Biggest bang for the buck: Cost-effective pathways to climate targets in German food retail

Authors:
Quantis: Patricia Granados • Elsa Guadarrama • Mollie Hoss-Kuhne • John Willard
Madre Brava: Nico Muzi • Florian Wall

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Introduction

Abstract

This report provides a comprehensive analysis of cost-effective strategies that German food retailers can adopt to reduce Scope 3 FLAG (Forest, Land, and Agriculture) emissions and meet 2030 climate targets. The analysis focuses on three key areas: a plant-rich food system, improvements in agricultural practices, and reductions in food loss and waste (FLW) in meat and dairy products. The findings suggest that promoting a plant-rich food system offers the most immediate and cost-effective opportunity for emissions reduction. Enhancing and transitioning agricultural practices – although requiring greater investment and more resources – provide improvements which are essential for achieving long-term, holistic sustainability goals. Reducing FLW in dairy and meat products has a relatively smaller impact on emissions but should continue to be scaled to enhance its role within comprehensive climate and sustainability strategies.

Motivation

The forest, land, and agriculture (FLAG) sectors are not only highly vulnerable to the impacts of climate change but also major contributors to global emissions, accounting for **22% of global greenhouse gas (GHG) emissions**, making it the second-largest emitter after the energy sector (SBTi, n.d.). This significant contribution to global emissions underscores the importance of addressing emissions from the land sector in efforts to limit global warming to 1.5°C by 2030.

In recent years, **climate change has caused increasingly erratic weather patterns**, with more frequent and severe droughts, floods and heatwaves **impacting agricultural productivity.** The Intergovernmental Panel on Climate Change (IPCC) notes that these extreme events can **reduce** crop yields, **disrupt** livestock production and **threaten** food security, particularly in regions already vulnerable to food shortages (IPCC, 2019). Additional research suggests that rising temperatures and altered precipitation patterns can **reduce** the nutritional **quality** of staple crops like wheat and rice, further **complicating** the challenge of improving **food security** in a warming world (Myers et al., 2014).

As the climate crisis worsens, **the EU aims to reduce** its total greenhouse gas emissions **(GHG) by 55% by 2030** compared to 1990 levels (European Commission, 2024). While the EU has steadily decreased its greenhouse gas emissions by 37% between 1990 and 2023 (European Commission, 2024), an **additional 29% reduction from 2023 levels is still** required **to meet the** 2030 climate targets. Germany, as one of the largest contributors to EU GHG emissions, **has particularly ambitious reduction targets** aiming for a **65% total reduction** in GHG emissions by 2030, compared to 1990 levels of 1,251 $MtCO_2e$ (UBA, 2024). To reach this target, Germany still must reduce emissions by 35% (or 236 $MtCO_2e$) from 2023 levels (674 $MtCO_2e$). With pressure to meet

targets rapidly growing, the need to transform the food system becomes particularly urgent, and **food retailers** have a unique opportunity to drive **meaningful** climate **action**.

Given the high proportionality of food vs. non-food sales for German food retailers, **FLAG emissions make up a significant and** often are a majority portion of overall emissions. In light of this, **leading retailers in Germany have committed** to setting or are in the process of setting **SBTi targets.** As part of SBTi target setting, companies are required to set FLAG targets if FLAG emissions make up 20% or more of their total emissions across scopes 1, 2 and 3 if they wish to establish near-term or long-term net-zero targets under the Science-Based Targets (SBT) bbbframework (SBTi, n.d.).

Top supermarket chains in Germany[1]	Near-Term Target	Net-Zero Target	SBTi Scope 3 & FLAG Targets[2]:
ALDI Einkauf SE & Co. oHG	Targets set	--	Near-term engagement target: 75% of suppliers by emissions covering purchased goods and services will have science-based targets by 2024.
Aldi SÜD Dienstleistungs-SE & Co. oHG	Targets set	By 2050	Near-term targets: Reduce absolute scope 3 GHG emissions 25% (incl. land-related emissions & removals from bioenergy feedstocks) and absolute FLAG Scope 3 emissions 30.3% by 2030 from a 2022 base year. Long-term targets: Reduce absolute scope 3 GHG emissions 90% (incl. land-related emissions and removals from bioenergy feedstocks), absolute scope 1 FLAG GHG emissions 72% by 2050 from a 2021 base year, and absolute scope 3 FLAG GHG emissions 72% by 2050 from a 2022 base year.
EDEKA ZENTRALE Stiftung & Co.KG	Targets set	By 2045	Near-term engagement target: 85.33% of its suppliers by emissions covering purchased goods and services, upstream transportation and distribution, will have science-based targets by 2028. Near-term targets: Reduce absolute scope 3 GHG emissions from use of sold products 30%, reduce all other absolute scope 3 GHG emissions from use of sold products 50.40% (incl. land-related emissions and removals from bioenergy feedstocks), and absolute scope 3 FLAG GHG emissions 36.4% by 2032 from a 2022 base year. Long-term targets: Reduce absolute scope 3 GHG emissions by 90,00% by 2045 from 2022 base year (incl. land-related emissions and removals from bioenergy feedstocks) and absolute scope 3 FLAG GHG emissions 72% by 2045 from a 2022 base year (incl. FLAG emissions and removals).
Schwarz Gruppe	Targets set	Commited	Near-term engagement target: 78% of suppliers by emissions covering purchased goods and services will have science-based targets by 2026.
REWE Markt GmbH	Targets set	by 2050	Near-term targets: Energy & Industry: Reduce absolute scope 1 and 2 GHG emissions 42% by 2030 from a 2021 base year. Reduce absolute scope 3 GHG emissions from purchased goods and services, capital goods, upstream transportation and distribution, and use of sold products 42% within the same timeframe (incl. land-related emissions and removals from bioenergy feedstocks). FLAG: Reduce absolute scope 3 FLAG GHG emissions 30.3% by 2030 from a 2021 base year. Long-term targets: Energy & Industry: Reduce absolute scope 1 and 2 GHG emissions 90% by 2050 from a 2021 base year. Reduce absolute scope 3 GHG emissions from purchased goods and services, capital goods, upstream transportation and distribution, and use of sold products 90% within the same timeframe (incl. land-related emissions and removals from bioenergy feedstocks). FLAG: Reduce absolute scope 3 FLAG GHG emissions 72% by 2050 from a 2021 base year (incl. FLAG emissions and removals).

Sources: [1]Retail Index, 2022; [2]Science Based Targets. (n.d.). Companies taking action. Available at: https://sciencebasedtargets.org/companies-taking-action#dashboard. Accessed on: 17 October 2024.

While these commitments reflect the urgent need to address climate change and **unprecedented momentum for the industry,** there's **still a critical need for reliable guidance on the most cost-effective strategies to reduce emissions.**

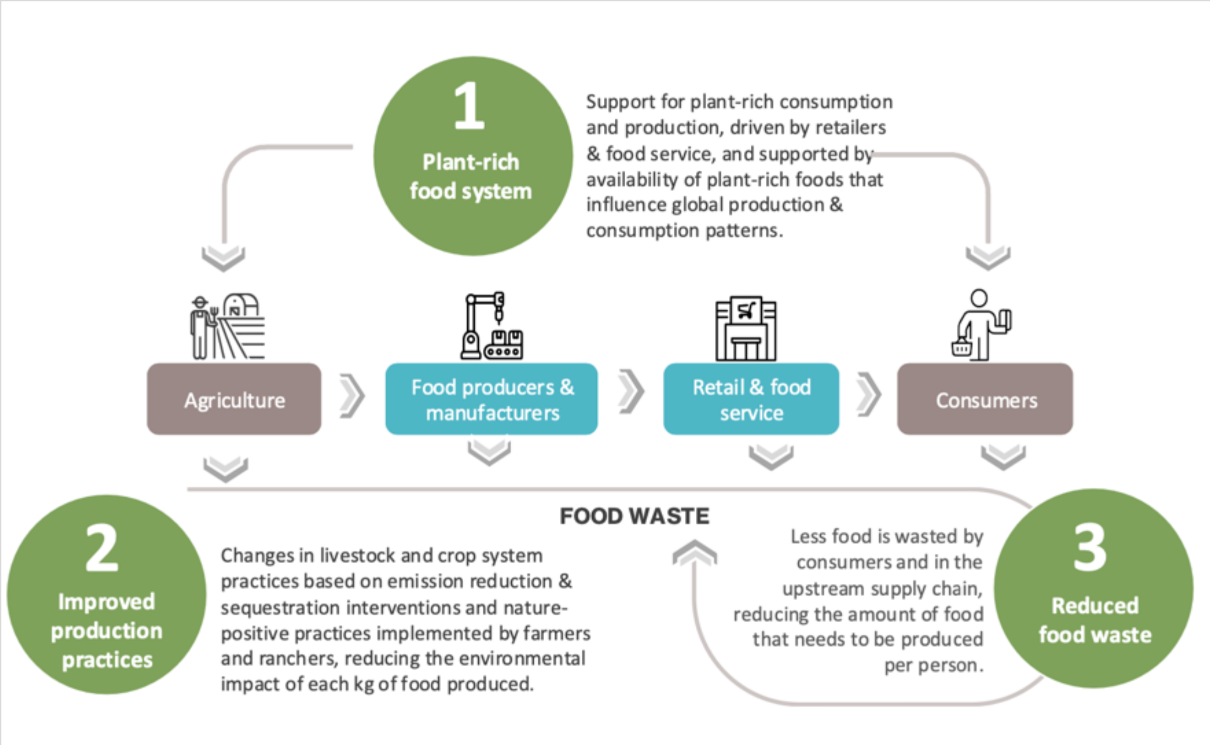

Figure 1: Sustainable Food System Pathway (Tilt Collective, 2024)

According to findings by EAT-Lancet Commission (2019) and Tilt Collective (2024), **there are three key approaches required** to transition to a more sustainable food system globally: **shifting to plant-rich consumption and production**, **improving agricultural production practices** to reduce emissions and increase carbon sequestration, and **reducing food loss and waste** at every stage, from production to consumption. Among these, the study by Tilt Collective showed that **a plant-rich food system has the highest emissions reduction potential,** projected to reduce 8 $GtCO_2e$ of emissions by 2050, compared to 5 Gt through improved production practices and 1 Gt from waste reduction. While findings from these studies highlight strategic pathways for transforming the global food system, a regionally tailored analysis for the German food retail sector is still needed.

