From Material Flows to Environmental Impacts: *Modelling Food Systems to support EU policies and boost innovation*

94th LCA Discussion Forum

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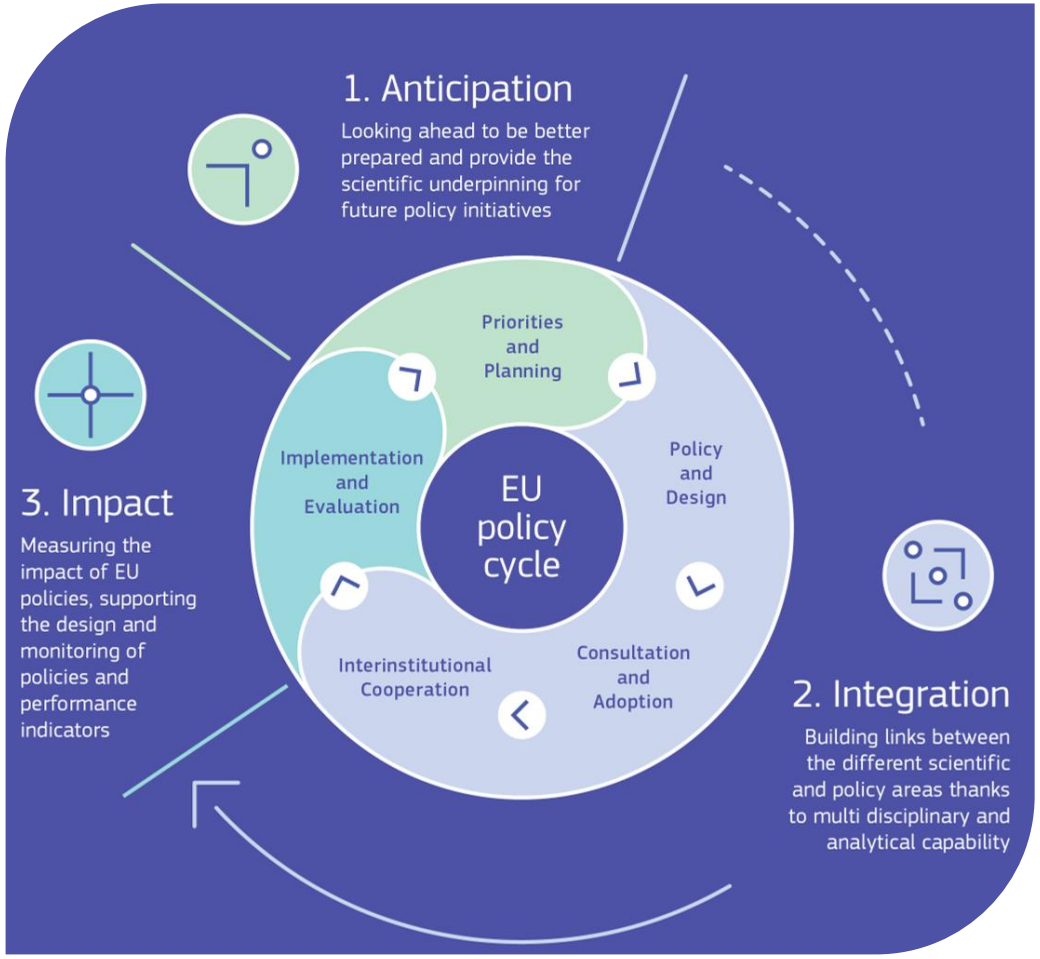
European Commission

