

Plant-based

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Supplement to: This white paper summarizes the key results and opportunities of the ISO-certified LCA report, [“Comparative Life Cycle Assessment of Plant-Based Meats and Conventional Animal Meats”](#) (Bonales et al. 2024; herein referred to as “the LCA report”). The LCA report, including the detailed processes, life cycle inventory, and an interactive data dashboard with data available for download are available at gfi.org.

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Cover photo courtesy of: Beyond Meat

About Good Food Institute

[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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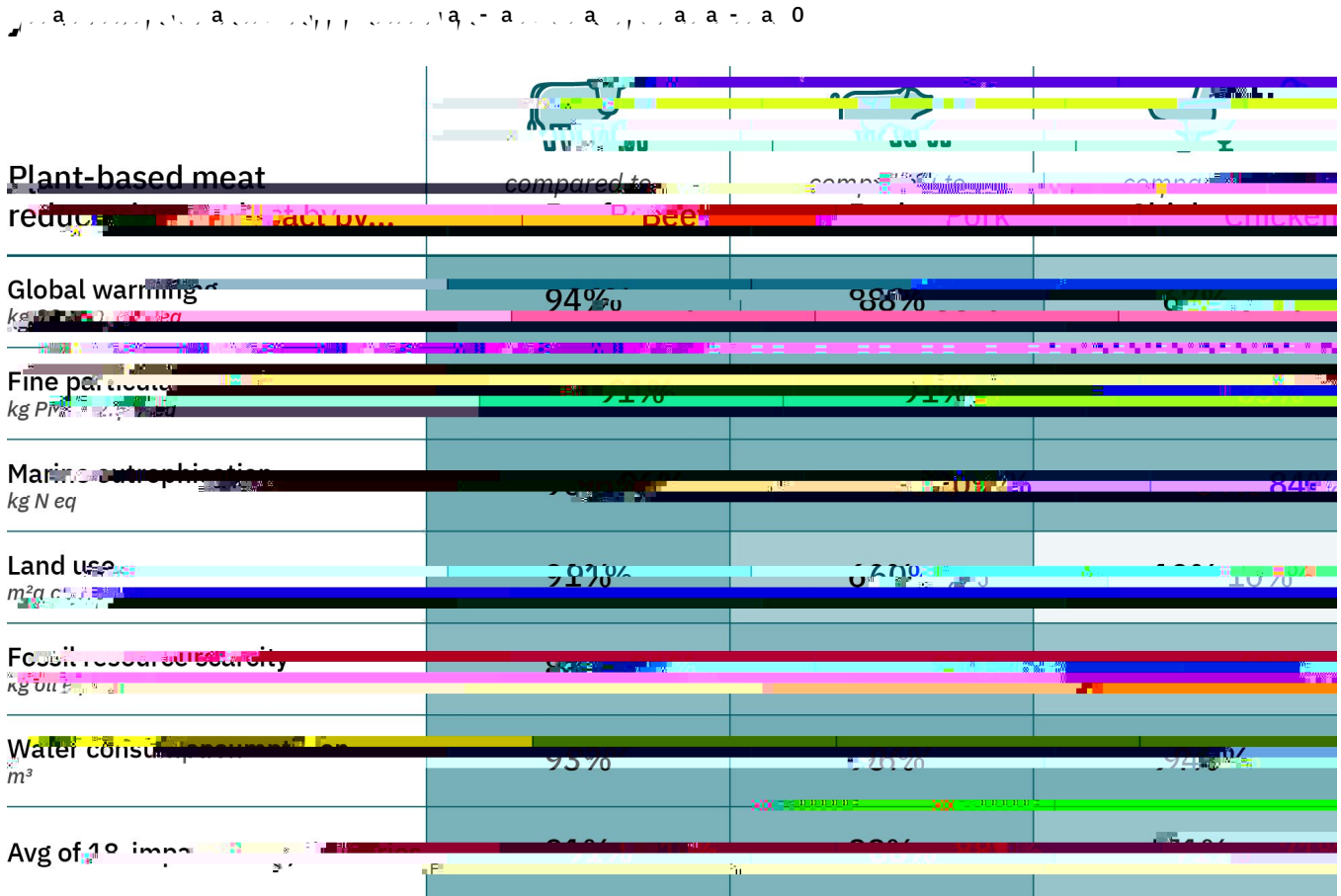
This report presents the key findings and opportunities from the ISO-certified comparative life cycle assessment of plant-based and animal-based meat (Bonales et al. 2024) conducted by the Good Food Institute (GFI) and EarthShift Global. It is the most comprehensive, open-access analysis of plant-based meat's environmental impacts to date.