In this context, **Madre Brava** commissioned **Quantis**, a leading environmental sustainability consultancy, to **identify a cost-effective mix of strategies to reduce emissions for the food retail sector in Germany.** These strategies include demand-side approaches, like promoting a plant-rich food system (by reducing meat consumption and adopting more sustainable protein sources—such as plant-based proteins), and educating consumers on reducing food loss and waste (FLW), alongside supply-side measures like enhancing and transitioning on-farm agricultural practices.

The goal of this research is **to provide the German food retail** sector with insights into **the climate and economic impacts** of implementing these measures, based on publicly available- and scientific-studies. This comprehensive assessment provides knowledge for food retailers to **guide the development of mitigation strategies** which align with existing climate commitments and enable transformation of the agrifood system.

Study structure and approach

Objectives

+ Assess the **climate and economic impacts** on retailers of demand-side (e.g., portfolio transition to plant-based or other alternative proteins, consumer education) and supply-side (e.g., on-farm practices) and measures.
+ Establish a **guidance for German food retailers** to reference when building mitigation strategies related to plant-rich food systems, improving agricultural practices, and reducing food loss and waste (FLW), considering cost-effectiveness and reduction potential.
+ Determine an optimal **consumption balance between animal and plant-based meat** that achieves impactful emissions reductions efficiently, which food retailers can support to meet near-term climate targets through a plant-rich food system.

Category levers & pathways[1]

This **research model builds on existing studies, focusing on three of the most impactful levers** for emission reduction in the food sector (EAT-Lancet Commission, 2019). Specific pathways were selected to ensure relevance to the German market and include:

Category lever	Plant-rich food system – DE	Improved agricultural practices – EU	Reduced food loss and waste (FLW) –DE
Pathway	Up to 30% replacement of animal-based meat and milk with plant-based options.	Average implementation of identified practices to up to 20%.	Average implementation of identified practices to up to 100%.

[1]These pathways were chosen based on best practices for climate impact reduction.

Data sources

+ **Plant-rich food system:** To establish current and future consumption patterns, data on German meat consumption (BMEL, 2024a) and meat substitutes production were used (Destatis, 2023), considering projected changes in the population of Germany until 2030 (UN, 2024). Prices of animal protein sources were retrieved from Statista reports (Statista, 2024a). Emission factors from the WFLDB (WFLDB, n.d.) and AGRIBALYSE (AGRIBALYSE, n.d.) databases were applied to estimate the corresponding emissions.
+ **Agricultural practices:** Quantis applied additional analysis and expert judgement, based on previous reports of several of the interventions to identify the near-term feasibility, costs and reduction potential (see reference list).
+ **Food loss and waste (FLW):** German waste amounts from statistics were used (BMEL, 2024b) (GfK SE, 2021) to define the baseline emissions from the avoidable waste quantities of meat and dairy categories. ReFED (ReFED, n.d.) and the PACT for FLW reduction (BMEL, 2023) were used to extract relevant measures and their associated costs and reduction

potential. Emission factors from the WFLDB (WFLDB, n.d.) and ecoinvent (ecoinvent, n.d.) databases were applied to estimate the corresponding emissions.

+ **Industry perspective:** European retailers have **long focused on reducing FLW** and **promoting sustainable agricultural practices**. A plant-rich food system, with increased consumption of plant-based or alternative protein sources (e.g., meat made from plants, cultivated from animal cells, or produced via fermentation), is now emerging as a **key strategy** for cutting FLAG emissions. With multiple strategies for reducing FLAG emissions and factors like economic and logistical constraints, limited control over farm-level production and the complexity of the agrifood value chain, data-driven recommendations and strategic prioritization are essential for achieving meaningful progress.

Research tools

+ **Marginal Abatement Cost (MAC) curves** were built to understand the cost-effectiveness of each intervention, i.e. the cost of implementation (in €) per ton of CO_2e reduced for each intervention. MAC curves allow decision-makers to prioritize interventions that achieve the **greatest emissions reductions** (abatement potential) **at the most optimal cost**.
+ **Linear relationships:** Linearity within each intervention and their outcomes is assumed, acknowledging that, diminishing returns or nonlinear effects (e.g., technological innovation, policy support and market demand) could occur as interventions scale. This assumption was applied to assess two key outcomes:
    - **Climate impact** (GHG emissions reductions): measured in tonnes of CO_2e.
    - **Cost:** the cost of implementing each intervention in euros.

Limitations

+ **Data comparability**: Emissions and costs are based on global, European and German averages, which may not reflect specific regional or national circumstances. Where possible, data from Germany is applied in the model. In the case of data gaps, EU-level, US or global data was scaled and used. Direct comparison between levers should be used for reference only.
+ **Data gaps:** Publicly available data, particularly on emerging technologies such as alternative proteins and innovative agricultural levers, may be limited, outdated, or must be rescaled to fit the scope of this report. We mitigated this by incorporating expert knowledge, but some uncertainty remains.
+ **Simplification of complex systems:** The food system is complex and interconnected. While key interventions are modeled, factors like consumer behavior, policy changes and market dynamics are beyond its scope. Interventions can experience diminishing returns as they scale, and the linear model may not fully capture these effects.
+ **Time horizon:** The main focus on achieving short-term (2030) climate targets. Longer term impacts, such as soil carbon sequestration in farm-level production or full market transformation of alternative proteins, are not fully reflected in the model.

Summary of overall key results

All investigated interventions —a plant-rich food system, improving agricultural practices, and reducing FLW—are impactful and important for comprehensive climate strategies with **promoting a plant-rich food system** emerging as the most economic **option to make progress in meeting near-term climate targets**. **Improving agricultural practices** is also effective to make progress against near-term targets. However, it's resource-intensive, **requires long-term investments,** and primarily delivers impact over a longer timeframe. Meanwhile, reducing **food loss and waste** in dairy and meat products, while having a **smaller impact on emissions**, remains an essential element of a comprehensive climate action strategy from a broader perspective.

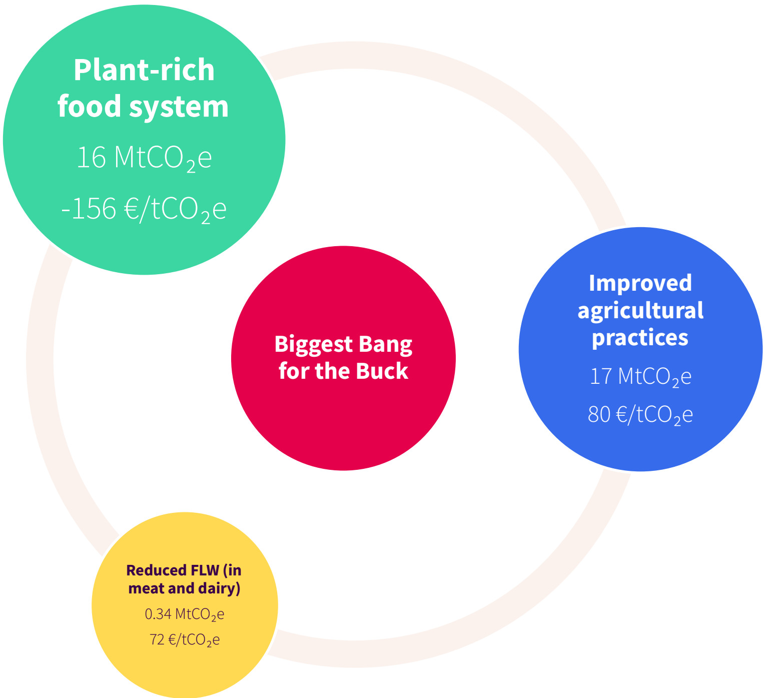

Figure 2: Key strategies for cost-effective emissions reduction in the food retail ($MtCO_2e$ and marginal abatement cost).

As retailers in Germany develop strategies to meet both short-term and long-term goals, levers from both the demand and supply sides should be applied to ensure transformational progress. Additionally, **scalability and regional adaptability must guide the prioritization** and execution of these interventions across diverse geographies.