The Joint Research Centre





Facts and figures

>60 physical research infrastructures

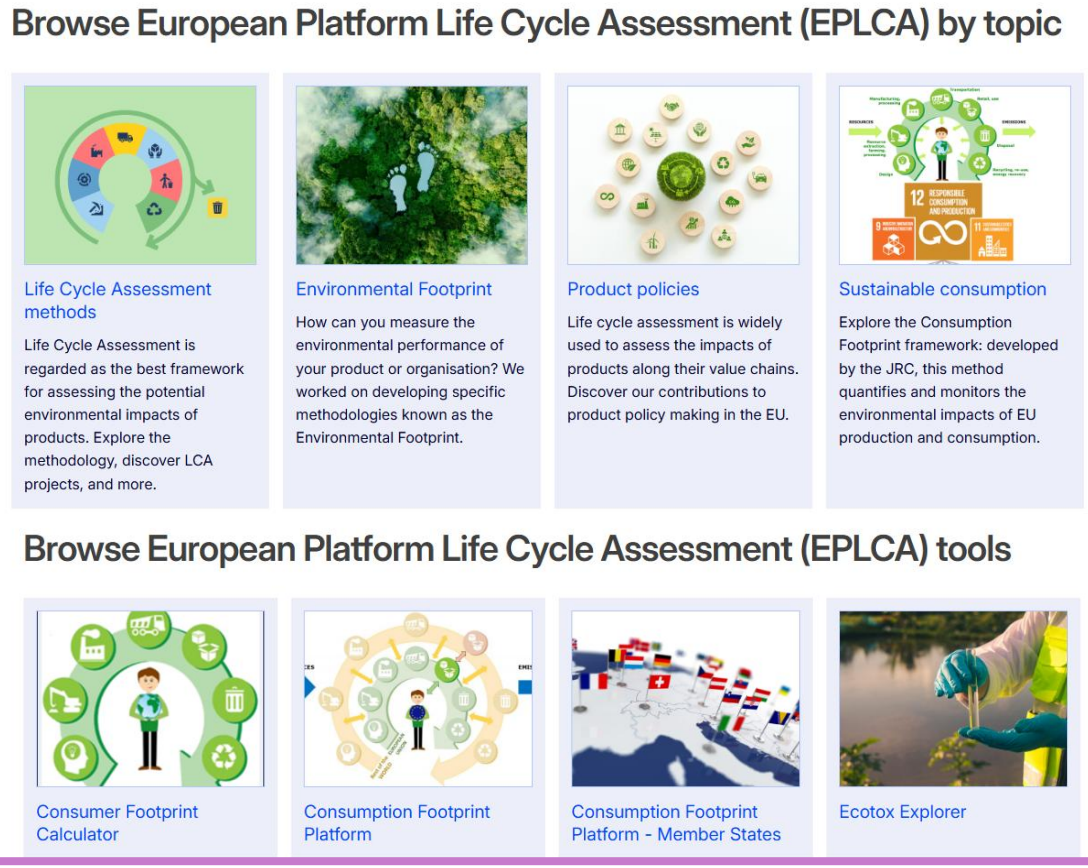
About EUR 600 million annual budget

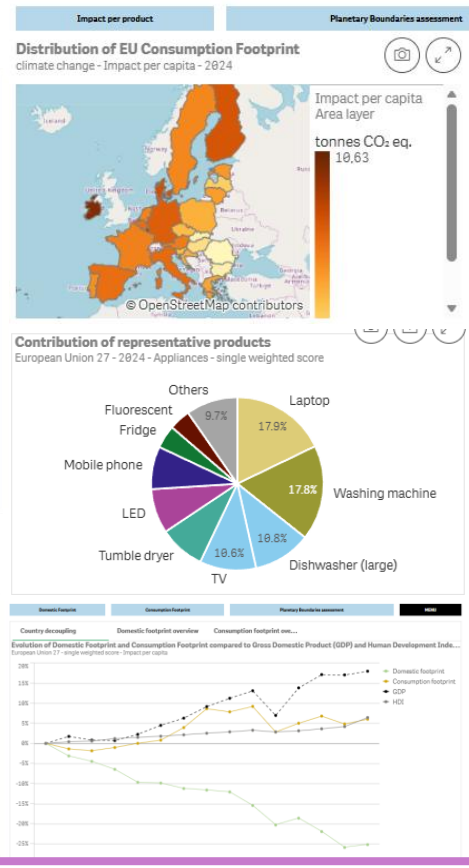
3000+ open data sets
>100 economic, bio-physical and nuclear models

About 2.700 staff

JRC tools and platforms: European Platform on life cycle assessment







https://knowledge4policy.ec.europa.eu/european-platform-life-cycle-assessment-eplca_en

EU policy landscape and sustainability frameworks

2025 Bioeconomy strategy

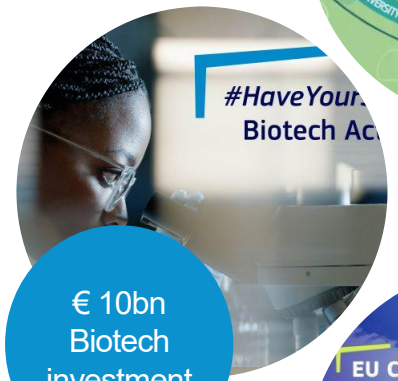
Sustainable, circular biomass & secondary feedstock, bio-waste materials and waste valorisation



Bio-based Lead Markets

Biotech Act (II)

Forthcoming - Sustainable feedstocks, biomanufacturing, system innovation



€ 10bn Biotech investment 2026-27

Chemicals Industry Action Plan

PFAS and food-contact materials, bio-based chemicals and fertilisers, by-products and waste, recycling…