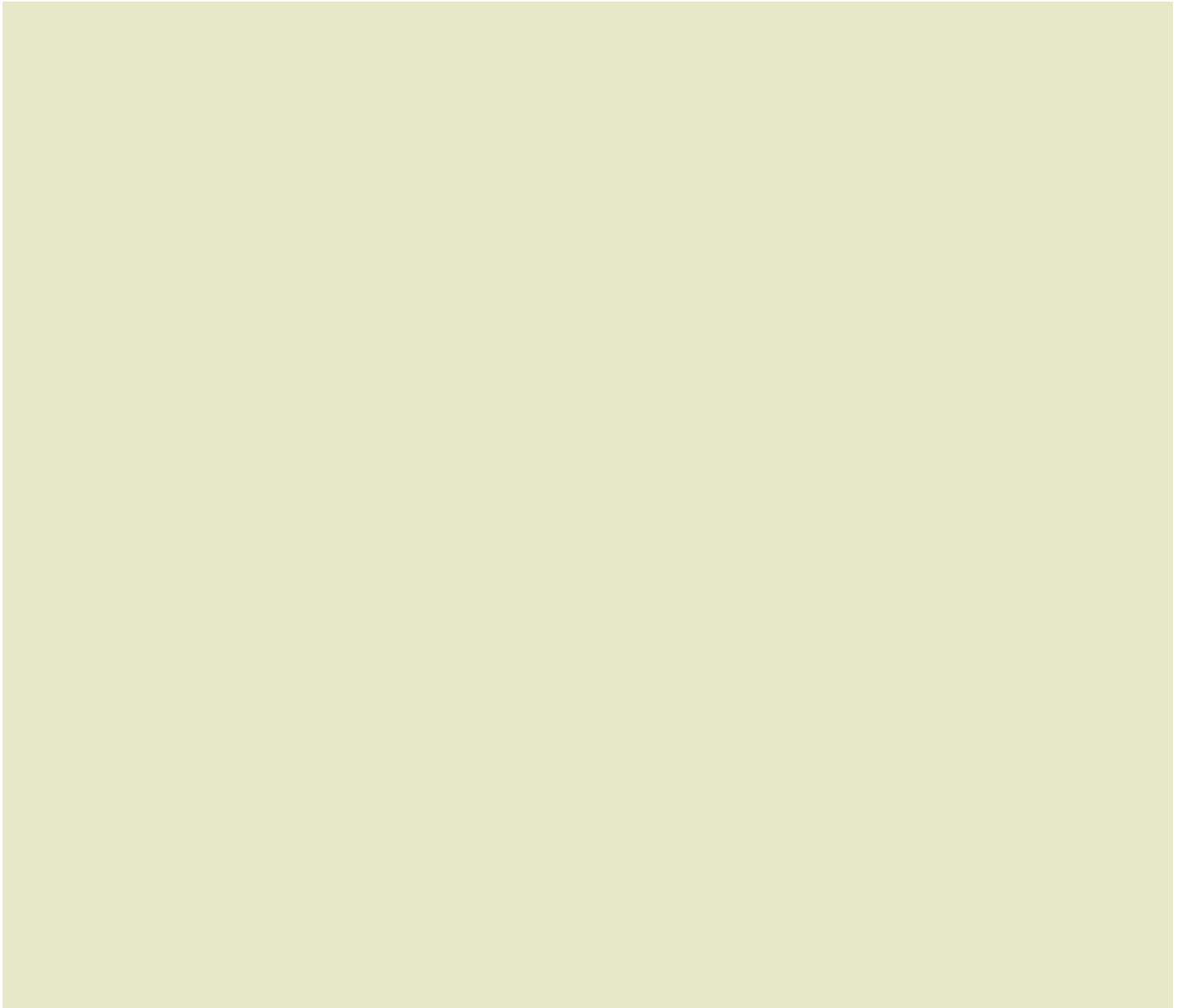
Reducing the environmental impacts of food

Key findings

1. Plant-based meat provides the same amount of meat while reducing pressure on the environment:

Plant-based meat has, on average, 89% less environmental impact than animal-based meat across the impact categories evaluated in this study (see table below). When averaged across the three plant-based meat recipes, plant-based meat has 91% lower impacts than beef, 88% lower impacts than pork, and 71% lower impacts than chicken. These trends remain consistent when considering economic versus mass allocation, uncertainty of input data, and plant-based crop geography.