Emission savings and investment potential

Strategies	Baselines	MtCO2e saving potential by 2030 in %	Potential investment in EUR
Plant-rich food systems	60 MtCO2e[1]	32%	- 2,000 million
Agricultural Practices	365 MtCO2e[2]	5%	Above 1.000 million
Food loss and waste	2.7 MtCO2e[3]	13%	Above 20 million

[1]Meat and milk emissions in Germany for projected 2030 population sizes under 2023 consumption patterns. [2]EU-wide excluding LULUCF in 2023. [3]calculated based on avoidable waste volumes of meat and dairy products in German retail and households in 2023.

Marginal abatement cost curve for 2030 – All levers

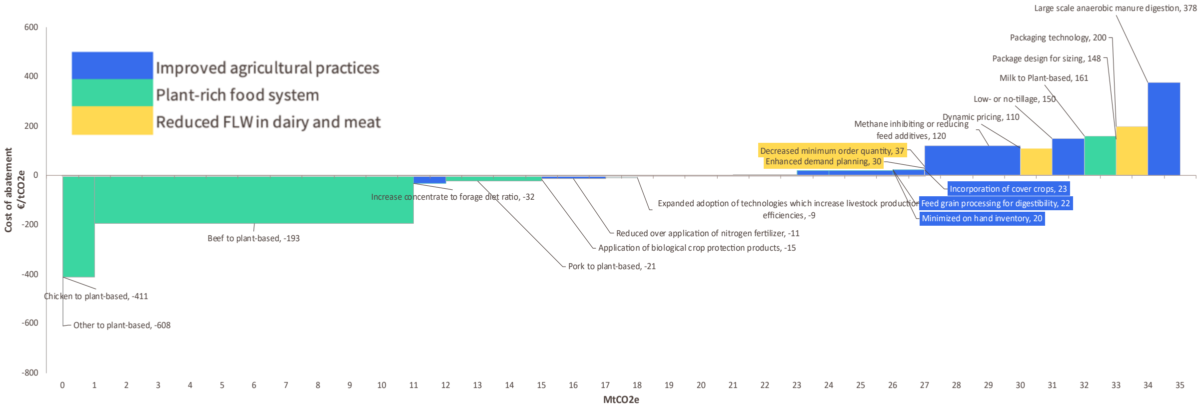

Figure 3: All Levers- $MtCO_2e$ and abatement cost (levers with 0 abatement potential were omitted in this graph)

Background

A plant-rich food system involves shifting primarily protein sources from animal-based products to plant-based proteins or cultivated and fermentation-based options. On average, these types of foods are less resource-intensive, requiring less land and water for production and generating fewer greenhouse gases emissions than meat production (GFI, 2023), and can reduce the risk of heart disease and cancer (WHO, 2021). In Germany, a plant-rich food system is being rapidly adopted. Meat and milk consumption hit historic lows in 2023, with meat intake down 12% from 2019 levels (BMEL, 2024a) and milk consumption dropping to below 46 kg per person (BLE, 2024b). In contrast, in 2023, plant-based meat production grew by 16.6%, reaching 121,600 tonnes — more than double the output from 2019 (Destatis, 2023). Moreover, the number of companies producing meat alternatives grew from 51 in 2022 to 67 in 2023 (Destatis, 2023). With a visible increase in investments, Germany is positioning itself as a leader in plant-based protein innovation, with plant-based products reaching tipping points in price, taste and function.

Key results – Plant-rich food system

Research levers

This research refers to a plant-rich food system primarily as the transition from animal products (e.g., meat and milk) to plant-based meat and milk sources. These levers were used to explore viable, near-term pathways forward using optimal dietary models (e.g., planetary healthy diet). The consumption of more whole plant foods such as legumes and nuts were not included. Future research should focus on including these plant-based proteins for a more comprehensive impact assessment.

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Methodology

To evaluate the impact of a plant-rich food system — particularly through changes in meat and milk consumption — on emissions and costs in Germany, the following baseline consumption levels (2023) were established: 51.6 kg of meat per person (BLE, 2024a) and 46 kg of milk per person (BLE, 2024b) (Trademagazin, 2024).

By 2030, aligning with EAT-Lancet recommendations would require a 14% reduction in global meat consumption — equivalent to a 2% year-on-year decrease observed since 2020. To explore pathways toward this target, the research modelled two forward-looking pathways (2023–2030) for emission reductions and cost impacts:

+ **Accelerated pathway:** Assumes the continuation of the historical trend of reduced meat and milk consumption, with this decline accelerating.
+ **Transformative pathway:** Doubles the pace of reduction compared to the Accelerated pathway.

By comparing these two scenarios, the goal of this research is to highlight pathways that can **reduce emissions faster and more effectively** than what would naturally happen under the "business-as-usual" scenario. It's not just about cutting emissions compared to today's levels but speeding up progress toward deeper reductions.

Both pathways assumed **linear reductions** in meat and milk consumption and are fully offset by a 1:1 increase in plant-based alternatives. This approach ensured total per capita food consumption (kg/year) remained constant, **maintaining overall food availability**.

Levers	Key assumptions	Main limitations
Meat replacement with plant-based protein • Beef to plant-based • Pork to plant-based • Chicken to plant-based **Milk replacement with plant-based milk** • Cow milk to plant-based milk	The dietary shift focuses on animal meat and cow's milk (in liquid form) consumption to plant-based meat and milk (in liquid form). Protein sources and substitutes for meat products were selected based on data availability and substitution was made based on protein content. Tempeh is used as an approximation for alternative meat proteins in terms of the relationship between emissions and cost impact. Average costs stem from the Statista report, for milk they cover a variety of types, including regular, full-fat, reduced-fat, low-fat, skimmed, semi-skimmed, pasteurized, UHT, raw, flavored, barista, and lactose-free milk, whereas for plant-based milk, plain options were included such as almond, soy, oat, coconut, rice, cashew, pea, hemp, macadamia, flax, quinoa, hazelnut, and walnut), as well as flavored and unsweetened plant-based varieties. Cost-effectiveness of plant-based alternatives is evaluated assuming price parity with animal-based protein sources.	Following protein sources were excluded: Animal-based proteins: • Eggs. • Dairy products: yogurt, cottage, cheese, ice cream, etc. • Fish and seafood. Plant-based proteins. • Other grains, legumes and nuts. • Plant-based yogurt, cottage, cheese, ice cream, etc. • Tofu. The production of meat substitutes may impact other nature indicators, such as land use change or water consumption. While these effects were not investigated, there is potential of mitigation through sustainable agricultural practices.

2023 consumption (per capita kg/a)		Accelerated pathway (15% reduction)	Change by 2030 (kg)	Transformative pathway (30% reduction)	Change by 2030 (kg)
Meat	52[1]	44	-8	36	-16
Milk	46[2]	39	-7	32	-14

Numbers rounded. Meat refers to beef, pork, and chicken, while milk specifically refers to liquid cow's milk. [1] Based on per capita consumption of meat in Germany (Statista, 2024). [2] Based on milk consumption trends in Germany (BLE, 2024b) (Trade Magazin, 2024).

2023 consumption (per capita kg/a)		Accelerated pathway (1:1 replacement per capita kg/a)	Change by 2030 (kg)	Transformative pathway (1:1 replacement per capita kg/a)	Change by 2030 (kg)
Plant-based Meat	1,4[3]	9	+8	18	+16
Plant-based Milk	4[4]	11	+7	18	+14

Numbers rounded. Plant-based meat includes tempeh, while plant-based milk refers to a mix of various sources such as soy, oats, peas, and other plant-based ingredients, all in liquid form. [3, 4] Based on Statista Market Insights (Statista, 2024a).

While **these shifts will require significant buy-in** and cooperation from governments, industries and consumers, they are grounded in **efforts to achieve visible emissions reductions,** conserve natural resources and address food system challenges. Accelerated trends in Germany suggest promising potential for a rapid transition towards a plant-rich food system.

To estimate the economic implications of these shifts, average retail price data for each protein category, factoring in projected price increases, was used. Based on inputs from a variety of industry forecasts, retail price increases of approximately 15% by 2030 were estimated and taken into consideration. These price projections were integrated into the model to assess the financial impacts relevant for both retailers and consumers. For meat, the estimated retail prices per kilogram as of 2023 were as follows: €15.40 for beef, €8.30 for pork, €9.40 for chicken, and €10.70 for other meats (Statista, 2024a). To achieve a normalized price with the average price of animal meat, meat alternatives stood at a price of €9.70 per kilogram. The price for milk was established at €1.05 per kg as of 2023 (Statista, 2024a), for plant-based milk, 1 kg at €2.04 (Statista, 2024a). With current market projections indicating price parity between cow milk and plant-based milk will be reached eventually in Germany (vegconomist.com, 2023), we set price parity as of 2027.

Lastly, by comparing the marginal abatement costs (MAC) across different pathways, the cost-effectiveness of shifting from conventional meat to plant-based proteins was evaluated.

