damaging due to overgrazing or erosion, it can also be low-emission and sustainable under good management.

2.2 Semi-Intensive Systems: These systems represent a middle ground: animals may be tethered or enclosed but graze part-time and receive some supplemental feed. Manure is partly recycled, and productivity tends to be higher than in extensive systems. These systems vary widely depending on farmer resources and land access.

2.3 Zero-Grazing (Cut-and-Carry): Widely promoted under Girinka and related programs, zero-grazing systems rely on stall feeding. Farmers must grow or purchase fodder, and manage waste manually. The rationale is to reduce land pressure and methane emissions per unit of milk, but these systems often come with hidden costs: fossil fuel use, erosion on fodder plots, nutrient imbalances, and high labor demands.

2.4 Brachiaria-BNI Pasture Systems (SACPP Model): Using Brachiaria (Urochloa) species that are native to Africa and have been used with succes in Rwanda among other African nations, and extensively in South America an emerging system has emerged using Biological Nitrate Inhibition as a managment cornerstone. This has been demonstrated at the SACPP Farm in Ngoma district. This model integrates Brachiaria species known for BNI traits into rotational grazing. These grasses provide high-quality forage and also suppress soil nitrification, reducing nitrous oxide emissions and nitrate leaching. While not yet in common use in Rwanda, this approach is a potential hybrid system: it retains the land-based, low-input character of grazing while offering measurable environmental benefits.

3.0 Environmental Indicators and Methodology

This analysis evaluates the environmental impact of each production system based on the following indicators:

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- Greenhouse Gas Emissions (CH_4/N_2O)
- Nitrogen Cycling and Loss
- Land Use and Erosion Risk
- Input Dependency
- Soil Health and Biodiversity
- Annual Milk Yield (liters/cow/year)
- Carrying Capacity (cows/ha/year)
- Farmer Economic Benefit (net return)

The data sources included peer-reviewed studies, national livestock planning documents, and operational data from SACPP. Annualized milk yield estimates reflect realistic reproductive performance, including calving intervals and lactation lengths. Emissions are assessed using GWP★.

Table 1: Results and Comparative AnalysisCattle Systems Comparison

System	Annual Milk Yield (L/cow)	Carrying Capacity (cows/ha)	GHG Emissions (CH4/N2O)	Land Use Pressure	Farmer Economic Return
Extensive Grazing	700–1,200	0.5–1.0	Low/stable (GWP★)	Low (communal)	Low (minimal input)
Semi-Intensive	1,200–1,800	1.5–2.5	Moderate	Moderate	Moderate
Zero-Grazing	540–600	~5.0	High (esp. N2O)	High (feed crops)	Variable (input dependent)
Brachiaria-BNI (SACPP)	~2,700	5.0	Stable or cooling (GWP★)	Low (rotational)	High (low input, high yield)

SACPP averages 10 L/day over 300 days, with a 13.5-month calving interval. Annualized yield is ~2,700 L/cow/year. The government target for cut-and-carry is 5 cows/ha, but SACPP achieves this through managed pasture rather than cropped feed.

4.0 Discussion and Recommendations

The comparison across systems demonstrates an important misalignment in livestock development: policies aimed at maximizing per-animal productivity while often not quantifying broader environmental and economic realities. Zero-grazing systems are widely promoted for their theoretical efficiency and climate benefits, but when examined through the lens of real-world reproduction, labor burden, and input costs, their advantages become less clear.

Labor remains one of the most significant hidden costs in cut-and-carry systems. Farmers are feeding non-lactating cows for months at a time while managing manure and forage systems that add further work without proportional gain. Meanwhile, extensive and semi-intensive systems—

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especially when improved with rotational Brachiaria pasture can offer better returns per unit of land and labor.

SACPP's results suggest that high-yield, low-input systems are possible under real Rwandan conditions. Using GWP★ rather than GWP100 reveals that methane emissions from stable herds do not necessarily add warming. Integrating BNI pastures further enhances nitrogen efficiency, soil health, and climate performance.

5.0 Recommendations

- Adopt GWP★ in national livestock GHG accounting.
- Use annualized milk yield as a standard metric.
- Promote Brachiaria-BNI systems in grazing zones.
- Incorporate labor and land efficiency into livestock policy.
- Support training on pasture rotation and reproductive management.

REFERENCES

Allen, M. R., Shine, K. P., Fuglestvedt, J. S., Millar, R. J., Cain, M., Frame, D. J., & Macey, A. H. (2018). A solution to the misrepresentations of CO_2-equivalent emissions of short-lived climate pollutants under ambitious mitigation. *npj Climate and Atmospheric Science*, 1(1), 16. https://doi.org/10.1038/s41612-018-0026-8

Cain, M., Lynch, J., Allen, M. R., Fuglestvedt, J. S., Frame, D. J., & Macey, A. H. (2019). Improved calculation of warming-equivalent emissions for short-lived climate pollutants. *npj Climate and Atmospheric Science*, 2(1), 29. https://doi.org/10.1038/s41612-019-0086-4

FAO. (2013). *Tackling climate change through livestock: A global assessment of emissions and mitigation opportunities*. Food and Agriculture Organization of the United Nations. https://www.fao.org/3/i3437e/i3437e.pdf

Hristov, A. N., Oh, J., Firkins, J. L., Dijkstra, J., Kebreab, E., & Tricarico, J. M. (2013). Mitigation of methane and nitrous oxide emissions from animal operations: I. A review of enteric methane mitigation options. *Journal of Animal Science*, 91(11), 5045–5069. https://doi.org/10.2527/jas.2013-6583

Ripple, W. J., Smith, P., Haberl, H., Montzka, S. A., McAlpine, C., & Boucher, D. H. (2014). Ruminants, climate change and climate policy. *Nature Climate Change*, 4, 2–5. https://doi.org/10.1038/nclimate2081

Subbarao, G. V., Ishikawa, T., Ito, O., Nakahara, K., Wang, H. Y., & Berry, W. L. (2013). Biological nitrification inhibition (BNI)—Is it a widespread trait among tropical grasses? *Plant and Soil*, 362, 177–192. https://doi.org/10.1007/s11104-012-1319-3