EU Innovation & Substitution Hubs

Vision for Agriculture & Food

for a competitive and resilient food system, within Planetary Boundaries

FW targets:
-30% retail & consumption
-10% processing



Revised Waste Framework Directive

Monitoring and prevention of food waste across the food chain



Advanced Materials Act

Forthcoming – Sustainable Public Procurement, Packaging

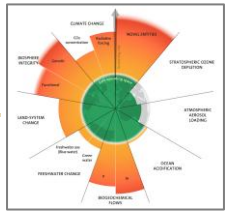


100% recyclable packaging by 2030

Circular Economy Act

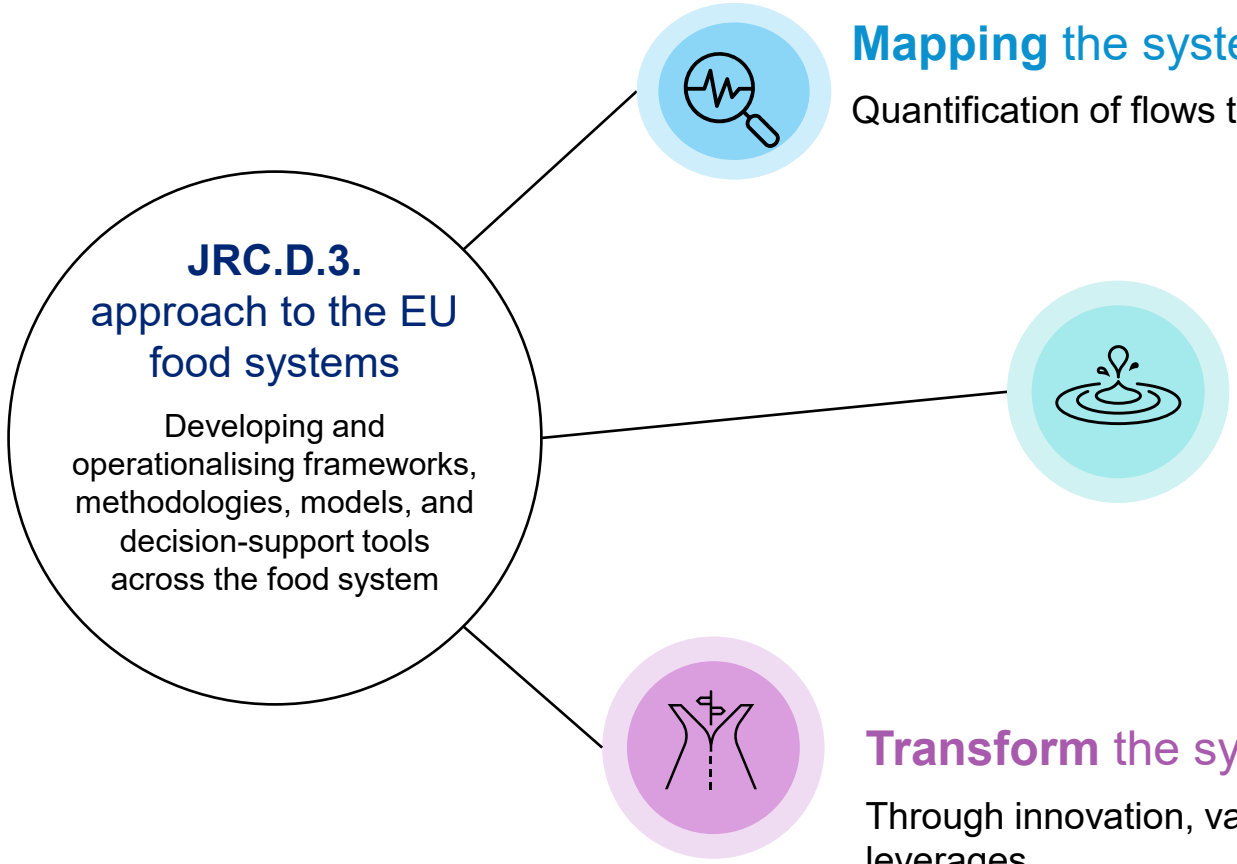
Forthcoming – and Packaging Packaging Waste Regulation (Art. 8)

12 RESPONSIBLE CONSUMPTION AND PRODUCTION



Ensure sustainable consumption and production patterns

Our approach towards a sustainable food system…



Mapping the system and its evolution over time

Quantification of flows through Mass Flow Analysis (MFA)

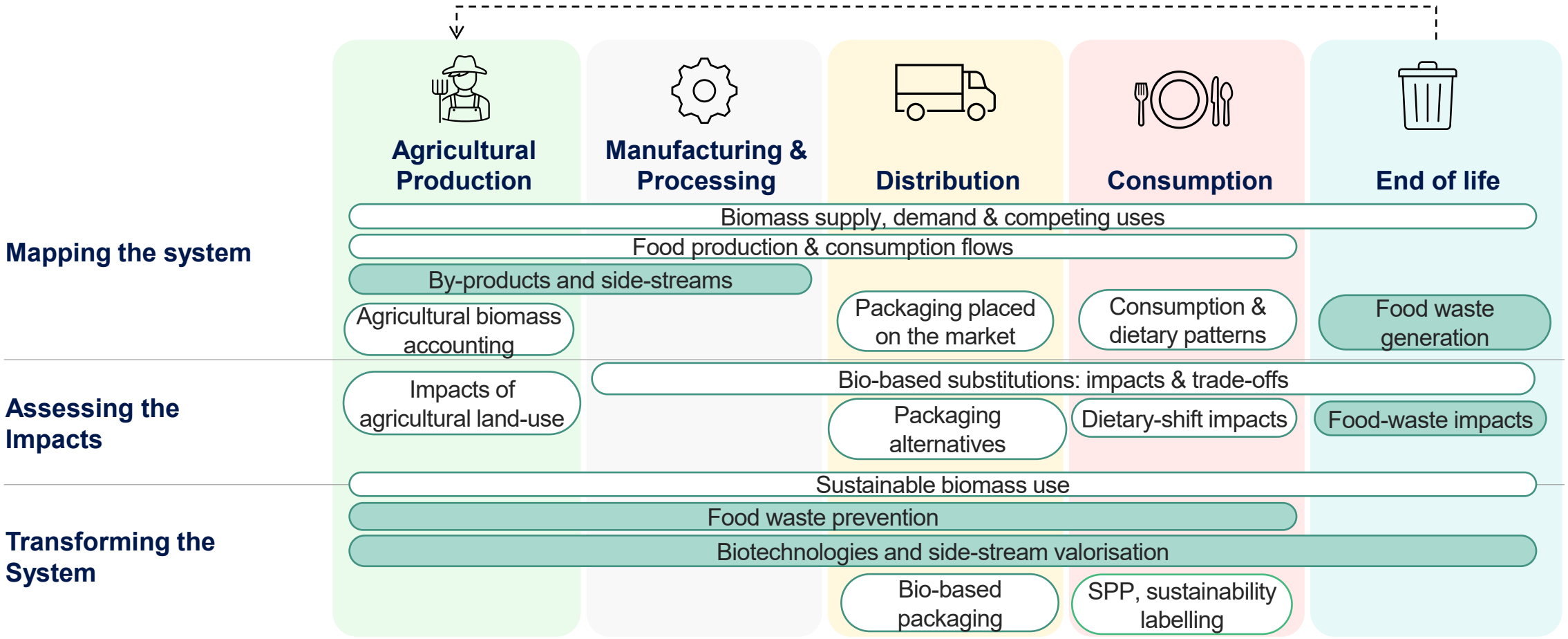
Assessing the impacts

Assessing environmental impacts of production and consumption through LCA approach

Transform the system

Through innovation, valorisation, circular solutions, and behavioral leverages

…across the value chain (and related activities)



Modelling food production and consumption in EU

How much food is produced, consumed, and wasted in the EU?