Results

Plant-based food system - Marginal abatement cost curve for 2030

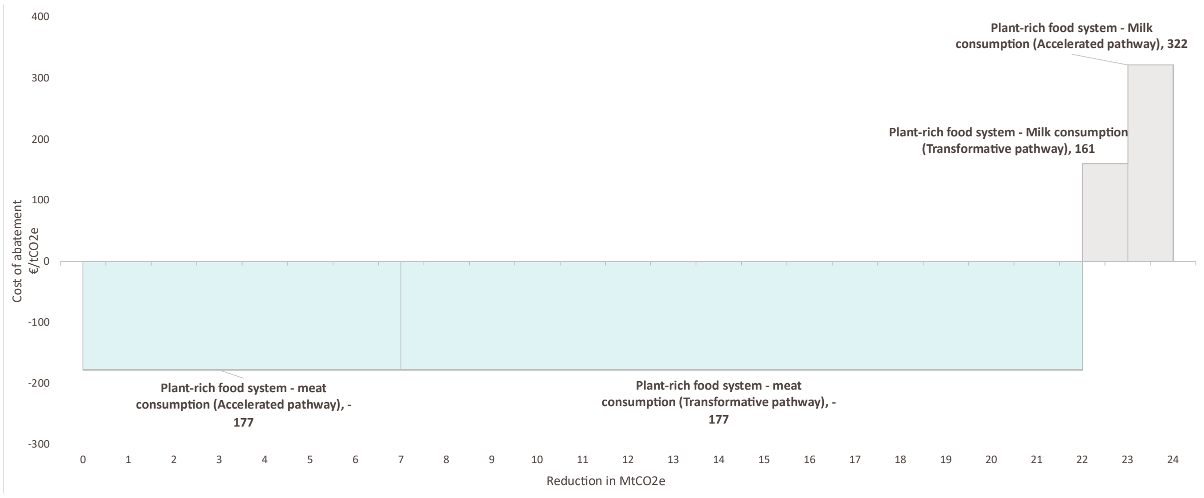

Figure 4: Marginal abatement costs of different pathways of a plant-rich food systems in Germany

The most efficient marginal abatement cost comes from the Transformative pathway, particularly through **shifts in meat consumption,** which offer **greater environmental and economic benefits** compared to milk. Although the Accelerated pathway for meat could also achieve significant reductions. In contrast to meat, milk contributes less to emissions, indicating that more ambitious reductions (or greater substitutions), as seen in the Transformative pathway, are needed to achieve meaningful impact. This disparity underscores the importance of **prioritizing meat reduction** while balancing efforts for both meat and milk to optimize marginal abatement costs.

For changes in meat consumption, the abatement cost (~-177 €/tCO_2e) remains the same across both pathways due to the assumed price parity between animal-based and plant-based alternatives, resulting in identical substitution costs.

The difference in abatement costs for changes in **milk** consumption (~161 €/tCO_2e in the Accelerated pathway vs. ~322€/tCO_2e in the Transformative pathway) arises from **smaller emissions savings per unit of substitution**, **higher scaling challenges** and **different substitution dynamics.** The assumption that price parity would only be achieved by 2027 in this category led to higher costs during the initial four years. Assuming earlier price parity could have reduced these marginal costs significantly.

Promoting a plant-rich food system, by prioritizing the replacement of animal meat with plant-based meat alternatives, delivers substantial emissions reductions and significant financial savings, making it a key strategy for achieving 2030 climate targets.

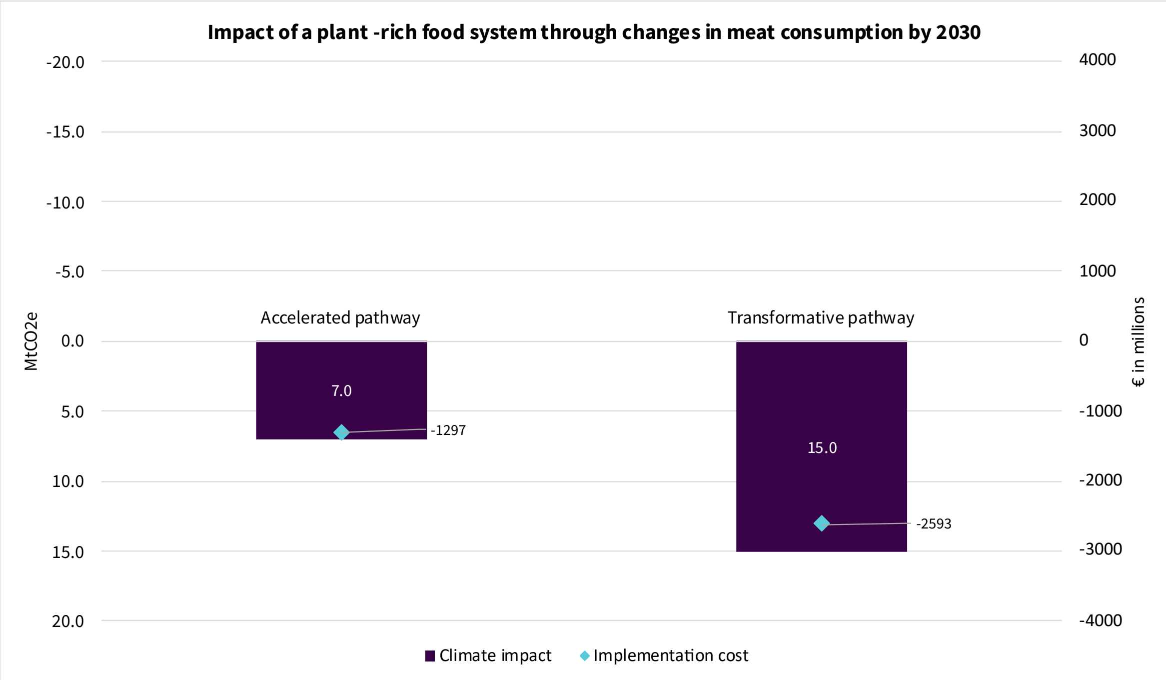

Figure 5: German meat emission pathways 2030

If the **current meat consumption ratio** in Germany — including beef, pork, and chicken and plant-based meat options — is maintained until 2030, it can lead to approximately **54 MtCO_2e of emissions** annually, in which animal products account for over 95% of total emissions. Under an **Accelerated pathway,** emissions savings can be up to **7 MtCO_2e (or 13% less)**. In the more ambitious **Transformative** pathway, emissions **savings** could reach up to **15 MtCO_2e (or 28% less).**

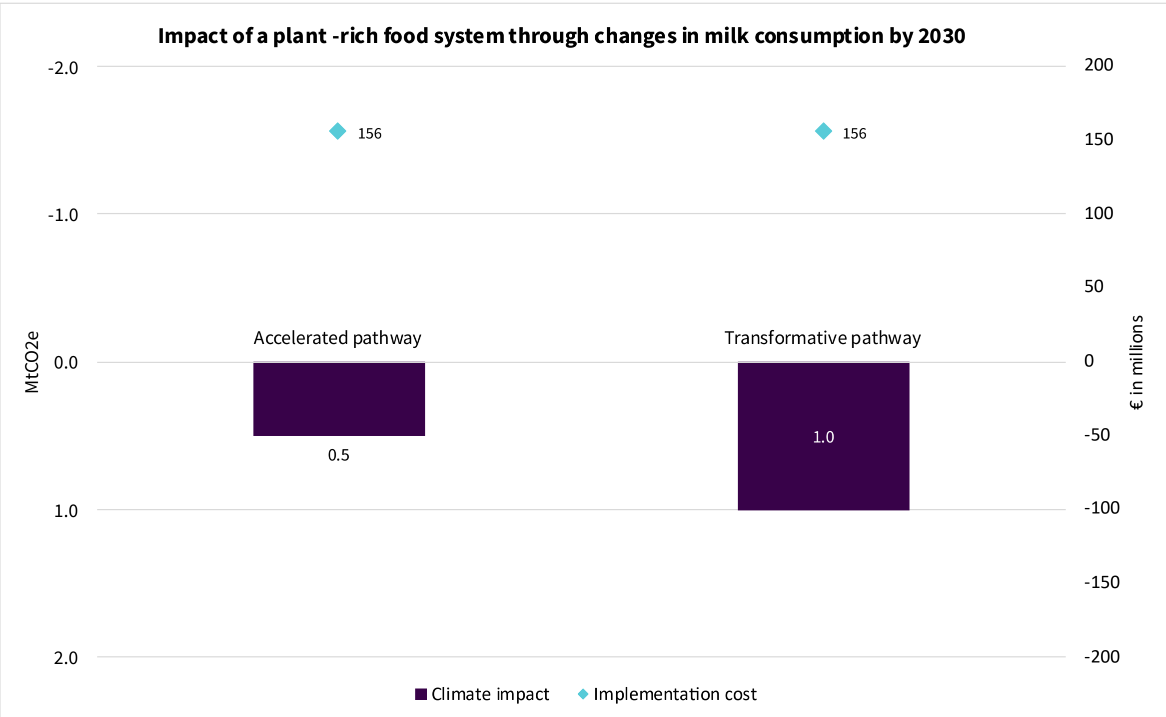

Figure 6: German milk emission pathways 2030

If the current **milk consumption ratio in Germany** — including cow's milk and plant-based milk options in liquid form — is maintained by 2030, it will lead to approximately **5 MtCO_2e** of emissions annually, in which cow's milk account for 95% of total emissions. The **Accelerated pathway can lead to** emissions savings by up to **0.5 MtCO_2e (or 10% less)**. In a **Transformative** pathway, emissions **savings** could reach up to **1 MtCO_2e (or 20% less).** These modest reductions could be because cow's milk emissions still account for over 80% of total milk emissions, even in a Transformative pathway.

The overall climate impact of substituting milk with plant-based alternatives could be limited given that only liquid milk was considered. Opting for **a complete dairy substitution,** including products like cheese, yogurt and butter, can yield significantly **higher savings** in emissions at a smaller cost, as seen in other research.