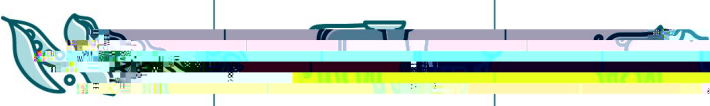
Life cycle assessments are critical to understanding the environmental impact of foods

Life cycle assessment (LCA) is an internationally recognized methodology that quantifies the environmental impacts of a product during its entire life cycle, including all relevant inputs and

While these recipes are representative of some plant-based meat products currently on the market, many plant-based ingredients are used to create a wide variety of meat products. For example, unlike the recipes explored here, most commercially available plant-based chicken products typically do not contain coconut oil, instead relying on canola, corn, or soybean oil, which provide less than 1.6 grams of saturated fat per 100 gram serving.

Coconut oil is more commonly used in plant-based beef products to mimic red meat adipose tissue. Including both coconut oil and canola oil in the plant-based recipes evaluated in the LCA is intended to be conservative (i.e., inclusive of potentially environmentally impactful ingredients) and encompass the potential impacts of a wide range of plant-based meat products.

Table 2. Nutritional composition of plant-based meat products (Prea/Soy meat, Beef meat, Chicken meat, and Pork meat) (values are per 100g serving)



Nutrient	Prea/Soy meat	Beef meat	Chicken meat	Pork meat
Protein g/100g	17	17	17	17
Fat g/100g	9	20	21	8
Saturated Fat g/100g	1.4	8	8	2.7
Cholesterol mg/100g	0	0	0	0
Iron mg/100g	3	2	4	4
Fiber g/100g	2	0	0	0
Calories kcal/100g	177	234	207	118

System boundary

The system boundaries established for this study are cradle-to-manufacturing gates, including cultivation



Plant-based meat production technology

Meat is made up of proteins, fats, vitamins and minerals, and water. While this combination of nutrients is difficult to find outside of animal muscle, each is available in plant sources.

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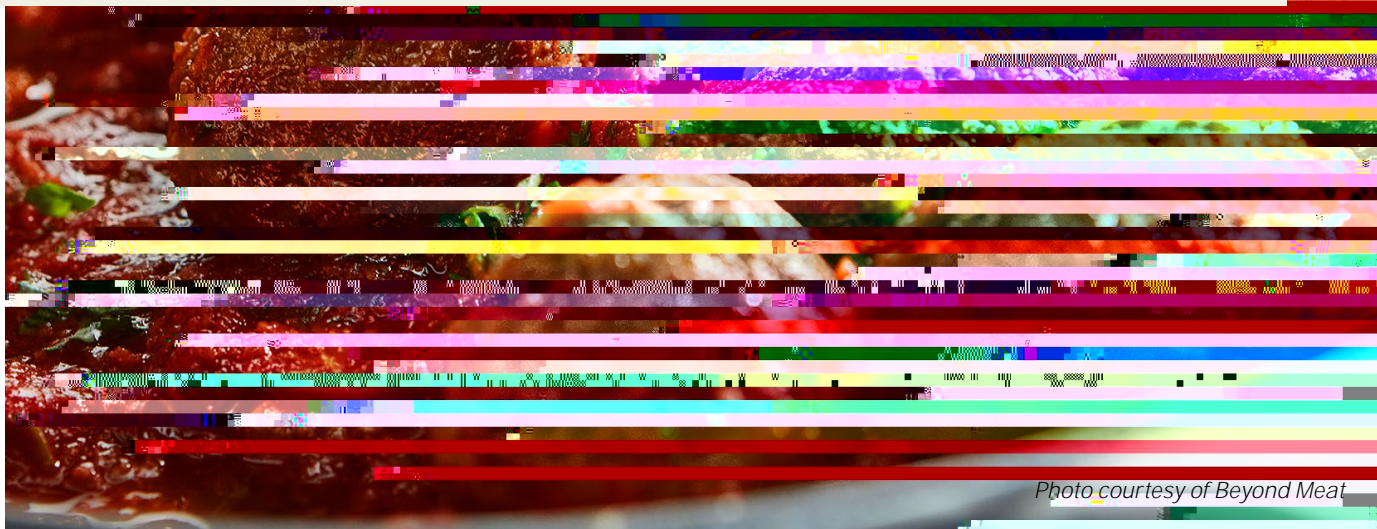


