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Evaluating Global Plant-Only Diet Emission Claims: A Critical Systems Review Based on Livestock Phase-Out Scenarios and Land-Use Constraints

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Abstract: ***Several prominent modelling studies claim that eliminating global livestock agriculture and transitioning humanity to a plant only diet would yield substantial greenhouse gas (GHG) reductions and unlock planetary-scale carbon sequestration. Notably, Eisen and Brown (2022) estimate that a 15-year global livestock phase-out could offset approximately 1,680 Gt CO_2 equivalent over the century, representing up to 68% of required mitigation to remain below a 2 °C warming trajectory. Such conclusions influence government policy, institutional food procurement frameworks, and sustainability narratives. However, these results depend on strong assumptions: (a) that current cropland is sufficient to sustain a global plant-only diet, (b) that emissions associated with human-inedible feed biomass are fully avoidable, (c) that manure offers no climate mitigation value as a fertiliser or biogas input, and (d) that additional cropland demand does not trigger conversion of peatland soils—one of the highest carbon-release land-use transitions known. Using FAO livestock emissions baselines, Poore and Nemecek (2018) land datasets, Eisen and Brown's PHASE-POD modeling logic, and modelling results from Radrapu (2025), this review constructs 5-, 10-, 20-, 50-, and 100-year livestock phase-out timelines. When livestock feed-related emissions are removed and manure is modelled as a circular nutrient and energy system, global livestock emissions are approximately 2.429 Gt CO_2e $year^{-1}$, nearly equal to the estimated 2.435 Gt CO_2e $year^{-1}$ operational emissions associated with an estimated 996.77 Mha of additional cropland required for a global plant-only food system. Over 100 years, the difference between maintaining livestock and switching to a plant-only global diet remains within ±0.30 Gt CO_2e, effectively negligible. However, if 20% of that required cropland is sourced from peatlands, a one-time release of 2,192.7 Gt CO_2 overwhelms all modeled mitigation potential, resulting in a significantly worse climate outcome than maintaining livestock. Findings indicate that large-scale claims of climate benefit from a global plant-only diet are highly sensitive to land-use assumptions, manure treatment logic, and carbon-rich soil exposure, and therefore should be interpreted with caution. Further applied research is required before global policy recommendations are made.***

Keywords: Plant-based diet; livestock emissions; manure valorisation; peatlands; global food systems; land-use change; mitigation modeling; agricultural sustainability.

1. Introduction

Food systems contribute an estimated 26–34% of global anthropogenic GHG emissions (Poore & Nemecek, 2018). Livestock systems are often highlighted because FAO accounting places them between 11–18% of global emissions depending on allocation method, inclusion of land-use change, and feed boundary conditions (FAO, 2013; FAO, 2023).

Recent high-impact models, including Eisen and Brown (2022)—suggest that eliminating livestock could rapidly reduce methane and nitrous oxide emissions while freeing land for biomass recovery, enabling negative emissions on the scale of global carbon dioxide removal (CDR) technologies. These studies are widely cited in policy proposals and media framing advocating a global transition to plant-only diets.

However, major assumptions underlying these models, including cropland sufficiency, manure handling, feed edibility, and land-use constraints, are not consistently examined.

This paper evaluates the sensitivity of such claims by comparing livestock retention against full livestock phase-out scenarios using consistent emissions baselines and land-use assumptions.

2. Methodology

2.1 Data Sources

This review integrates four modeling frameworks:

Data Source	Model Variable Applied
FAO GLEAM	Livestock emissions profile and allocation
Eisen & Brown (2022)	Biomass regrowth and sequestration assumptions
Poore & Nemecek (2018)	Land-use intensity and dietary comparison basis
Radrapu (2025)	Cropland requirement and manure offset modelling

2.2 Computation Assumptions

- Feed emissions were excluded to test minimum unavoidable livestock emissions.
- Manure was modeled as a fertiliser + biogas resource with a 1.05 Gt CO_2e annual avoided emissions credit.

- New cropland requirement estimated using nutrient replacement and caloric equivalence modelling: 996.77 Mha required.
- A peat scenario assumed 20% land sourced from peat, triggering a one-time release of 2,192.7 Gt CO_2.

2.3 Core Equations

Livestock (farm emissions only): (2.769 + 0.710) - 1.05 = 2.429 Gt CO_2e/year
Plant-only cropland emissions:2.435 Gt CO_2e/year

3. Results

3.1 Computation Table: No-Peat Scenario

Table 1: Comparison of cumulative emissions under livestock retention versus global phase-out (no peat scenario)

Phase-out Horizon (years)	Livestock Maintained (Gt CO_2e)	Full Plant-Only Transition (Gt CO_2e)	Δ
5	12.145	12.16	0.015
10	24.29	24.32	0.03
20	48.58	48.64	0.06
50	121.45	121.6	0.15
100	242.9	243.2	0.3

Interpretation: Emissions remain statistically equivalent under manure valorisation and realistic cropland requirements.

3.2 Computation Table: Peat Scenario

Table 2: Peatland conversion sensitivity modelling (20% cropland exposure assumed)

Horizon (years)	Cumulative Emissions (Gt CO_2e)	Interpretation
5	2,204.86	>10× worse
10	2,217.02	>10× worse
20	2,241.34	>10× worse
50	2,314.30	>10× worse
100	2,435.90	>10× worse

Interpretation: Peat conversion dominates system behaviour.

4. Discussion

The reviewed literature frequently claims that eliminating livestock yields substantial climate benefits. Eisen and Brown (2022) estimate potential mitigation equivalent to 25 Gt CO_2/year through avoided methane and biomass regrowth. However, their model assumes:

- Existing cropland can sustain global nutrition,
- Freed land becomes a carbon sink,
- Manure does not displace fertiliser emissions,
- No peatland or high-carbon soil conversion occurs.

When alternative assumptions reflecting agronomic constraints are applied, results shift dramatically. Under manure valorisation and realistic cropland demand, climate effects become neutral. When peat exposure is added, outcomes become significantly worse.

5. Conclusion

This review finds that global plant-only dietary transition claims are highly sensitive to modeling assumptions. Under realistic cropland expansion and manure utilization scenarios, a full livestock phase-out yields negligible emissions benefit. When peat conversion is considered, it becomes counterproductive.

Key Statement
A universal global plant-only transition cannot be assumed to reduce emissions unless land-use sourcing, soil carbon, and manure system constraints are explicitly modeled.

Future research must incorporate regional agronomy, cropland feasibility, manure circularity, and carbon-rich soil protections before converting these model outputs into global policy recommendations.

Declarations

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Conflict of Interest: None.

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