A Transformative pathway towards a plant-rich food system in Germany by 2030 could lead to:			
	PB milk/cow milk	PB meat/ animal meat	Total
Total reduction potential	1 MtCO_2e	15 MtCO_2e	≈ 16 MtCO_2e
Total economic cost/savings	156 million €	- 2.6 billion €	≈ - 2.5 billion €
Average marginal abatement cost	161 €/tCO_2e	- 177 €/tCO_2e	≈ - 156 €/tCO_2e

Note: figures are rounded

How do these pathways align with cost-effective mitigation strategies for food retailers aiming to meet climate targets by 2030?

While retailers may not directly shape dietary habits, they play an essential role in facilitating this transition. For instance, plant-based alternatives to meat and milk (and others) must be widely **affordable**, **accessible** and **appealing**. Achieving **retail price parity** between animal-based and plant-based options is **particularly important,** as it removes cost barriers, making plant-based choices more attractive to consumers. This can be further supported by exploring incentives, subsidies and mandates to stabilize costs and maintain market balance.

Although revenues from high-emission products like meat may decrease, this can be offset by the growing demand for plant-based alternatives, if their availability increases sufficiently to replace visible amounts of animal-based products. Leading retailers in Germany are already driving this change: Lidl Germany is leveraging price parity through private label strategies (Mridul, 2023), while the Rewe Group has opened Germany's first fully plant-based supermarket in Berlin, offering over 2,700 vegan products (REWE Group, 2024). These efforts illustrate how retailers can accelerate the transition to sustainable diets while creating new profit opportunities.

The **overall strategy should prioritize both** optimizing the **balance of animal and plant proteins** and achieving **price parity to be successful in promoting a plant-rich food system.** By addressing both the ratio of protein sources and the competitive pricing of plant-based options, the industry can support a more sustainable protein supply chain that meets consumer demand and environmental objectives.

Key results – Agricultural practices (EU)

Background

In 2023, agricultural processes like crop and livestock production were responsible for around 11% of global GHG emissions (Statista, 2024b). Conventional agricultural activities contribute significantly to environmental degradation through GHG emissions, deforestation, land depletion and overuse of water. Moreover, they also threaten biodiversity and exacerbate issues like hunger, obesity, and economic disparities, especially for farmers (FAO, 2023). The transition to improved agricultural practices refers to farm-level techniques for crop (human consumption and livestock feed) and livestock production, commonly known as regenerative, sustainable, conservation agriculture, or agroecology. These practices focus on restoring and enhancing soil health, biodiversity, and ecosystems, while simultaneously improving crop yields and farm productivity (Lal, 2020). For food retailers, encouraging such practices can help reduce Scope 3 emissions and supports compliance with initiatives like the Farm to Fork Strategy, under the EU Green Deal, and the COP28 UAE Declaration on Food Agriculture.

Research levers

In this analysis, agricultural practices exhibited a wide range of feasibility, abatement potential, and incremental implementation across both livestock and crop production (for human consumption and livestock feed). An EU-wide scope was selected to account for the fact that although retailers source products globally, a majority of the sourcing of meat and dairy products occurs at an EU-level (Industry interviews, 2024).

Levers	Key assumptions	Main limitations
Livestock production • Increase concentrate to forage diet ratio • Heat stress management • Improved animal health and disease treatment • Expanded adoption of technologies which increase livestock production efficiencies • GHG emissions reduction focused breeding and genetic selection • Methane inhibiting or reducing feed additives • Small- & large-scale anaerobic manure digestion • Feed grain processing for digestibility **Crop production** • Application of biological crop protection products • Reduced over application of nitrogen fertilizer • Electrification of on-farm machinery • Hydrogen power of on-farm machinery • Variable rate fertilizer application • Nitrification/De-nitrification inhibitor application on crop fields • Biochar as fertilizer • Incorporation of covers crops • Low- and no-tillage	The analyzed practices target short- and mid-term emissions reductions, carbon sequestration, and focus on meat and dairy production, including livestock and crops.	The data sources of selected agricultural actions have a global representativity, adjustments were necessary to reflect the EU level of impact. The EU represents approximately 10% of global agricultural output but only 7% of global agricultural emissions (Eurostat, 2023) (FAO, 2024). Narrowing the scope further to Germany was deemed unsuitable as it could lead to an oversimplification, given the disparity in scale and regional context. Some levers might not be accessible to small- and mid-size farms. The suitability and impact of levers is strongly dependent on geography and other factors.

Methodology

For agricultural practices, recent literature on livestock and crop production decarbonization levers was reviewed, focusing on practices that are expected to increase in adoption, are emerging or are being optimized. Both livestock and crop production levers were considered as approximately 53% of the EU's arable land is dedicated to growing crops like cereals such as maize and barley (European Commission, 2022a) which are important constituents of human and livestock diets. While many reports highlight the long-term impact of these measures towards 2050, the goal of this work was to narrow the focus to the near-term (2030) and scale the analysis to the European Union (EU) – applicable for the German food retail sector.

Next, estimates of marginal abatement costs and total abatement potential from key decarbonization strategies were reviewed, considering the degree of implementation to date. Using expert judgment and recent data, a limit on implementation by 2030, to 20% of the projected or potential adoption rate by 2050, was set. A 20% implementation rate reflects a balance between optimistic targets and realistic feasibility and sets an ambitious and challenging, yet feasible goal, requiring significant adoption rates across EU production. It was assumed that most levers would require an initial investment, despite longer-term cost savings. For example, electrification of on-farm machinery may lead to lower operational costs over time but requires upfront investment in infrastructure and/or equipment upgrades. An abatement curve to reflect how costs are expected to evolve over time was developed, ensuring alignment with long-term trends in marginal abatement costs. The curve was calibrated using publicly available data to match the average marginal abatement costs from 2022 to 2050. The primary focus was to identify the upfront investments required by 2030, while considering the potential for future savings as decarbonization efforts scale. Finally, linear programming was utilized to prioritize the most impactful and cost-effective decarbonization levers for the near term, balancing costs with climate impact to create an optimized pathway for emission reductions in the agricultural sector.

Linear programming was deployed to analyze the constraints and interactions between different levels of agricultural interventions. Constraints were applied to assess the maximum reduction potential achievable by 2030, with the assumption that agricultural levers can be implemented by up to 20% of the total incremental lever implementation possible by the year 2050 (for example, if electric farm machinery is expected to achieve 30% by 2050, we assume only 20% or 6%). The optimization process then focused on selecting and applying these levers in a way that minimizes costs while achieving the targeted reductions.

Algorithm optimization

The model identified the optimal combination of interventions by identifying the intersection where progress towards 2030 science-based targets is maximized, while minimizing overall investment costs. This optimization process is applied to agricultural interventions and follows these key steps:

+ Assess the emissions reduction potential and cost of each intervention.
+ Combine the interventions in different implementation rates to determine the cumulative effects.
+ Apply constraints to ensure the solutions maximize progress toward achieving 2030 targets.

The **agriculture MAC curve:** displays the costs and climate benefits of transitioning farming practices from conventional systems to systems which offer the opportunity to reduce GHG emissions and sequester carbon.

Pathway: A 20% implementation rate of selected agricultural practices.

Results

Agricultural practices - Marginal abatement cost curve for 2030

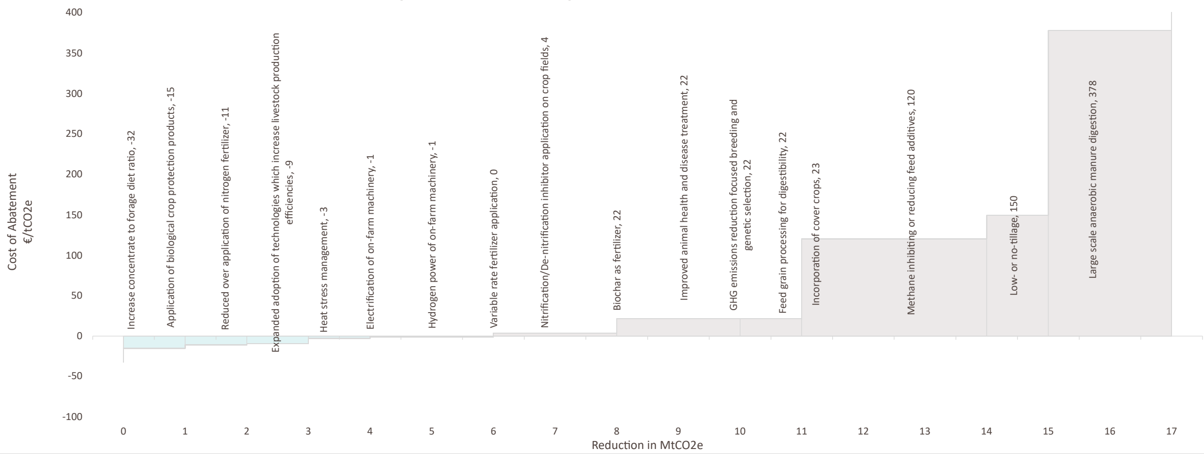

Figure 7: Marginal abatement costs of agricultural decarbonization measures in the European Union.
Note: Small scale anaerobic digestor is not included due to difference in scale (+1000 €/tCO2e)

Improving agricultural practices exhibits **significant potential for emissions reduction**, with an estimated **17 $MtCO_2e$** reduction achievable when focusing on direct impacts within the EU. The total investment, required by 2030, is estimated at **nearly 1.4 € billion.** However, the **average marginal abatement cost** (€/tCO_2e) for these interventions **varies, ranging** from -32 €/tCO_2e to over 1000 €/tCO_2e. There is a clear distinction between cost-saving, lower-impact measures (such as feed management and health improvements) and high-cost, higher-impact measures (such as methane inhibitors). Balancing these approaches is crucial for achieving effective emission reductions in the agricultural sector, as best results require a holistic approach.