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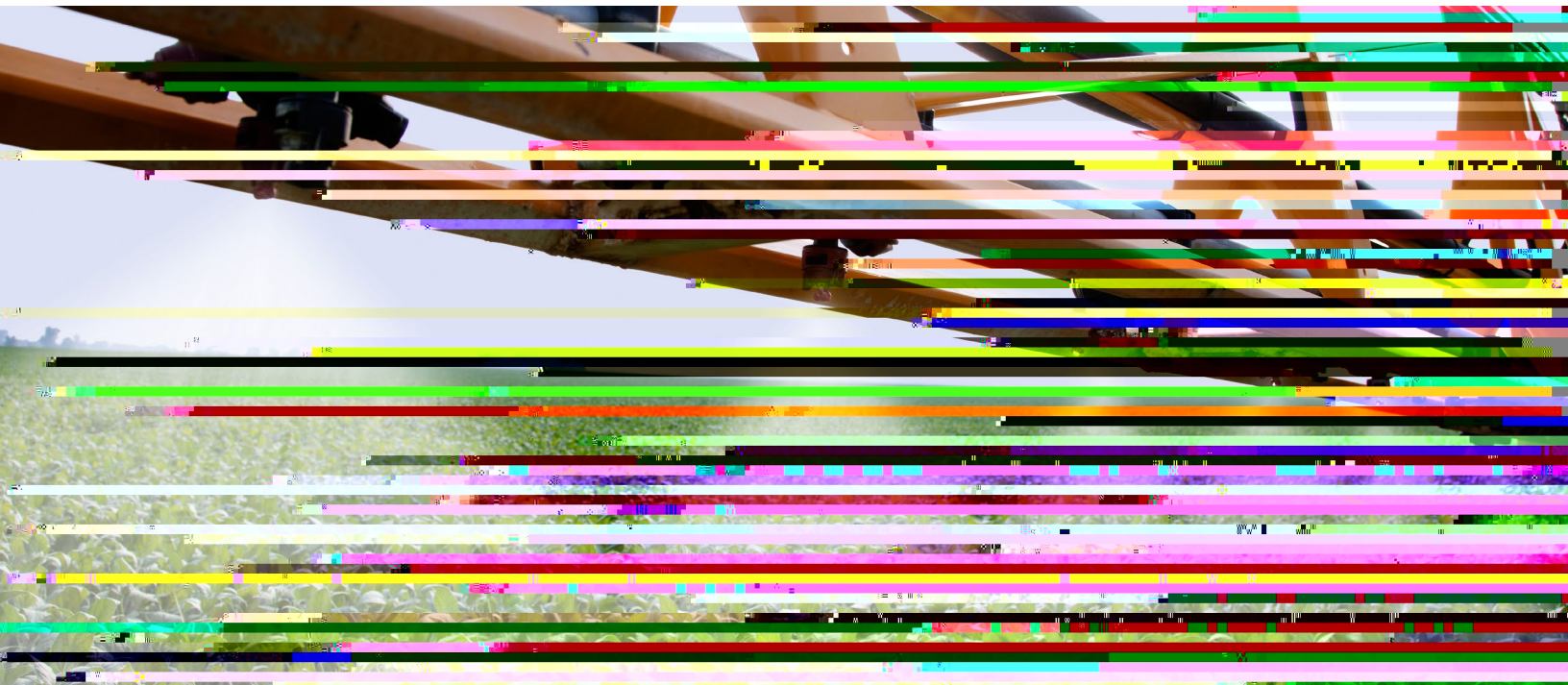


