Good Food Institute

Policy action report

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A policy action report for

Comparative life cycle assessment of plant-based meats and conventional animal meats

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The Good Food Institute's "Comparative life cycle assessment of plant-based meats and conventional animal meats" (Bonales et al. 2024) quantifies the sustainability benefits of plant-based meat. This policy summary highlights key insights from the study and outlines recommended actions for policymakers to support the development of the plant-based meat industry.

Bonales, Joel, Juanita Barrera-Ramirez, Amalia Sojo, Nathan Ayer, and Earthshift Global. (2024). Comparative Life Cycle Assessment of Plant-Based Meats and Conventional Animal Meats. The Good Food Institute, 2024. https://doi.org/10.62468/casv3213.

Study overview

The global food system accounts for more than a third of total greenhouse gas (GHG) emissions, consumes significant land and water resources, and produces harmful air and water pollution. Finding ways to produce food more efficiently is imperative to reduce environmental degradation and promote long-term sustainability as the planet nears 10 billion people by 2050.

The UN's Sustainable Development Goals (SDGs) include promoting sustainable agriculture and achieving food security alongside urgent action to restore ecosystems. As animal agriculture plays an outsized role in our food system's environmental impacts, alternative proteins such as plant-based meat—meat produced directly from plants—are of particular interest as potential food-system interventions.

Plant-based meat requires fewer resources, including land and water, and produces less air and water pollution and fewer climate emissions than animal-based meat. The Good Food Institute (GFI) and EarthShift Global recently completed a comprehensive, comparative life cycle assessment (LCA) that investigates plant-based meat's environmental footprint relative to animal meat, finding significant sustainability advantages.

This LCA, certified by the International Organization for Standardization (ISO), builds on the existing literature by evaluating the relative impacts of plant-based meat across 18 environmental categories based on real-world, commercial production data and a range of ingredients and production methods. Baseline figures for animal-based meat represent highly optimized production systems.

Key findings

Diversifying our protein supply with plant-based meat can significantly reduce our food system's environmental impacts.

Across 18 categories, plant-based meat results in 81–99.9% lower environmental impacts than conventional beef, 60–97% lower than pork, and 10–94% lower than chicken.

This study demonstrates the significant efficiency of plant-based meat and its reduced environmental footprint across each impact category. Diversifying our protein supply with plant-based meat, therefore, can significantly reduce our food system's environmental impacts.

Table 1. Summary of plant-based meat environmental benefits.*

	Average reduction for plant-based meat compared to...		
Environmental Impact	Beef	Pork	Chicken
GHG emissions	94%	88%	67%
Land use	91%	60%	10%
Water use *(Water consumption)*	93%	96%	94%
Air pollution *(Fine particulate matter formation)*	91%	91%	83%
Water pollution *(Marine eutrophication)*	96%	90%	84%
Fossil resource use *(Fossil resource scarcity)*	81%	86%	69%
Avg of 18 impact categories	91%	88%	71%

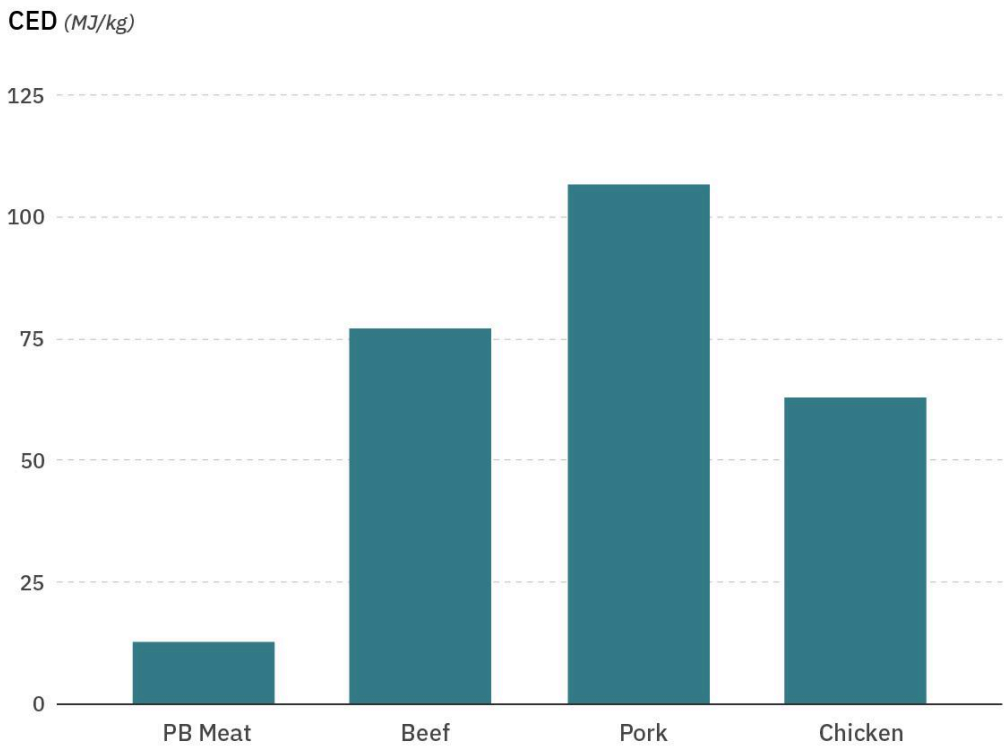
*The averaged impacts for the three plant-based meats studied were compared to beef, pork, and chicken impacts. To view relative impact calculations for all 18 environmental categories, reference Table 5-1 in the LCA report (Bonales et al. 2024).

