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From trade-offs to synergies: Sustainable intensification pathways in the global cattle sector

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Abstract

The global cattle sector plays a central yet paradoxical role in achieving the Sustainable Development Goals (SDGs) of the 2030 Agenda. While it contributes significantly to poverty alleviation, food security, and economic growth, it is also a major driver of deforestation, greenhouse gas emissions, water pollution, and biodiversity loss. We examine these dual dynamics by systematically analysing the synergies and trade-offs between cattle production and selected SDGs through a systems theory lens. A systematic literature review following PRISMA guidelines was conducted, covering peer-reviewed studies, global datasets, and empirical case studies published after 2016. The analysis focused on key SDGs linked to cattle systems and mapped their interrelations using a framework that distinguishes between synergy multipliers, trade-off multipliers, and buffers. In addition, three sustainable intensification (SI) practices, namely wastewater treatment, biogas production from manure, and silvopastoral systems, were assessed for their potential to mitigate trade-offs and enhance synergies. Results show that SDGs 1 (No Poverty), 2 (Zero Hunger), and 8 (Decent Work and Economic Growth) function as primary synergy and trade-off multipliers. While these goals benefit from cattle production through income generation, employment, and food provision, they often exert negative pressures on environmental and health-related goals, particularly SDGs 3 (Good Health and Wellbeing), 6 (Clean Water and Sanitation), 12 (Responsible Consumption and Production), 13 (Climate Action), and 15 (Life on Land). These trade-offs manifest in land-use change, water contamination, and increased emissions, reflecting a pattern of systemic suboptimisation in current production models. The evaluated SI practices demonstrate strong potential to rebalance these interactions. Wastewater treatment improves water quality and public health outcomes; biogas production transforms waste into renewable energy while reducing emissions; and silvopastoral systems enhance carbon sequestration, biodiversity, and farm resilience. However, their adoption remains uneven due to financial, technical, and institutional barriers. We conclude that transitioning toward sustainable cattle systems requires not only technological innovation but also integrated governance, cross-sectoral coordination, and context-specific policy frameworks. By proposing an SDG interaction framework tailored to the cattle sector, we provide actionable insights for policymakers, researchers, and development practitioners seeking to align livestock production with the holistic vision of the 2030 Agenda.

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