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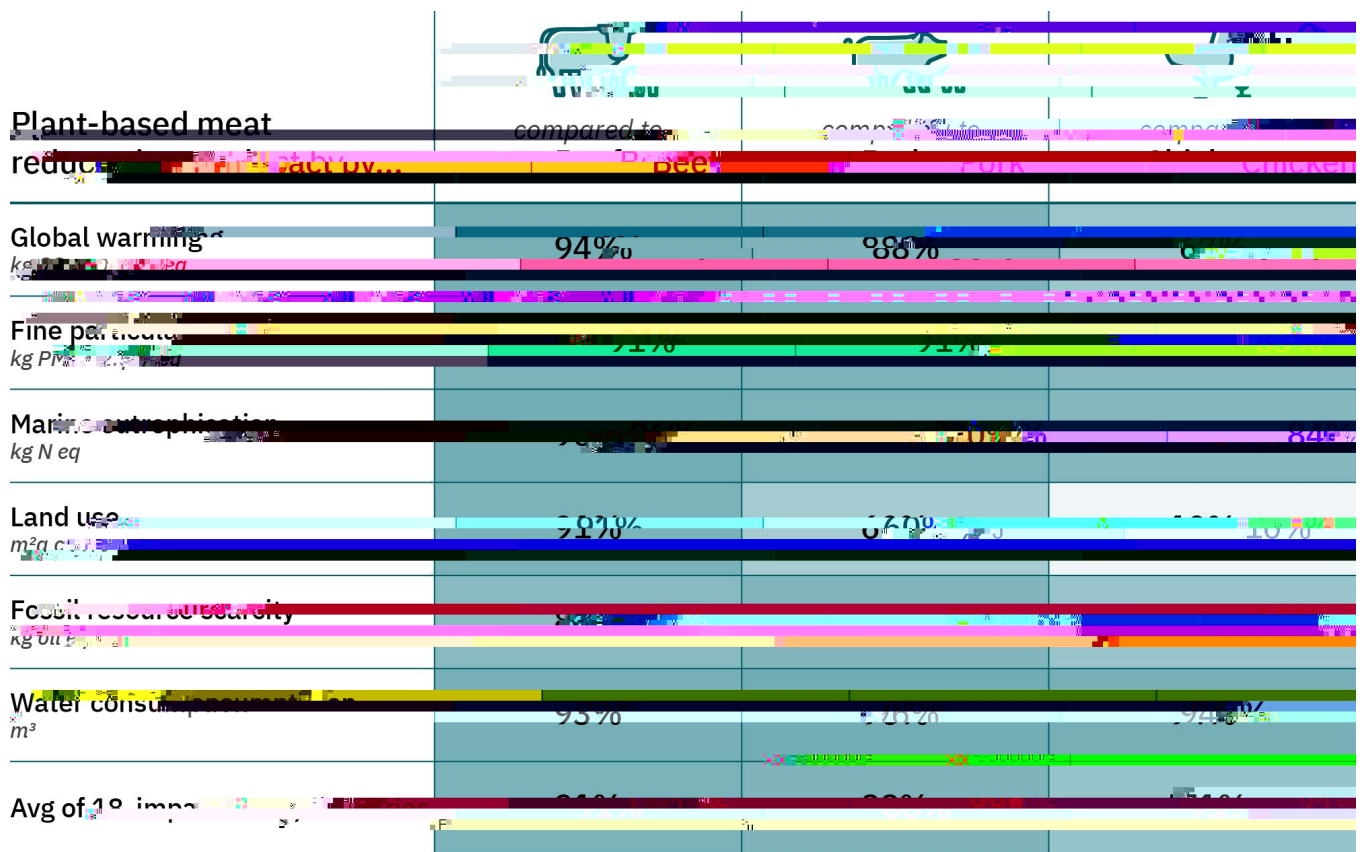
Key findings and opportunities: Comparative life cycle assessment of plant- and animal-based meats

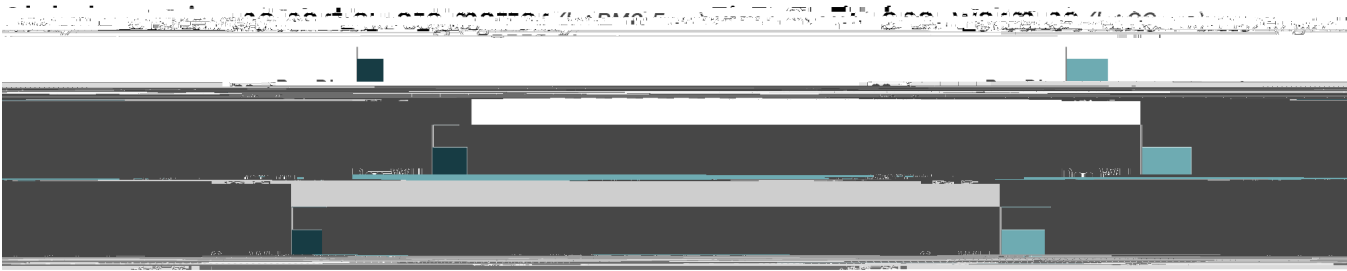
Plant-based meat provides the same amount of meat while reducing environmental impact by 89% compared to animal-based meat.