New Publication!!

Waste Management 227 (2027) 115928

Contents lists available at ScienceDirect

Waste Management

journal homepage: www.elsevier.com/locate/wasman

Research Paper

Assessing food waste generation in the EU: a comparison of the food system material flow analysis model with Member State-reported data

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European Commission, Joint Research Centre, Ispra, Italy

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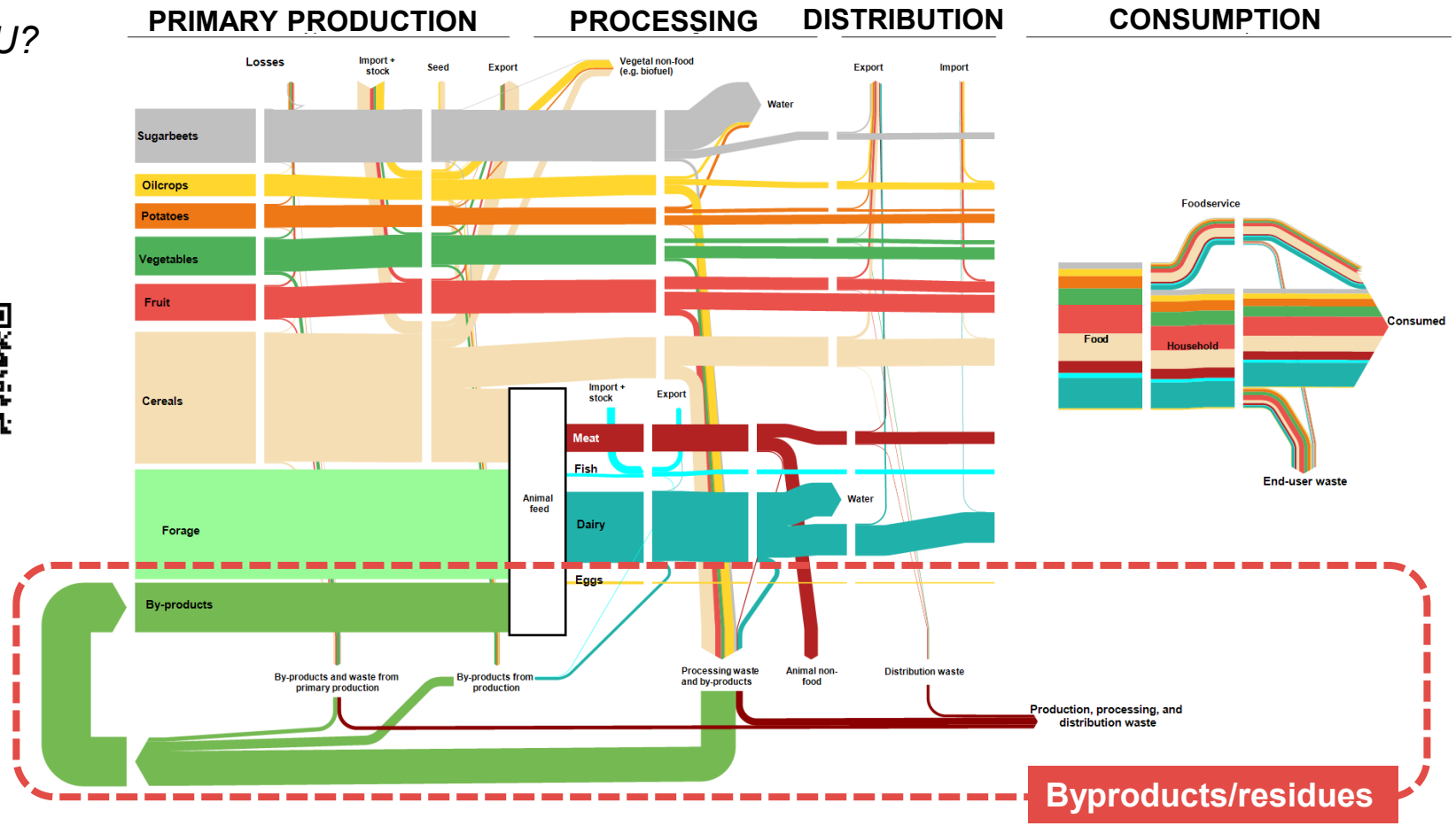
Keywords:
Food waste
Material flow analysis
European Union
Sustainable food system
Waste reduction strategies
Food waste modelling

ABSTRACT

The European Union generates an estimated 58 million tonnes of food waste annually, with significant environmental, social, and economic implications. To address this issue, the EU has established a monitoring framework and introduced binding food waste reduction targets. This article presents the latest version of the Food System Material Flow Analysis (FS MFA) model, a detailed tool for estimating food waste generation in EU Member States, and compares FS MFA model estimates with Member State-reported data, revealing a good degree of similarity, despite differences in methodology and data sources. However, discrepancies highlight the need for model refinement and improved data collection and harmonization. The article recommends that Member States enhance data robustness through primary data collection, industry collaboration, and novel technologies like blockchain and mobile crowdsensing. An improved understanding of food waste generation and the development of effective measurement and reporting tools can support the reduction of food waste in line with Sustainable Development Goal 12.3, thus enabling the transition to a sustainable food system.