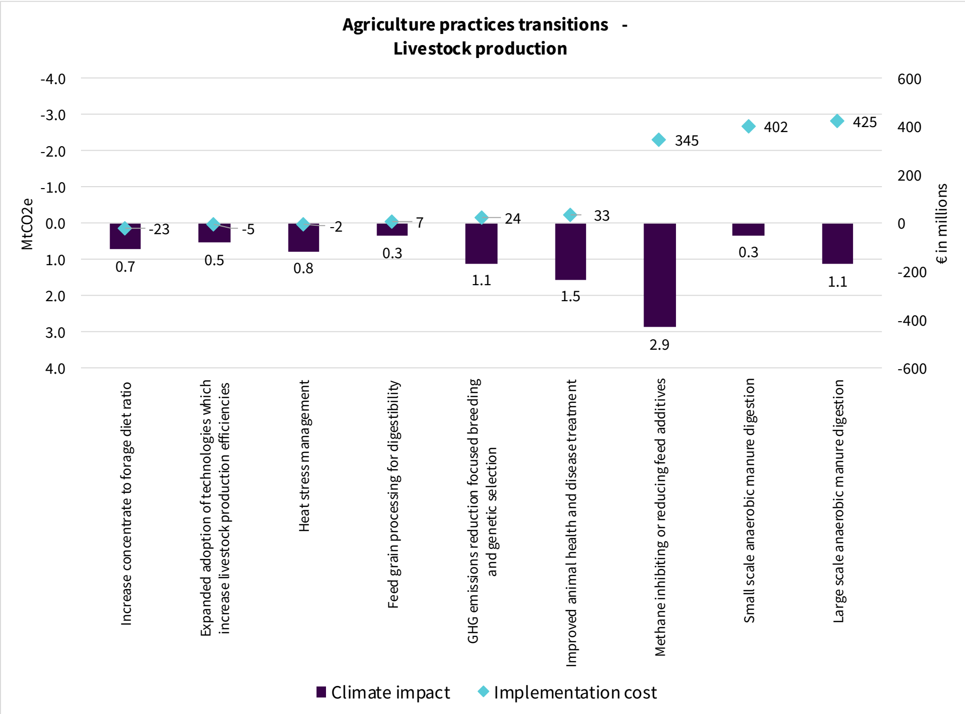

Figure 8: Climate impact and implementation costs of emergent sustainable agricultural practices (livestock)

As shown in the chart above, within livestock production, **methane inhibiting or methane reducing-feed additives** provide the **largest emissions reduction** at almost 3 $MtCO_2e$ but come with a **significant** implementation **cost** of €345 million. **Improved animal health and disease treatment** also offers reductions (**1.5 $MtCO_2e$**) with a moderate cost of **€33 million**. High-cost interventions like large-scale anaerobic manure digestion achieve 1 $MtCO_2e$ reductions at a cost of €425 million. Cost-effective strategies, such as heat stress management and increasing concentrate to forage ratio, deliver smaller reductions while providing cost savings

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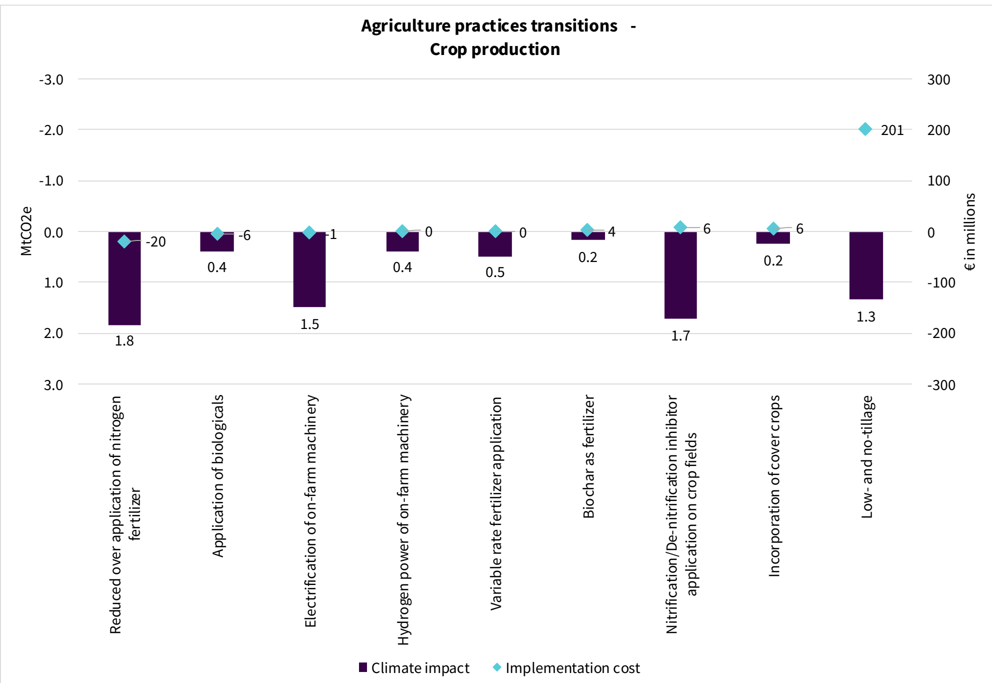

Figure 9: Climate impact and implementation costs of emergent sustainable agricultural practices (crop production for human livestock feed)

Within **crop production practice improvements**, one of the most promising near-term measures is the **electrification of on-farm machinery**, which is estimated to reduce approximately **2MtCO_2e** and offers potential marginal cost savings, as shown in the chart below. **Reducing nitrogen fertilizer** also is estimated to have a strong impact, reducing approximately **2 MtCO_2e** and saving around **€20 million**. In contrast, **low and no-tillage** offers around **1 MtCO_2e** reduction and has the **highest cost at €201 million**. For a comprehensive strategy, a combination of high-impact, high-cost interventions (like methane-inhibiting feed additives) alongside more affordable practices (like concentrate-to-forage ratio adjustments) would provide a balanced approach, achieving meaningful emissions reductions while considering budget limitations.

A blended approach that integrates regenerative agriculture with plant-based proteins gives retailers a stronger opportunity to drive sustainability in the food sector.

A combination of improved **agricultural practices especially in the production of plant-based or alternative** protein products could serve as a **joint strategy to accelerate stronger reductions** in the food system's climate impact. For example, practices like crop rotation and low/no-tillage are well-suited to key crops used in plant-based proteins, such as chickpeas, fava beans and lentils (Smart Protein Project, n.d.). These practices not only have the potential to enhance yields and soil health but also can lower emissions, supporting a shift toward less resource-intensive proteins.

However, the implementation of agricultural strategies will likely **involve substantial upfront investments**, particularly through 2030 and up to 2035. While the current analysis does not conclusively demonstrate a savings from implementing reduction levers, it strongly suggests that the **introduction of new technologies, infrastructure and innovative practices could help lower costs over time, particularly by the late 2030s.** Still, as agricultural practices and technologies evolve, and adoption increases, **the costs associated with decarbonization measures**, such as low or no tillage, cover crops, electrification of farm equipment and methane reduction strategies, **are likely to decrease.** We see evidence of this trend already visible in other sectors such as renewable energy and battery technology where scaling and innovation have led to significant cost reductions (S&P Global, 2024).

Total agricultural practice transitions in EU by 2030 can lead to a: (implementation up to 20%)	
Total reduction potential	17 MtCO_2e
Total economic impact/cost	1.4 billion €
Average marginal abatement cost	**80 €/tCO_2e**

Key results – Food loss and waste (FLW) of meat and dairy products (Germany)

Background

Food loss and waste (FLW) refers to the discarding or loss of edible food at various stages of the food supply chain, from production and processing to retail and consumption. This waste can occur for numerous reasons, including overproduction, spoilage, improper storage, and consumer behaviors such as over-purchasing and discarding food that is still safe to eat. Globally, FLW is a significant issue, with the United Nations Food and Agriculture Organization (FAO, n.d.) estimating that around 931 million tonnes of food are wasted annually. This accounts for an estimated 8-10% of global GHG emissions being linked to food that goes uneaten (UNEP, 2021). In Germany, national statistics indicate that approximately 11 million tonnes of food were wasted across the value chain in 2021 (BMEL, 2024a), out of a total food consumption of about 55 million tonnes (BMEL, 2022). FLW thus represents a significant environmental, economic and social challenge, as it not only contributes to wasted use of resources like water, land and energy, but also exacerbates food insecurity by diverting food away from those who need it. Reducing FLW is a key aspect of creating more sustainable food systems, minimizing environmental impacts and improving food distribution efficiency.