Plant-based meat has, on average, 89% less environmental impact than animal-based meat across the 18 impact categories evaluated in this study. Compared separately, the plant-based meat

¹ "Animal housing operations" category includes infrastructure, energy, and maintenance.

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► **Key findings and opportunities: Comparative life cycle assessment of plant- and animal-based meats / November 2024**

In this study, plant-based systems have comparable land use to chicken production, a result that contrasts with LCAs comparing plant-based chicken

Key findings and opportunities: Comparative life cycle assessment of plant- and animal-based meats

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8. The Impossible Burger's slightly higher carbon footprint and water consumption are mostly attributed to the recipe containing leghemoglobin (fermentation-derived) and potato proteins, which both have slightly higher carbon and water footprints than other plant-based meat ingredients. Still, Impossible Burger provides one kilogram of meat with 89% less global warming potential and 87% less water consumption compared to a beef burger (Khan et al. 2019).

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Carbon footprint, land use, and water consumption impact categories were chosen to compare to other studies because the impact assessment

Table 8. Comparative life cycle assessment of plant-based and animal-based meats.

Impact Category	Plant-based meat	Beef	Pork	Chicken
Global warming	✓	✓	✓	✓
Stratospheric ozone depletion	✓	✓	✓	✓
Ionizing radiation	✓	✓	✓	✓
Ozone formation, Human health	✓	✓	✓	✓
Fine particulate matter formation	✓	✓	✓	✓
Ozone formation, Terrestrial ecosystems	✓	✓	✓	✓
Terrestrial acidification	✓	✓	✓	✓
Freshwater eutrophication	✓	✓	✓	✓
Marine eutrophication	✓	✓	✓	✓
Terrestrial ecotoxicity	✓	✓	✓	✓
Mineral resource scarcity	✓	✓	✓	✓
Fossil resource scarcity	✓	✓	✓	✓
Land use	✓	✓	✓	✓
Freshwater ecotoxicity	○	○	○	○
Marine ecotoxicity	○	○	○	○
Human carcinogenic toxicity	○	○	○	○
Human non-carcinogenic toxicity	○	○	○	○
Water consumption	○	○	○	○
Confidence interval: 95%	✓	✓	✓	✓

Animal husbandry drives the high global warming impacts of meat production

The environmental impacts of the animal meat systems modeled in this study are driven primarily by animal husbandry, specifically the associated feed production, emissions, manure management, and housing operations. The global warming impacts of each process associated with animal meat production, including animal husbandry, slaughtering, grinding, and transport, are presented in Figure 9 with further granularity provided for animal husbandry.

Animal husbandry alone is responsible for 92% of the global warming impacts of beef, compared to 90% for pork and 66% for chicken. The impacts of beef cattle production are driven by raising



Figure 9. Global warming impacts of beef production, broken down by process and sub-process.

Climate change

The ISO-certified LCA provides a uniquely granular view of the environmental impacts of plant-based meat, comparing dominant inputs and processing methods and using real-world, commercial-scale data. Despite variations in ingredients and production methods, plant-based meat consistently offers substantial environmental benefits compared to animal-based meat.

Plant-based meats offer substantial environmental benefits across different inputs and production methods.

Ingredients

The plant-based meat systems included in this analysis are composed of varying levels of texturized, extruded plant protein and water, along with equivalent amounts (by mass) of coconut oil, canola oil, wheat gluten, spices, and potato starch (see Table 3).

Extrudate is the primary ingredient in this study's plant-based meat recipes and the largest contributor to plant-based meat's impact in nine of 18 impact categories. However, other ingredients are also major contributors and sometimes exceed extrudate impacts in certain categories even though they are present at lower levels.