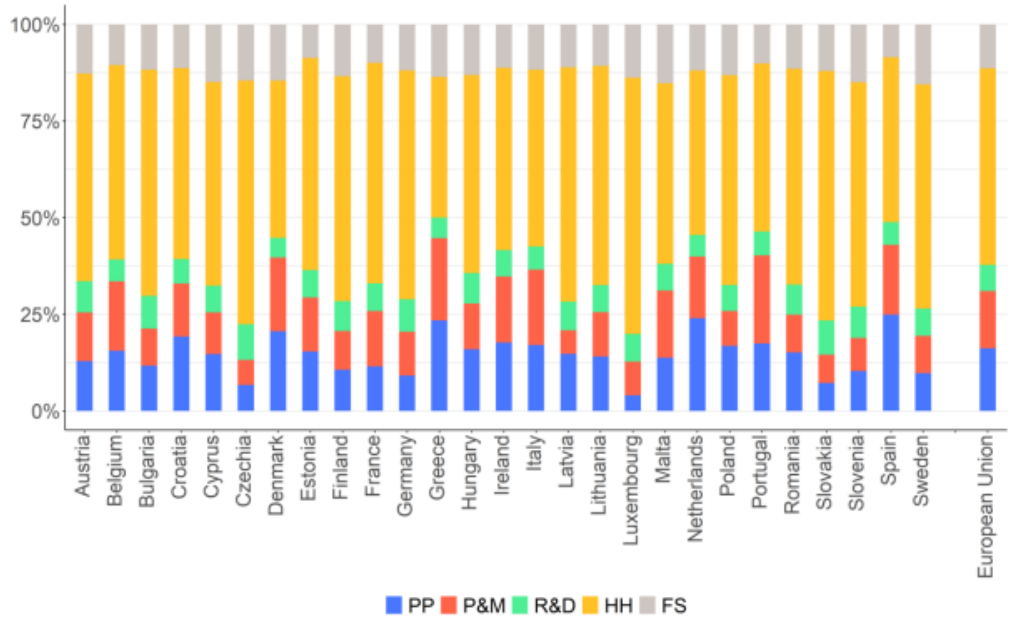
EU Food flow, wet mass

Modified from : Caldeira, C., De Laurentiis, V., Corrado, S., van Holsteijn, F., and Sala, S. (2019). Quantification of food waste per product group along the food supply chain in the European Union: a mass flow analysis. *Resources, Conservation and Recycling*, *149*(June), 479–488. https://doi.org/10.1016/j.resconrec.2019.06.011

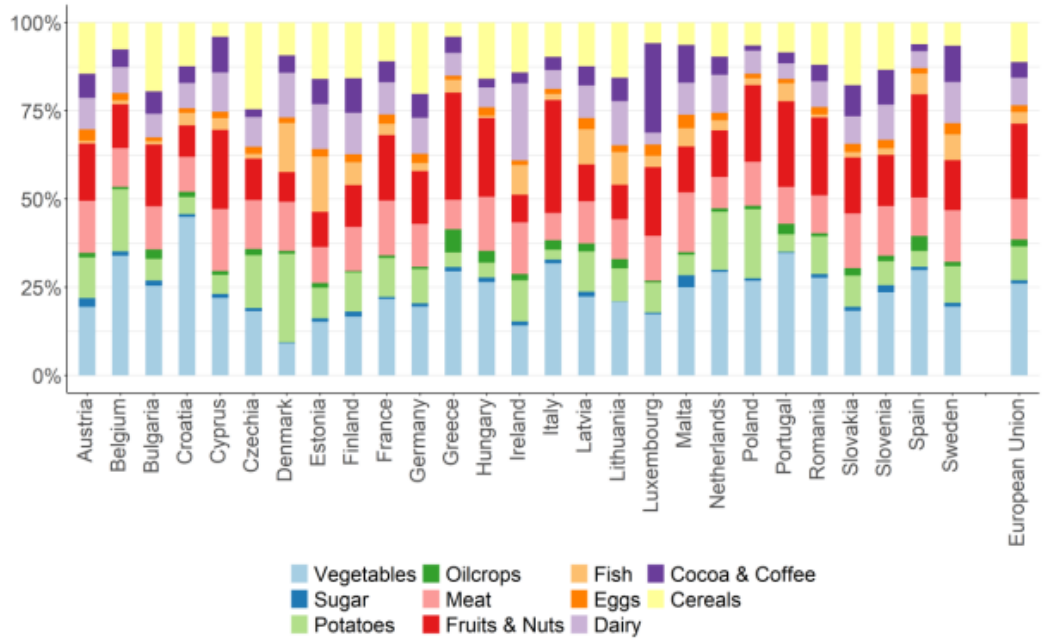
Contribution to EU food waste by supply chain stages and food groups

EU Bioeconomy Monitoring System dashboards

Relative contribution of food supply chain stages to the total food waste generated (solid and liquid components) in EU MSs in 2021



Relative contribution of food groups to the total food waste generated (solid and liquid components) in EU MSs in 2021.



Source: De Laurentiis, V., Biganzoli, F., Valenzano, A. and Sala, S. (2024). Estimating food waste generated and packaging placed on the market at national level, Publications Office of the European Union, Luxembourg, JRC138277 https://data.europa.eu/doi/10.2760/21595

