THE GOOD FOOD INSTITUTE

PLANT-BASED MEAT FOR A GROWING WORLD

Improving the efficiency of the Western diet is crucial to achieving sustainability. Plant-based meat allows consumers to enjoy the taste of meat at a fraction of the environmental cost.

Global demand for meat is projected to rise 50% between 2013 and 2050.[1] Considering animal agriculture's outsized impact on the environment, this could have dire consequences for Earth's life-supporting ecological systems.

But diets are hard to change. Despite decades of advocacy, the percentage of Americans following a plant-based diet has barely budged.[2] In fact, in 2018, per capita American meat consumption was within two pounds of being the highest in U.S. history.[3]

> "Meat is basically protein, fat and water. Our game is to find all that in plants and reassemble it against the architecture of meat."
>
> –Ethan Brown, CEO and co-founder of Beyond Meat[10]

Photo by vaun0815 on Unsplash

Plant-based meat offers a way out. Combining ingredients in novel ways can deliver the complete culinary experience of meat without the need for a single animal. Plant-based meat fits seamlessly into consumers' culinary traditions, all but eliminating barriers to behavior change.

Eating plants is fundamentally more efficient than growing plants to feed animals and eating those animals.[4,5,6] Even after accounting for the processing required to turn plants into plant-based meat, every study to date finds that replacing conventional meat with plant-based meat substantially reduces every environmental impact measured.[7,8,9]

PLANT-BASED MEAT USES 47%–99% LESS LAND THAN CONVENTIONAL MEAT (M^2-YR-LAND/KG-MEAT).

Animal agriculture takes up 77% of all agricultural land on Earth despite supplying only 17% of humanity's food supply.[11] This inefficiency drives the need for agricultural expansion, which is the single largest driver of ecosystem damage on land.[12] Fishing, whose yield can also be replaced with plant-based products, is the single largest driver of ecosystem damage in the oceans.[12]

Although pigs and chickens always require feed crops, cows can graze in some places where crops can't grow. However, there is only enough pasture in the United States to support 27% of current beef production, and that includes the grass growing where crops otherwise could.[13] Grass-fed meat alone cannot feed America.

In contrast, using all our cropland to grow food for humans instead of animals would allow American farmers to feed more than twice as many people.[14,15] That would increase the food supply three times as much as recovering all the food that spoils or gets thrown away before it can be eaten.[15] Plant-based

Table 1: Environmental benefits of plant-based meat products

Eating this plant-based meat	instead of this conventional meat	reduces this environmental impact by this much.			
		Land use	Greenhouse gas emissions	Water use	Aquatic eutrophication potential
		m^2-y/kg	kg-CO_2-eq/kg	L/kg	g-PO_4^{3-}-eq/kg
Impossible Burger 2.0[7]	Beef burger*	96%	89%	87%	91%
Beyond Burger[8]	Beef burger**	–	89%	99%	–
Grillers Original Burger[9]	Beef burger*	93%	85%	95%	77%
Spicy Black Bean Burger[9]	Beef burger*	97%	89%	96%	76%
Roasted Garlic & Quinoa Burger[9]	Beef burger*	93%	88%	98%	73%
Grillers Crumbles[9]	Ground beef**	99%	90%	96%	–
Original Sausage Patties[9]	Pork sausage patties*	47%	30%	81%	51%
Original Chik Patties[9]	Breaded chicken patties*	84%	36%	72%	75%

This table represents the results of all English-language comparative life cycle assessments of plant-based meat conducted as of May 1, 2019.[7,8,9] Because each study differs slightly in its methodology, the results from different studies cannot be precisely compared. *Sold frozen. **Sold fresh. Impact reductions are calculated as follows: *(impact of conventional meat - impact of plant-based meat) ÷ (impact of conventional meat).*

meat offers a promising pathway toward realizing most of this efficiency gain.

PLANT-BASED MEAT EMITS 30%–90% LESS GREENHOUSE GAS

THAN CONVENTIONAL MEAT (KG-CO_2-EQ/KG-MEAT).