Coconut and canola oil contribute disproportionately to the plant-based meat impact given each only constituting 4% of the recipe. Coconut oil contributes as much impact as extrudate for global warming and land use and significantly to a number of other

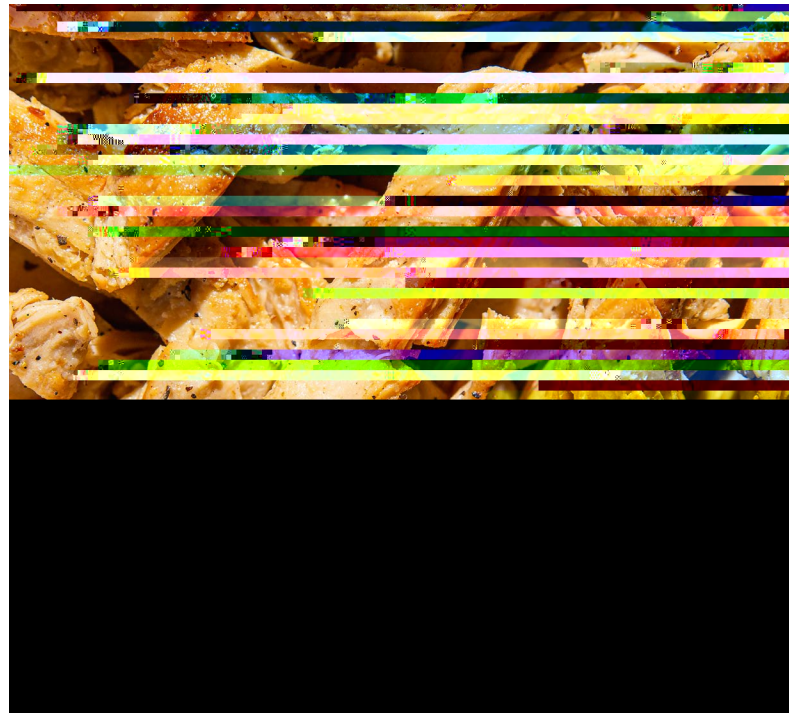
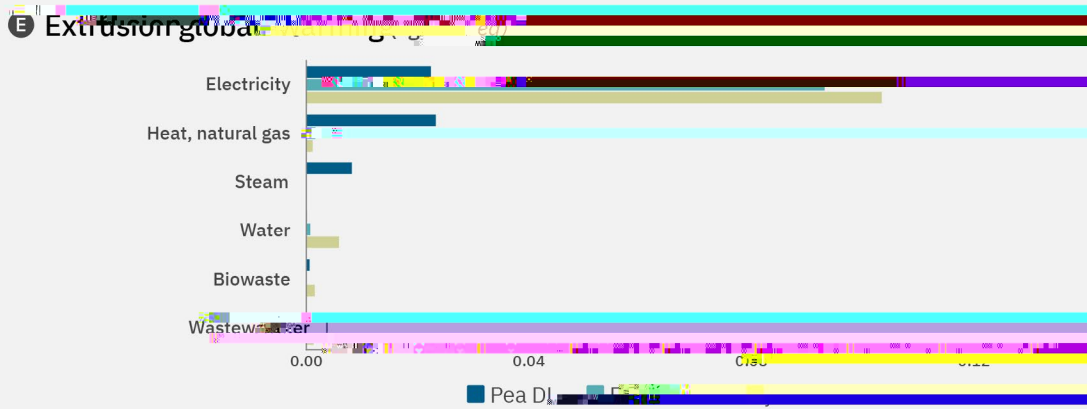
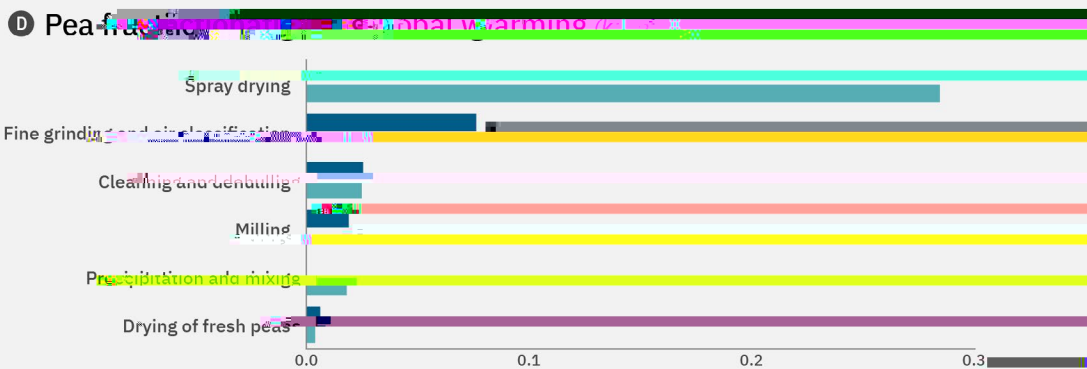
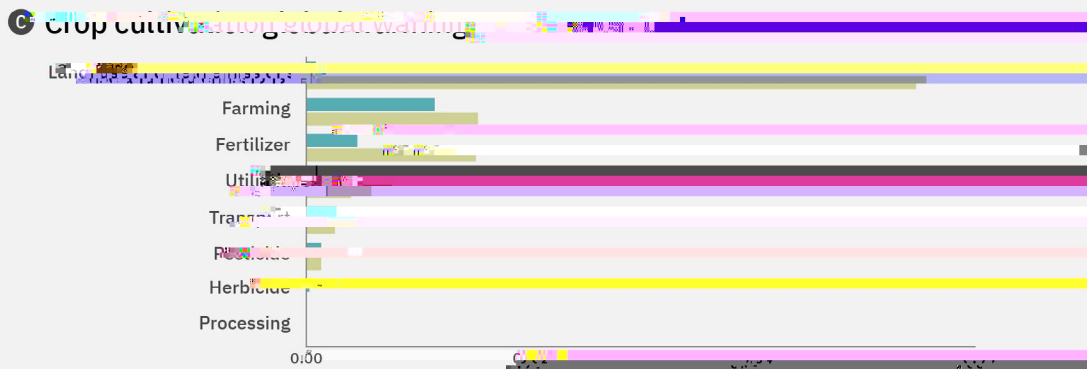
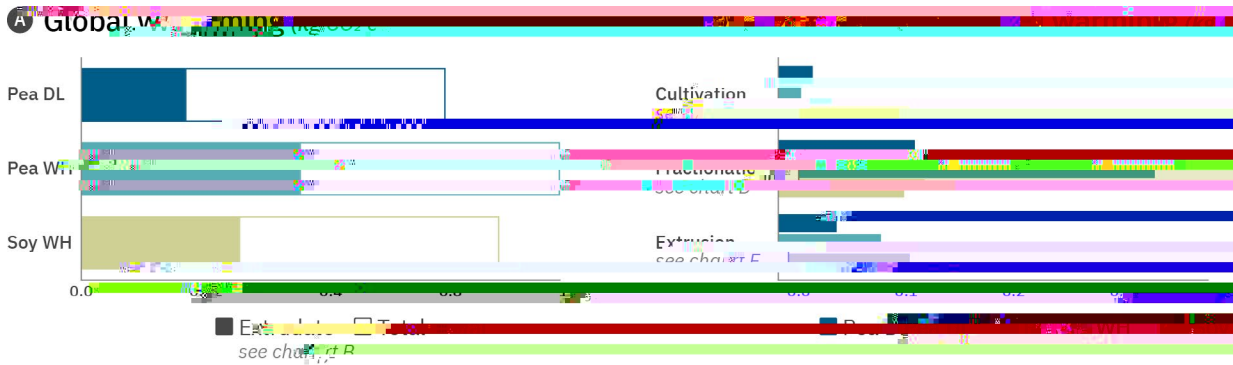


Photo courtesy of Julee Ho and Doaa Jamai

impact categories (Figure 10). Canola oil contributes disproportionately to marine eutrophication, fine particulate matter formation, and other categories primarily due to emissions related to cultivation. Potato starch and wheat gluten also show disproportionately large contributions to certain impact categories, especially water consumption.

Crop yield improvements, less reliance on fertilizers and pesticides, reduced irrigation requirements, and alternative oil ingredients could help further reduce the impacts of plant-based meat by reducing impact contributions from oil ingredients. Across the plant-based systems, differences in the total environmental impacts are driven by the protein extrudate as the other ingredients are held constant in all three recipes.



Electricity consumption drives impacts in the

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