Assesment of impacts

Life Cycle Assessment

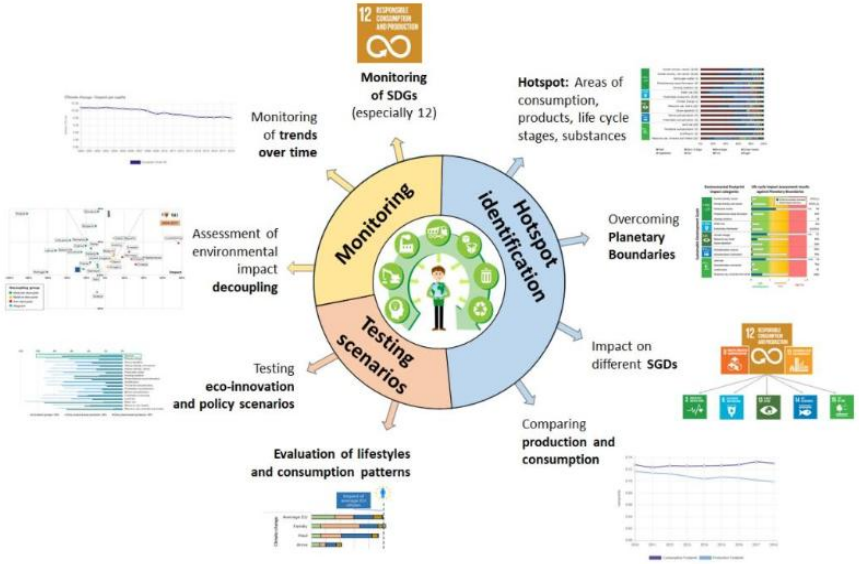
Product-level
Comparing Product A and B

Environmental Footprint methods



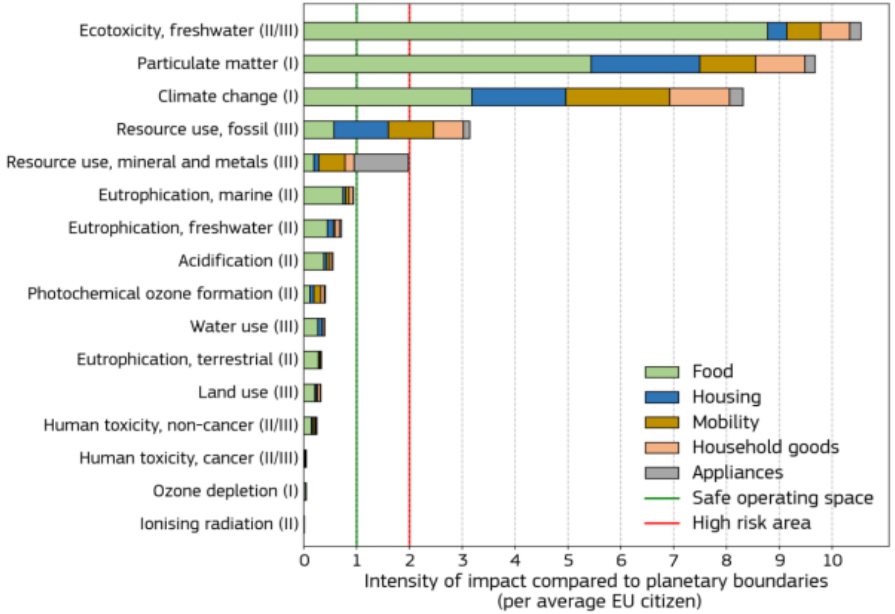
Macro-scale assessment
of EU production and consumption

Consumption Footprint, Bioeconomy Footprint, LCA of Plastic flows



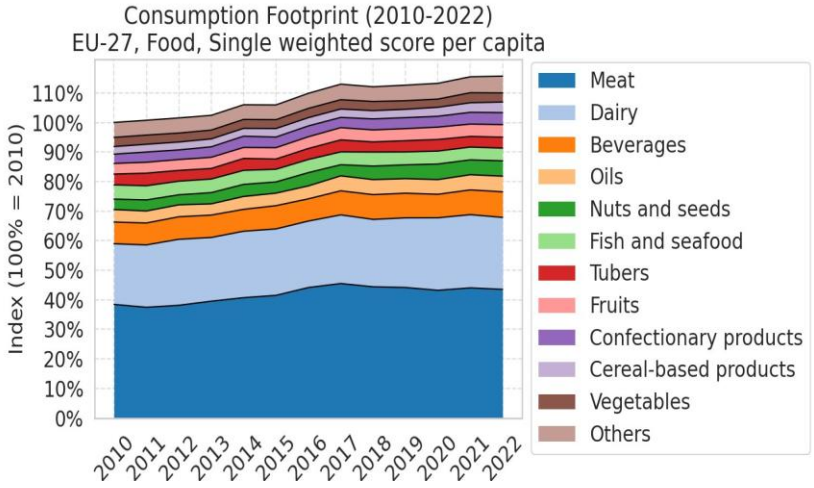
Environmental impacts of EU food system

Consumption Footprint



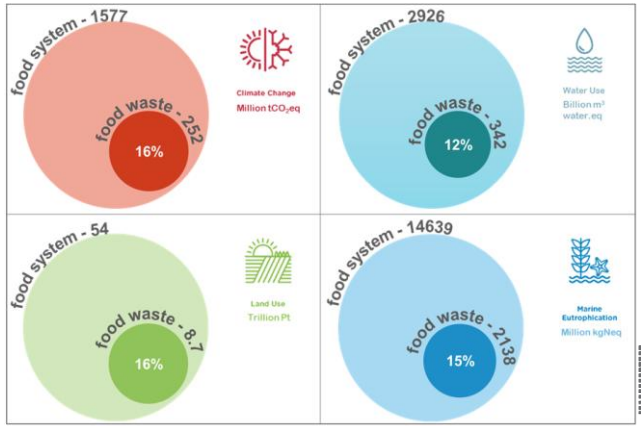
Source: Pasqualino, R., Valenzano, A., Chiorrini, A., Wierzgala, P., Frankowska, A., Sanye Mengual, E., Bennett, M.J., Listorti, G. and Sala, S., (2025). Consumption Footprint and Domestic Footprint Outlook Report 2025, Publications Office of the European Union, Luxembourg. JRC139655. https://data.europa.eu/doi/10.2760/6552881

