Quantifying the Impact of Shifting from Tier 1 to Tier 2 Frameworks for 'Other Cattle' Enteric Fermentation and Manure Management on Malaysian Agricultural GHG Emissions: A 1990–2021 Time-Series Comparison

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Abstract

Under the Paris Agreement's Enhanced Transparency Framework (ETF), transitioning national greenhouse gas (GHG) inventories from generalized IPCC Tier 1 defaults to higher-tier, country-specific methodologies are critical for robust climate compliance and accurate global stock takes. This study quantifies the systemic impact of upgrading the national inventory architecture for Malaysia's heterogeneous "Other Cattle" (beef) sub-sector across a comprehensive 1990–2021 time series. Utilizing the IPCC Inventory Software (Version 2.98), the reporting framework was elevated from legacy Tier 1 defaults—previously utilized in Malaysia's first Biennial Transparency Report (BTR1)—to an advanced Tier 2 approach for enteric fermentation and a simplified Tier 2 model for manure management. The refined analytical architecture integrates a granular, six-tier herd stratification based on localized live weights alongside an updated 2026 expert judgment matrix for animal waste management systems (AWMS) allocations. Retrospective recalculations across the 32-year time series reveal a profound structural divergence from previous baselines. Historical enteric methane (CH_4) emissions were found to be systematically underestimated under the Tier 1 regime, with recalculated values demonstrating an upward shift, notably expanding from 44.56 Gg to 50.57 Gg CH_4 in the 2021 inventory year alone. Conversely, due to over-generalized default parameters, direct and indirect nitrous oxide (N_2O) emissions from manure management were consistently over-reported by a margin of at least 32% throughout the historical baseline. By replacing rigid, regional defaults with empirical, population-disaggregated precision, this study successfully corrects decades of structural reporting biases. The findings demonstrate that empirical data disaggregation alters not only the absolute emission volume but also the perceived trajectory of agricultural emissions. Ultimately, this high-resolution recalculation directly aligns Malaysia's agricultural inventory with ETF transparency mandates for the forthcoming second Biennial Transparency Report (BTR2). More importantly, it establishes a scientifically validated, verifiable baseline that is indispensable for the strategic formulation, implementation, and domestic tracking of Malaysia's national low-carbon policies, net-zero pathway goals, and future targeted mitigation frameworks for the domestic agricultural sector.

Keywords: GHG Inventory Recalculation; Activity Data Disaggregation; Biennial Transparency Report (BTR); Emission Factor Refinement; Other Cattle