

# Plant-based food alternatives could support a shift to global sustainability

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Replacing 50% of meat and milk products with plant-based alternatives by 2050 can reduce agriculture and land use related greenhouse gas (GHG) emissions by 31% and halt the degradation of forest and natural land, according to new research in Nature Communications. Credit: International Institute for Applied Systems Analysis (IIASA)

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(GHG) emissions by 31% and halt the degradation of forest and natural land, according to new research.

According to the study just published in [\*Nature Communications\*](#), additional climate and biodiversity benefits could accrue from reforesting land spared from [livestock production](#) when meat and [milk products](#) are substituted by plant-based alternatives, more than doubling the climate benefits and halving future declines of ecosystem integrity by 2050.

The restored area could contribute up to 25% of the estimated global land restoration needs under [Target 2 of the Kunming Montreal Global Biodiversity Framework](#) by 2030.

"We'll need much more than 'Meatless Mondays' to reduce the global GHG emissions driving climate change—and this study shows us a path forward," said study co-author Eva Wollenberg of the University of Vermont (UVM).

"Plant-based meats are not just a novel food product, but a critical opportunity for achieving food security and climate goals while also achieving health and biodiversity objectives worldwide. Such transitions are challenging and require a range of technological innovations and policy interventions."

The study, by researchers at UVM, the International Institute for Applied Systems Analysis (IIASA), the Alliance of Bioversity International, and CIAT, is the first to look at the global food security and environmental impacts of plant-based meat and milk consumption at large scales that considers the complexity of food systems.

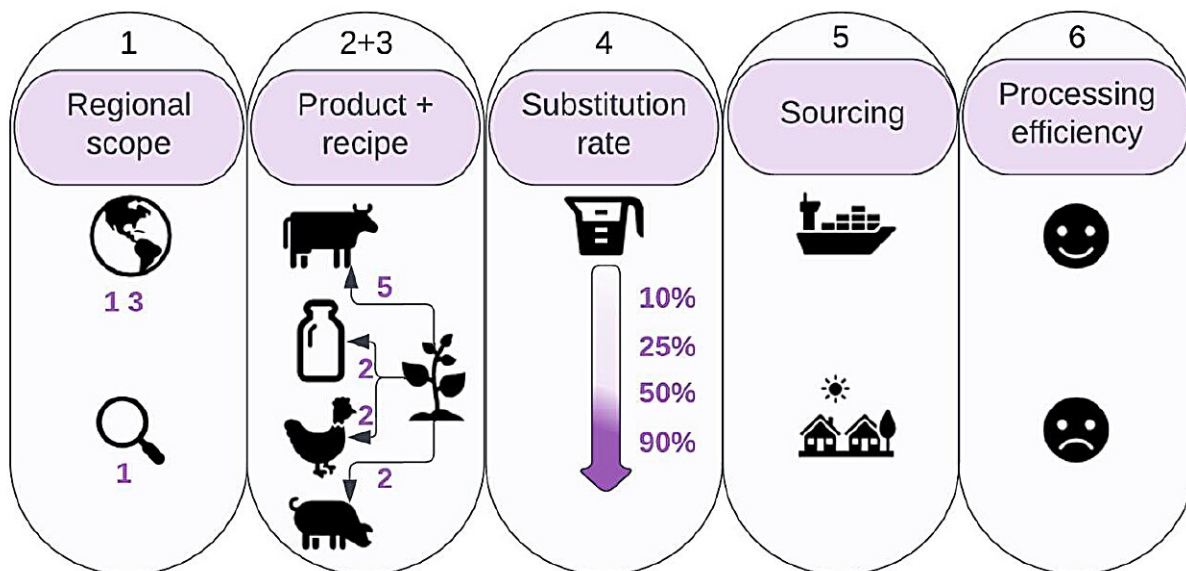


Figure 1. The substitution in the scenarios of plant-based market development is defined along six dimensions: 1) regional scope (13 regions), 2) meat product (i.e., pork, chicken, milk, & beef), 3) recipe type (e.g., soy, pea, nut, etc.), 4) scenario substitution rate (10-19%), 5) international or domestic sourcing of ingredients, and 6) efficiency of converting crops into processed products. Credit: Kozicka, M., et al. (2023).

"Understanding the impacts of dietary shifts expands our options for reducing GHG emissions," said study lead author Marta Kozicka, a researcher from IIASA. "Shifting diets could also yield huge improvements for biodiversity."

The authors found that a 50% substitution scenario would substantially reduce the mounting impacts of food systems on the natural environment by 2050. Compared to 2020, the impacts would include:

- Global agricultural area declines by 12% instead of expanding.

- The decline in areas of forest and other natural land is almost completely halted.
- Nitrogen inputs to cropland are nearly half of the projections.
- Water use declines by 10% instead of increasing.
- Without accounting for any carbon sequestration on spared land, GHG emissions could decline by 2.1 Gt CO<sub>2</sub>eq year<sup>-1</sup> (31%) in 2050 (1.6 Gt CO<sub>2</sub>eq year<sup>-1</sup> on average in 2020–2050).
- Undernourishment globally declines to 3.6%, as compared to 3.8% in the reference scenario (reducing the number of undernourished people by 31 million).

The authors developed scenarios of dietary changes based on plant-based recipes for beef, pork, chicken, and milk. These recipes were designed to be nutritionally equivalent to the original animal-derived protein products and realistic for the existing food manufacturing capabilities and globally available production ingredients.