Plant-based meat is significantly more resource-efficient and emits less air and water pollution.

Plant-based meat production results in 89% fewer GHG emissions, 89% less fine particulate matter, and 81% less fossil resource use, on average, compared to animal-based meat (Table 1). The lower cumulative energy demand (CED) of plant-based systems explains much of this result (Figure 1), as well as the absence of emissions from animal digestive processing and manure, which is a large contributor to the climate impact of beef and pork.

Additionally, plant-based meat production relies less on land, water, fertilizer, and pesticide resources. On average, plant-based meat has 79% less land use, 95% less water consumption, and 93% less water pollution (marine eutrophication) than animal meat (Table 1).

Figure 1. Energy demand (MJ/kg) of producing one kilogram of beef, pork, chicken, and plant-based meat.



Policy recommendations

To realize plant-based meat's sustainability benefits, the volume of production and consumption must grow far beyond the industry's current capabilities. The global manufacturing capacity for plant-based meat is about 2.2 MMT (million metric tons) per year, and production of plant-based meat is about 1 MMT per year (as of 2022). By comparison, current annual global meat production is approximately 360 MMT. On the demand side, increased consumer adoption of plant-based meat will depend on additional product innovation, including successful biomimicry of animal-based meat.

Private sector investment alone cannot meet this challenge on the timeframe required to avert natural resources depletion and climate change. Publicly funded open-access research and development (R&D) and commercialization support are necessary. Strong public investments are crucial to drive innovation, make plant-based products more competitive with animal-based meat, and scale the industry's capabilities. A Global Innovation Needs Assessment (GINA)—published by the Climateworks Foundation and the UK government—found that governments globally must invest $10.1B annually in alternative proteins, including plant-based, fermentation-derived, and cultivated meat, in order to reap their full benefits. Despite recent increases, global public funding in 2023 met less than 4% of this need. As the LCA findings demonstrate, further investments in alternative protein production are important for the same reasons governments invest trillions of dollars in renewable energy and global health.

Increasing R&D and innovation

Further technological advances and novel formulations will improve the taste and price of plant-based meat to better compete with animal-based meat. Public funding for open-access R&D will make these innovations possible. Additional R&D can further improve plant-based meat's efficiency and supply chain resilience, reducing agricultural resource reliance and embedding food production into circular bioeconomies.

Top R&D needs for the plant-based meat industry are:

- Enhance the protein quality and quantity of high-yielding crops, strengthening the upstream value chains of plant-based meat and other plant-based foods.
- Create innovative ingredients, such as alternative fats and flavors, that improve the taste and nutrition of plant-based meat.
- Innovate scalable manufacturing methods to enhance the texture and sensory experiences of plant proteins.
- Invest in public pilot-scale facilities to advance scaling technologies and conduct techno-economic analyses.

Supporting commercialization and scale-up

Public investment can incentivize private capital to grow the plant-based meat industry. Additionally, public support can enable products to enter the market at fair, competitive prices on a timeline that supports sustainability and food security goals. Policies to support the commercialization of plant-based meat include business grants and investments, loans, and loan guarantees.

Recommended actions to drive production scale-up of plant-based meat:

- Offer financial incentives for the construction and retrofitting of production facilities and contract manufacturers to increase production capacity.
- Develop loan and loan guarantee programs to complement and de-risk private investment in plant-based meat manufacturing.
- Support farmers and crop companies in developing and growing crops relevant to plant-based meat. Farmers play a fundamental role in the industry and require support, including financial incentives and optimized crop cultivars to shift to agricultural outputs that prioritize food, rather than feed and fuel, production.

Countries worldwide are increasingly recognizing the potential of the plant-based meat and alternative protein sector. Canada, the European Union, and Denmark have emerged as leaders in public investments in R&D and commercialization funding for alternative proteins, and other countries are increasingly prioritizing the sector. In the United States, the U.S. Departments of Agriculture and Energy have identified alternative proteins as a key component of the American bioeconomy. Meanwhile, India has committed to advancing domestic biomanufacturing of innovative products like alternative proteins, and the Brazilian government continues to signal the sector's economic and sustainability benefits. China, Japan, South Africa, and Spain are similarly laying the groundwork for significant investments.

Conclusion

Plant-based meat presents a significant opportunity to improve sustainability for climate, water and land conservation, air and water pollution, and more. Across all of the 18 environmental categories studied, plant-based meat has a significantly reduced relative impact. Public support is necessary to capitalize on the plant-based meat industry's significant and cross-cutting sustainability advantages. Further public investments in the sector will drive product innovation, support production scale-up, improve our food system security, and make sustainability goals more achievable.

About GFI

The Good Food Institute is a nonprofit think tank working to make the global food system better for the planet, people, and animals. Alongside scientists, businesses, and policymakers, GFI's teams focus on making plant-based and cultivated meat delicious, affordable, and accessible. Powered by philanthropy, GFI is an international network of organizations advancing alternative proteins as an essential solution needed to meet the world's climate, global health, food security, and biodiversity goals. All of GFI's open-access insights and data are made possible by gifts and grants from our global community of donors. If you are interested in learning more about giving to GFI, please visit here or contact philanthropy@gfi.org.

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