Food area of consumption



Source: https://knowledge4policy.ec.europa.eu/european-platform-life-cycle-assessment-eplca_en

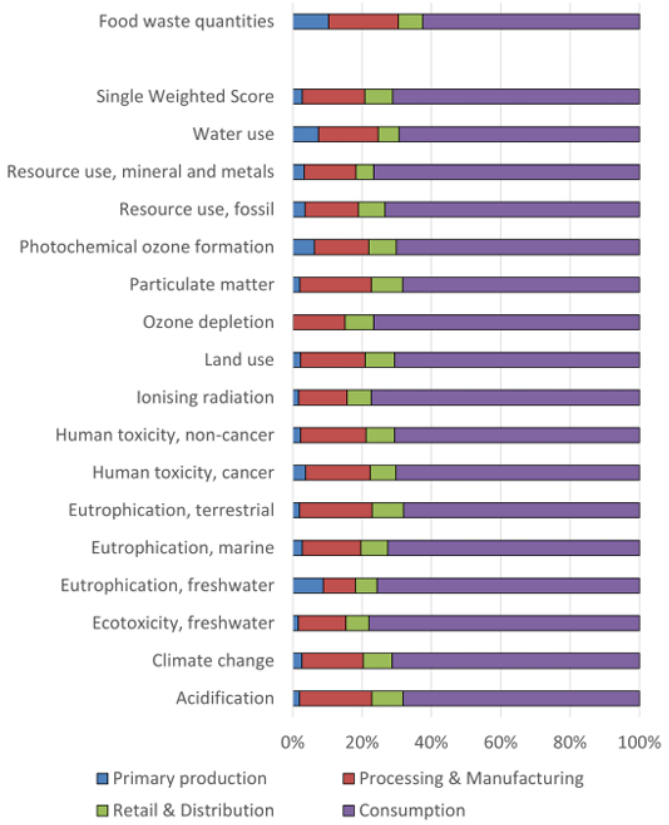
Food Waste



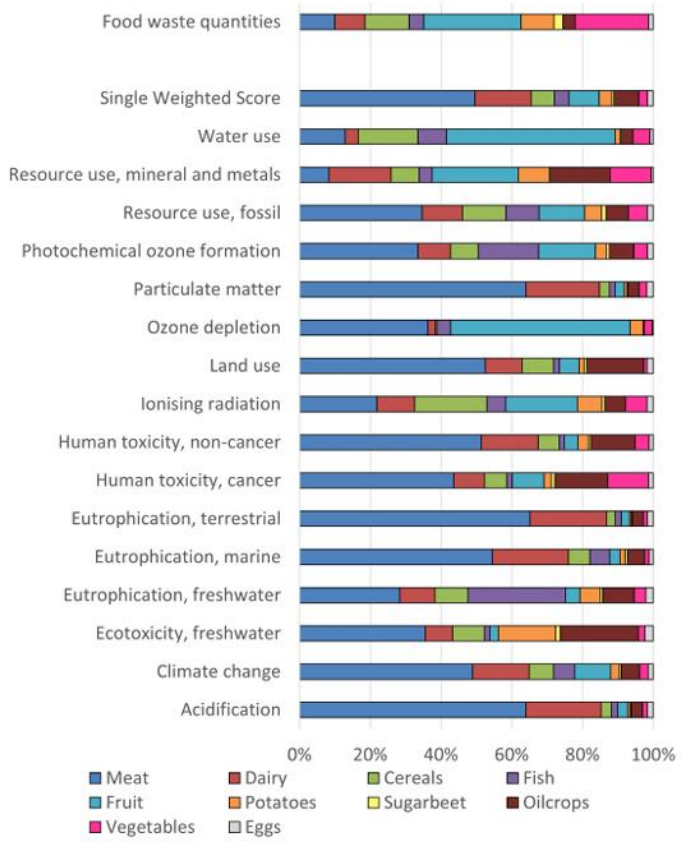
Source: Sala, S., De Laurentiis, V. and Sanye Mengual, E., (2023). Food consumption and waste: environmental impacts from a supply chain perspective, European Commission, JRC129245. https://publications.jrc.ec.europa.eu/repository/handle/JRC129245

Environmental impacts of EU food waste

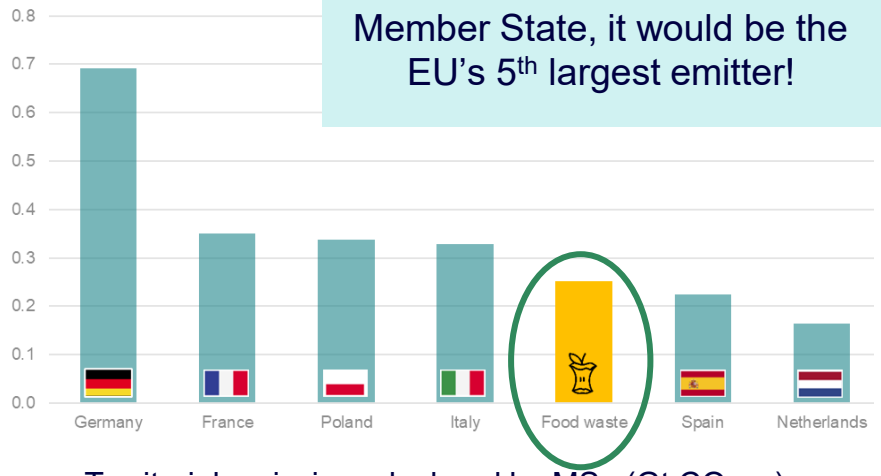
Contribution of the different **stages of the supply chain** to the total quantity and environmental impacts of food waste generation (EU-27, 2020)



Contribution of the different **product groups** to the total quantity and environmental impacts of food waste generation (EU-27, 2020)



If EU food waste were a Member State, it would be the EU's 5th largest emitter!