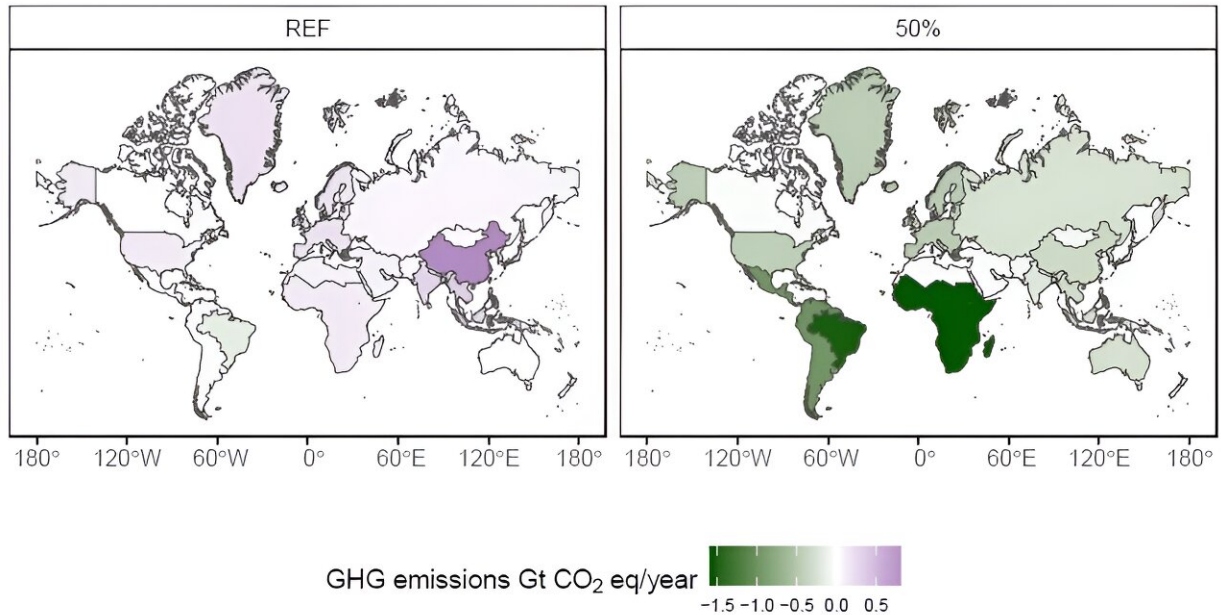


Figure 2. Change in emissions between 2050 and 2020 from agricultural and land use. Sinks from land restoration were included in the total emissions calculation. REF presents the distribution of emissions in the reference scenario, while (50%) presents results under the 50% global substitution scenario. Credit: Kozicka, M., et al. (2023).

To ensure relevance and as a potential user of the findings, the research team solicited input from Impossible Foods, a company that develops plant-based substitutes for meat products. The company provided generic recipes for the plant-based meat substitute products used in the analysis. The science team had complete control over decision-making for this peer-reviewed study, and the data are not specific to Impossible Foods.

The full environmental benefit of diet shifts can be achieved if the agricultural land spared from livestock and feed production is restored through biodiversity-minded afforestation. In the 50% scenario, the

benefits from reduced [land-use](#) emissions could double as compared to a scenario without afforestation—a total reduction of 6.3 Gt CO<sub>2</sub>eq year<sup>-1</sup>. The 50% substitution scenario would reduce predicted declines in ecosystem integrity by more than half.

"While the analyzed dietary shifts serve as a powerful enabler for reaching climate and biodiversity goals, they must be accompanied by targeted production side policies to deliver their full potential. Otherwise, these benefits will be partly lost due to production extensification and resulting GHG and land-use efficiency losses," explains IIASA Biodiversity and Natural Resources Program Director Petr Havlík.

While the results support the increased use of plant-based meat substitutes, the authors recognize that livestock are a valuable source of income and nourishment for smallholders in low- and [middle-income countries](#), and have significant cultural roles, reduce risk, and diversify smallholder income. Simultaneously, [climate change](#) threatens the livelihoods of smallholder farmers.

Rapid policy and management action to avoid environmental risk and support farmers and other livestock value chain actors for a socially just and sustainable food system transition will therefore be crucial. This is particularly important considering recent setbacks to achieving [food security](#) globally.

According to the study, impacts across regions could differ due to differences in population size and diets, unequal agricultural productivity, and participation in international trade of agricultural commodities. The main impacts on agricultural input use are in China and on environmental outcomes in Sub-Saharan Africa and South America. These regional differences could also be used to design better interventions.



"The food sector produces roughly one third of global GHG emissions—and has been notoriously difficult to de-carbonize," said Wollenberg, a researcher at UVM's Gund Institute for Environment, the Rubenstein School of Environment and Natural Resources, Alliance of Bioversity International, and CIAT.

"Given the magnitude of benefits we show from substituting meat with plant-based alternatives for global sustainability, climate action, and human health, this research provides important food for thought for consumers, food producers, and policymakers."

**More information:** Marta Kozicka, Feeding climate and biodiversity goals with novel plant-based meat and milk alternatives, *Nature Communications* (2023). DOI: [10.1038/s41467-023-40899-2](https://doi.org/10.1038/s41467-023-40899-2).  
[www.nature.com/articles/s41467-023-40899-2](https://www.nature.com/articles/s41467-023-40899-2)

Provided by University of Vermont

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