Research levers

In this work, FLW focused on meat and dairy to align with the context of a plant-rich food system and agriculture levers. Food loss and waste at the retailer and consumer levels were prioritized due to the high relevance, with 60% of food loss and waste occurring in the household (BMEL, 2024b).

Levers	Key assumptions	Main limitations
Integrated demand and inventory management systems • Dynamic pricing • Enhanced demand forecasting • Optimization of on-hand inventory • Decreased minimum order quantity **Technology and packaging** • Packaging technology • Package design for sizing **Consumer oriented** • Consumer education	Only retailer-borne costs were considered, except for technology and packaging measures, where manufacturer costs were factored in. It is assumed that packaging technology development will comply with existing or upcoming packaging regulations, such as the European Packaging and Packaging Waste Directive (94/62/EC). It is recognized that retailers alone are not responsible for behavioral interventions to reduce FLW.	Retailer food donations, a common practice in Germany, are considered business-as-usual and therefore excluded from the analysis. The climate impact of changes in packaging technologies or sizing was not assessed, as they are not expected to significantly outweigh the effects of reducing FLW. Main data source for the analysis of reduction potential and costs (ReFED) is based on a U.S. context. Its use as an approximation for Germany may not reflect similar local market conditions or consumer behaviors.

Methodology

The **FLW reduction MAC curve** highlights the cost-effectiveness and climate impact of reducing food loss and waste at both the retail and household levels in Germany.

A baseline of emissions was calculated by multiplying the avoidable waste volumes of meat and dairy products in German retail and households by relevant emission factors from ecoinvent and WFLDB. This provided an estimate of the emissions associated with the production and disposal of wasted food.

The emissions reduction potential for each intervention was estimated using FLW reduction volumes from ReFED data. The corresponding cost per tonne of waste was used to calculate the marginal abatement cost (MAC) per tonne of CO_2e reduced.

Pathway: 100% implementation rate of all suggested measures for total food loss and waste (FLW) within dairy and meat products.

Results

Based on the latest statistics on food loss and waste, emissions due to avoidable meat and dairy waste in retail and households are estimated at **2.7 MtCO2e** based on 2021 data. Meat and dairy waste interventions therefore offer a much smaller reduction potential relative to overall food loss and waste, estimated at **only by 0.34 MtCO_2e** with a modest **investment of an estimated €25 million**.

The reduction potential accounts for the incremental gain beyond current FLW reduction efforts (ReFED), showing that these measures may be close to being fully deployed and would thus have a limited influence. Considering this and an **average marginal abatement cost** of **72 €/tCO_2e**, their limited scale means they should **not be the sole focus of climate strategies for retailers.**

Food loss and waste (FLW) - Marginal abatement cost curve for 2030

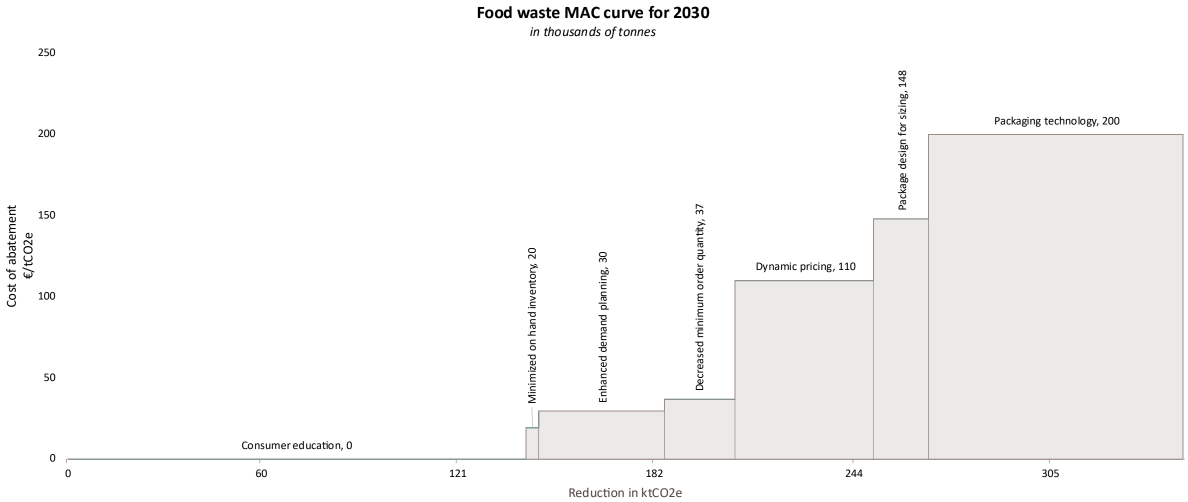

Figure 10: Marginal abatement cost curve of dairy and meat waste mitigation measures (in thousands of tonnes)

The **lowest cost intervention is consumer education, with almost no projected cost for retailers (0.02 €/tCO_2e)** and potentially large emission reductions, as shown in the chart above. Other relatively low-cost measures include minimizing on-hand inventory, enhanced demand planning, and decreasing minimum order quantities. More expensive interventions involve dynamic pricing, package design for optimal sizing, and the highest-cost option, packaging technology. These different approaches show a range of costs and impacts, with some requiring significant investments while others are more cost-effective.

Overall, prioritizing high-impact actions like consumer education and integrated demand and inventory management is the most cost-efficient way to reduce emissions through waste reduction practices, while new packaging technologies could support a comprehensive approach to reducing food loss and waste emissions but at an elevated marginal cost.

Total FLW reduction practices by 2030 can lead to a:	
Total reduction potential	0.34 $MtCO_2e$
Total economic impact/cost	25 million €
Average marginal abatement cost	**72 €/tCO_2e**

Looking at FLW reductions holistically, across all food categories, is **far more impactful** than focusing solely on dairy and meat waste. While reducing waste in these categories is important, it represents only a portion of the total food system emissions. A comprehensive approach that tackles waste across all food types will lead to greater emissions reductions and a more sustainable food system. Isolating dairy and meat waste as a stand-alone intervention limits the overall potential of waste reduction efforts.

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Key takeaways

1. **A plant-rich food system,** through the substitution of animal meat and milk with plant-based alternatives, **could reduce emissions by** up to **16 $MtCO_2e$** at a cost-effective average **marginal abatement cost** of up to **-156 €/tCO_2e,** making them essential **for near-term** climate **investment** strategies.

2. **Improvement of agricultural practices** in the EU offer **high emissions reduction potential as well,** estimated at **17 $MtCO_2e$.** However, **near-term marginal abatement costs vary widely** from -32 €/tCO_2e to over 1,000 €/tCO_2e, making them essential **for long-term** climate **investment** strategies.

3. Germany's **FLW reduction** (in animal dairy and meat products) potential is modest at less than **1 $MtCO_2e$,** with an **average marginal abatement cost** of **72 €/tCO_2e,** indicating limited scale and suggesting it should **not be the sole focus of climate strategies.**

High-level recommendations to meet 2030 climate goals

+ **Prioritize promoting a plant-rich food system** by strategically **reducing** the **sale and distribution** of **higher-emission animal protein**, such as beef and milk, while **expanding** the **availability** of **plant-based meat** (and other) **alternatives** along with **competitive pricing** for plant-based options. This substitution approach can be adapted over time to maximize both environmental and economic outcomes.

+ **Incentivize the adoption of improved agricultural practices** by **engaging** with **suppliers** to **understand** the sustainability **status of specific supply chains** and **incentivizing transition** of production practices. The introduction of new technologies, infrastructure, and innovative practices could help lower costs over time and ensure supply chain resilience.

+ **Continue supporting food loss and waste (FLW) reduction efforts** by focusing on cost-effective consumer education and awareness initiatives while **prioritizing** a more **comprehensive approach** that tackles waste **across the whole food system** to lead to greater emissions reductions.

Risks & opportunities in optimizing climate strategies for German food retailers

The transformation of the food system presents both risks and opportunities. **Failure to act is likely to have serious consequences, including supply chain disruptions driven by climate change.** According to the Umwelt Bundesamt (UBA,2021), **supply chain disruptions** caused by climate change can lead to key crop yields in Germany to potentially decrease by 10-30% by 2050. Extreme weather events, such as the 2021 floods, have caused over €1 billion in **agricultural damage** already (Deutsche Welle, 2021). Additionally, **stricter regulations on emissions** and proposed carbon taxes could **increase food prices by up to 25%,** putting financial pressure on retailers (Potsdam Institute for Climate Impact Research, 2020). Overall, inaction could result in **alarming further degradation** and stark financial disadvantages.

Actively participating in the food system transformation also offers **opportunities to showcase leadership** and capture additional revenue within emerging markets like the plant-based sector. Moreover, retailers can benefit by expanding their plant-based portfolios and partnering with regenerative farms. The **German government's €38 million investment** in sustainable protein development and renewable energy incentives offers additional financial and environmental benefits for retailers (Clark, 2023). Ultimately, transforming the food system will advance the goal of ensuring sufficient, healthy and affordable food for the growing population within planetary boundaries.

Given retailer's influence over both the demand and supply sides of the food system, through relationships with different actors of the agrifood value chain, **retailers are uniquely positioned to accelerate these changes and strengthen the overall resilience and impact of the agrifood system.**

Appendix

The pathways in this research rely on linear assumptions, excluding factors like supply chain capacity, further climate degradation, policy support, and market stability in driving transformations. However, they serve as a foundation for frameworks addressing retailers' unique challenges and opportunities to meet climate targets. As trends evolve, this analysis should be revisited to align with emerging developments and ensure accuracy.