Worldwide, animal agriculture contributes more to climate change than exhaust emissions from the entire transportation sector.[16,17] Animal agriculture's emissions come from three major sources: conversion of forests and prairies to pasture and cropland,[6,18] production of animal feed,[19] and animal digestion and waste decomposition.[6,20]

The primary ingredients for plant-based meats, on the other hand, have very low greenhouse gas emissions,[6] and additional processing accounts for only 13%–26% of plant-based meat's climate impact.[8,9] The cropland no longer necessary for animal feed could even be used to mitigate climate change through reforestation, soil conservation, or renewable energy production.[21,22,23]

PLANT-BASED MEAT USES 72%–99% LESS WATER

THAN CONVENTIONAL MEAT (L-WATER/KG-MEAT).

Animal agriculture guzzles almost a third of the water used in global agriculture.[24] Of that water, 99.8% is used in the cultivation of feed crops, draining aquifers that could be used for drinking water or wasting rainwater that could be used to grow food for humans.[24]

By requiring only the crops that end up in the final product, plant-based meat production cuts out the primary water requirement in conventional meat production. Even though processing accounts for 14%–45% of plant-based meat's total water use,[8,9] conventional meat's water use far surpasses that of every plant-based meat evaluated to date.

PLANT-BASED MEAT CAUSES 51%–91% LESS AQUATIC NUTRIENT POLLUTION

THAN CONVENTIONAL MEAT (G-PO_4^{3-}-EQ/KG-MEAT).

Eutrophication is a leading threat to global water quality, and animal agriculture is one of its primary sources.[25] Eutrophication occurs when nitrogen and phosphorus run off into waterways, stimulating growth of algal blooms that suffocate aquatic life. Animal agriculture is doubly harmful, thanks to pollution from the fertilizer used on feed crops and the manure animals produce.[26] Each of the largest pig farms produce more excrement than the city of Philadelphia, but they don't have wastewater treatment facilities.[20] Manure often sits in open lagoons before being sprayed over nearby fields, creating extreme health risks for local communities.[20]

Table 2: Industrial animal agriculture threatens the environment and society in four key ways. Here's how plant-based meat stacks up:

	INDUSTRIAL ANIMAL MEAT	PLANT-BASED MEAT
Land Use	Over one-third of all habitable land on Earth is used to support animals, threatening a global ecological crisis	**Harm:** Greatly Reduced **Certainty:** High
Climate Change	Animal agriculture is responsible for the vast majority of food sector greenhouse gas emissions	**Harm:** Reduced **Certainty:** High
Water Pollution	Untreated manure and excess fertilizer are major sources of ecological damage and human illness	**Harm:** Greatly Reduced **Certainty:** High
Antibiotic Resistance	Feeding antibiotics to healthy animals causes microbes to become resistant, making life-saving drugs useless in human medicine	**Harm:** Eliminated **Certainty:** High

Plant-based meat solves both problems. It requires a fraction of the cropland and proportionately less fertilizer. It also produces no manure, eliminating both the eutrophication and the direct human health risks associated with massive amounts of untreated animal waste.

PLANT-BASED MEAT REQUIRES NO ANTIBIOTICS.

In the United States, over 70% of medically relevant antibiotics are used in animal agriculture.[27] Healthy animals are fed low doses of antibiotics to speed growth and prevent disease, causing bacteria to adapt and become resistant.[27,28] Many of these antibiotics are used in human medicine, so when bacteria become resistant, hospitals can no longer defend against them.[27,29]

If left unchecked, by 2050 drug-resistant microbes could kill 10 million people each year (more than currently die of cancer) and cause a cumulative $100 trillion in economic damage (as much as the global economic crisis of 2008–2009).[27]

Plant-based meat requires no antibiotics at all.

It also greatly reduces the risk of antifungal resistance, which can arise from the use of fungicides on crops,[31] because plant-based meat requires much less crop production than conventional meat.

Pathway to a Sustainable Food Supply

Between its resource efficiency and its appeal to consumers, plant-based meat has tremendous potential to help build a sustainable food supply. However, there's still a long way to go.

Truly meat-like products have been widely available to consumers only since 2013, and plant-based meat still makes up just 1% of the retail meat market.[31] After millennia of optimization, animal agriculture is hitting declining returns in quality and efficiency, but plant-based meat can continue to improve by leaps and bounds.

Public research can support the development of new products and processes to make plant-based meat even more delicious, affordable, and environmentally sustainable than it already is.

A level playing field will ensure that these products can compete fairly in the marketplace. This requires commonsense labeling rules and evidence-based safety standards.

Institutional support from food companies, food-service providers, governments, and environmental advocates can accelerate the transition to a sustainable food system.

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