Description of levers

Plant-rich diets

The lever of plant-rich diets exclusively considers a one-to-one replacement of reduced animal-based meat and milk consumption with increased plant-based alternatives. This approach intentionally overlooks a critical aspect of a two-fold protein transition: the need to reduce the current overconsumption of protein. According to Breidenassel et al. (2022), German consumers currently consume 50-70% more protein than recommended for both human and planetary health. Aligning actual protein intake with scientific recommendations would significantly amplify the positive impact of plant-rich diets. However, to make this dietary shift feasible for food retailers by 2030, the analysis in this report adheres to a short-term business approach, prioritizing replacement over reduction to sustain sales. Due to the lower protein density of the plant-based basket used in this research (190g protein/kg) compared to the animal-based basket it replaces (250g protein/kg), this replacement strategy still results in a reduction of protein intake — though not to the extent necessary for optimal human and environmental health. Increasing the availability of additional protein sources through an enhanced product assortment and product developments could mitigate this reduction in protein levels.

On average, The EAT-Lancet 2050 recommendation for red meat and chicken products is 16 kg per capita per year and 91 kg for dairy (ca. 30% attributed to milk, based on consumption patterns). Meat consumption in Germany should be reduced to approximately 43 kg/year to stay on track to achieve the 2050 targets by 2030, assuming a linear reduction. Similarly, by 2030, milk consumption should be reduced to approximately 42 kg/year to stay on track.

The Accelerated Pathway aligns closely with the EAT-Lancet 2030 target, achieving almost 100% coverage for the meat consumption target, and already exceeding it for milk consumption.

Meanwhile, the Transformative Pathway surpasses the meat and milk consumption target by more than 15%.

	2030 BAU consumption (per capita kg/a)	Accelerated Pathway (consumption per capita kg/a)	Change in kg	vs. EAT Lancet 2030 target	Transformative pathway (consumption per capita kg/a)	Change in kg	vs. EAT Lancet 2030 target
Meat	52[1]	44	-8	98% covered	36	-16	117% covered
Milk	46[2]	39	-7	115% covered	32	-14	130% covered

Meat refers to beef, pork, and chicken, while milk specifically refers to liquid cow's milk. [1] Based on per capita consumption of meat in Germany (BLE, 2024a). [2] Based on milk consumption trends in Germany (BLE, 2024b) (Trade Magazin, 2024).

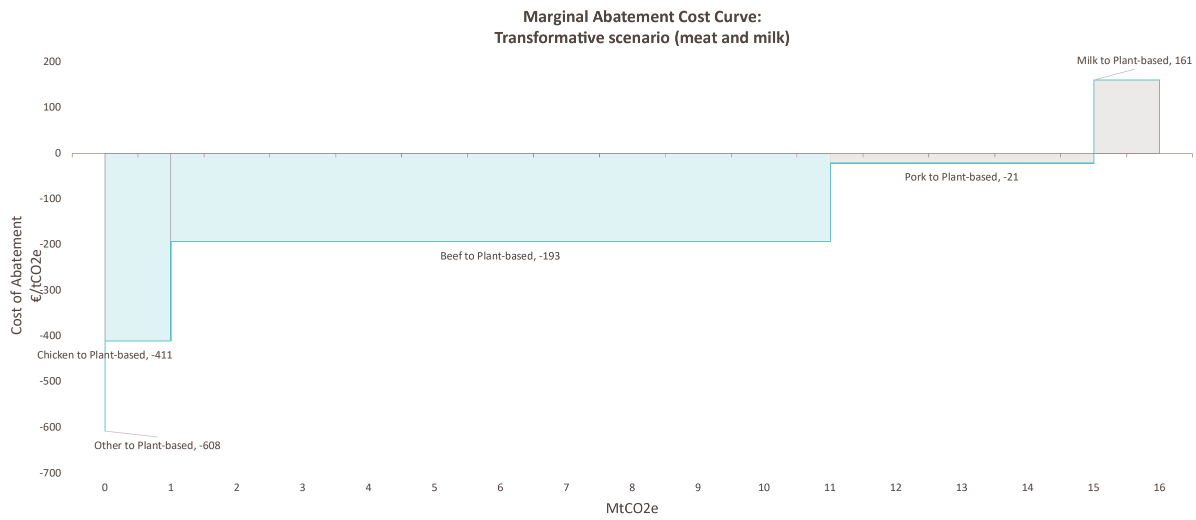

Figure 11: Marginal abatement cost curve of milk and meat replacements (transformative pathway)

EU Level for Agricultural Levers

German food retailers source products globally, though the majority of meat and dairy products are sourced within the EU. Given that the cost and environmental impact of agricultural interventions depend heavily on localized conditions, this analysis focused on the European Single Market. However, there are limitations to this approach. One major challenge is the current lack in alignment and standards relating to carbon reporting and accounting for Scope 3 Emissions. At the time of this report, the Greenhouse Gas Protocol Land Sector Removals Guidance was still being finalized.

For this report, a 20% adoption rate of the full potential of agricultural practices by 2030 was assumed, targeting full implementation by 2050. These changes were modelled as being initiated by and attributed to German food retail. We recognize that as consensus on carbon accounting becomes more harmonized and implementation expands, attribution will become more precise. Over time, as this accounting improves, the share of carbon reductions and removals, attributable to German food retail at the EU level could decrease.

Agricultural practices transition

Livestock production:

- **Increase concentrate to forage diet ratio**: Improves animal efficiency, reducing methane emissions by increasing the digestibility of feed.
- **Heat stress management**: Implements methods to reduce heat stress, enhancing productivity and reducing methane emissions.
- **Improved animal health and disease treatment**: Reduces GHG emissions by preventing animal illness, which improves productivity and reduces losses.
- **Expanded adoption of technologies to increase livestock production efficiencies**: Increases livestock productivity through technologies, reducing the carbon footprint per animal.

- **GHG emissions reduction focused breeding and genetic selection**: Uses selective breeding to reduce methane emissions per animal while maintaining productivity.
- **Methane inhibiting or reducing feed additives**: Reduces methane emissions from livestock digestion using feed additives.
- **Small- & large-scale anaerobic manure digestion**: Uses anaerobic digesters to capture methane from manure, which can then be used as energy.

Feed production:

- **Application of biological crop protection products**: Uses natural biologicals to protect crops, reducing the need for chemical fertilizers and pesticides.
- **Reduced overapplication of nitrogen fertilizer**: Limits the use of nitrogen fertilizers to prevent excess emissions from nitrogen runoff.
- **Electrification of on-farm machinery**: Replaces fossil-fuel-powered farm equipment with electric alternatives to cut emissions.
- **Hydrogen power of on-farm machinery**: Uses hydrogen-powered machinery as an emission-free alternative to traditional farm vehicles.
- **Variable rate fertilizer application**: Optimizes fertilizer use across fields, reducing waste and emissions by applying the right amount of fertilizer to each area.
- **Nitrification/De-nitrification inhibitor application on crop fields**: Reduces nitrogen emissions by using inhibitors that prevent the release of harmful gases from fertilizers.
- **Biochar as fertilizer**: Incorporates biochar into soil to improve soil health and sequester carbon, reducing emissions.
- **Feed grain processing for digestibility**: Enhances grain processing to improve livestock digestion, thereby reducing methane emissions.
- **Incorporation of cover crops**: Grows cover crops to improve soil health, reduce emissions from fertilizer use, and enhance carbon sequestration.
- **Low- and no-tillage**: Reduces soil disturbance through limited tilling, which helps sequester carbon and reduce emissions from fuel and fertilizer use.

Food loss and waste (FLW)

Integrated demand and inventory management systems

- **Dynamic pricing:** Automate markdowns based on shelf life and inventory, encouraging sales of near-expiration items, while lowering the manual effort needed for in-store discounting (ReFED, n.d.).
- **Enhanced demand forecasting:** Improve demand planning and reduce excess inventory through better order calculation. However, tool investment may be costly for small retailers (ReFED, n.d.).
- **Optimization of on-hand inventory:** Reduce product dwell time in distribution centers by not holding safety stock and excess days on-hand (ReFED, n.d.).
- **Decreased minimum order quantity:** Adjust contracts to prevent overproduction and accept smaller orders, which may increase delivery frequency and transportation impacts. Potential consequences need to be carefully evaluated (ReFED, n.d.).

Technology and packaging

- **Packaging technology:** Promote packaging innovations that extend shelf life without increasing waste or violating regulations like the European Commission's Packaging and

Packaging Waste Regulation (PPWR) (European Commission, 2022b). While this could reduce food loss and waste, it is unclear how much consumers would pay for longer-lasting products (ReFED, n.d.).

- **Package design for sizing:** Adjust packaging sizes to reduce waste and cater to small households, which make up over 40% of households in Germany (Destatis, 2024). While larger packages may still be favored for cost savings, resizing could increase packaging waste and require logistical changes (ReFED, n.d.).

Consumer oriented

- **Consumer education:** Initiatives to educate consumers on reducing FLW, like meal planning tips, leftover recipes, and date label guidance, target household waste, where most food loss and waste occurs. However, it is difficult to assess the direct impact, as food waste can result from various factors, making the measurement of the effectiveness difficult (ReFED, n.d.).

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