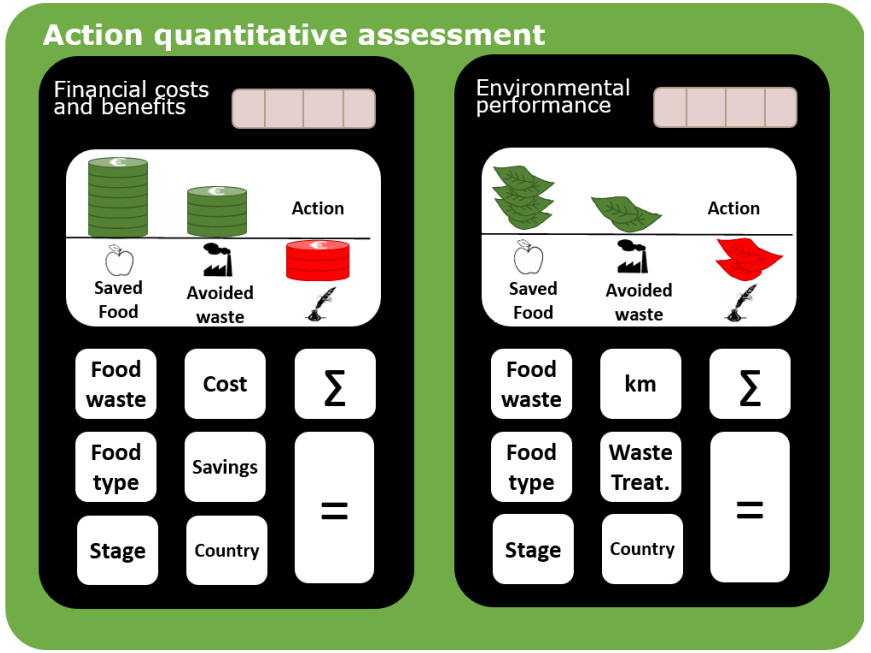
Territorial emissions declared by MSs (Gt CO_2eq)

Source: Sala, S., De Laurentiis, V. and Sanye Mengual, E., (2023) Food consumption and waste: environmental impacts from a supply chain perspective, European Commission, JRC129245.
https://publications.jrc.ec.europa.eu/repository/handle/JRC129245

Providing solutions: identifying and sharing best practices in food waste prevention

Criteria	Description
Quality of the intervention design	Objectives and aims are defined, appropriate targets and related KPIs are established both in terms of impacts (food waste reduction quantities) and/or outcomes (behaviour change or outreach), presence of a consistent monitoring plan, identification of food waste drivers and levers in the design of the intervention.
Effectiveness	Whether the intervention reached the objectives set out in the design phase, preferably providing quantitative evidence of food waste reduction or consumer behaviour change.
Efficiency	A ratio measuring the performance of an intervention (results achieved/resources spent).
Perceived wider systemic effects of the intervention	Assessing the possible connection between the food waste prevention intervention and other impacts on the food system (positive or negative). For example, the intervention could result in a more healthy diet or may lead to increased use of packaging.
Sustainability over time	The longevity of the intervention (how long the effect of the intervention was maintained), if known, and the availability of resources needed to maintain the effect (funds, dissemination efforts).
Transferability and scalability	Whether an intervention can be transferred to a different context or geographical area and if it can be scaled up.

Source: Own elaboration.

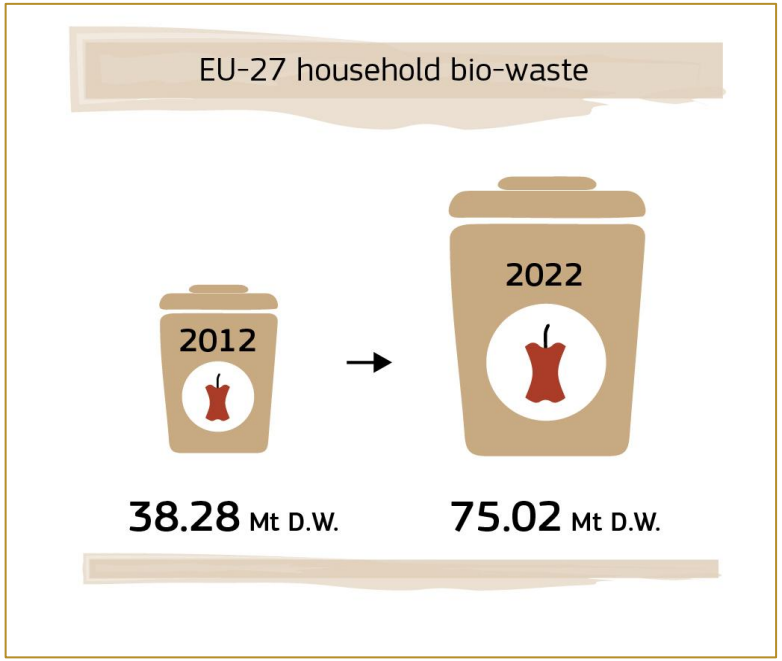


https://knowledge4policy.ec.europa.eu/visualisation/food-waste-prevention-calculator_en

- **74** actions targeting FW at consumer level (https://publications.jrc.ec.europa.eu/repository/handle/JRC133003)
- **53** actions targeting FW across the supply chain (https://publications.jrc.ec.europa.eu/repository/handle/JRC139920)

Find out more on best practices in food waste prevention at consumer level on the **Knowledge Centre for Bioeconomy**!

Waste streams: more potential for circularity



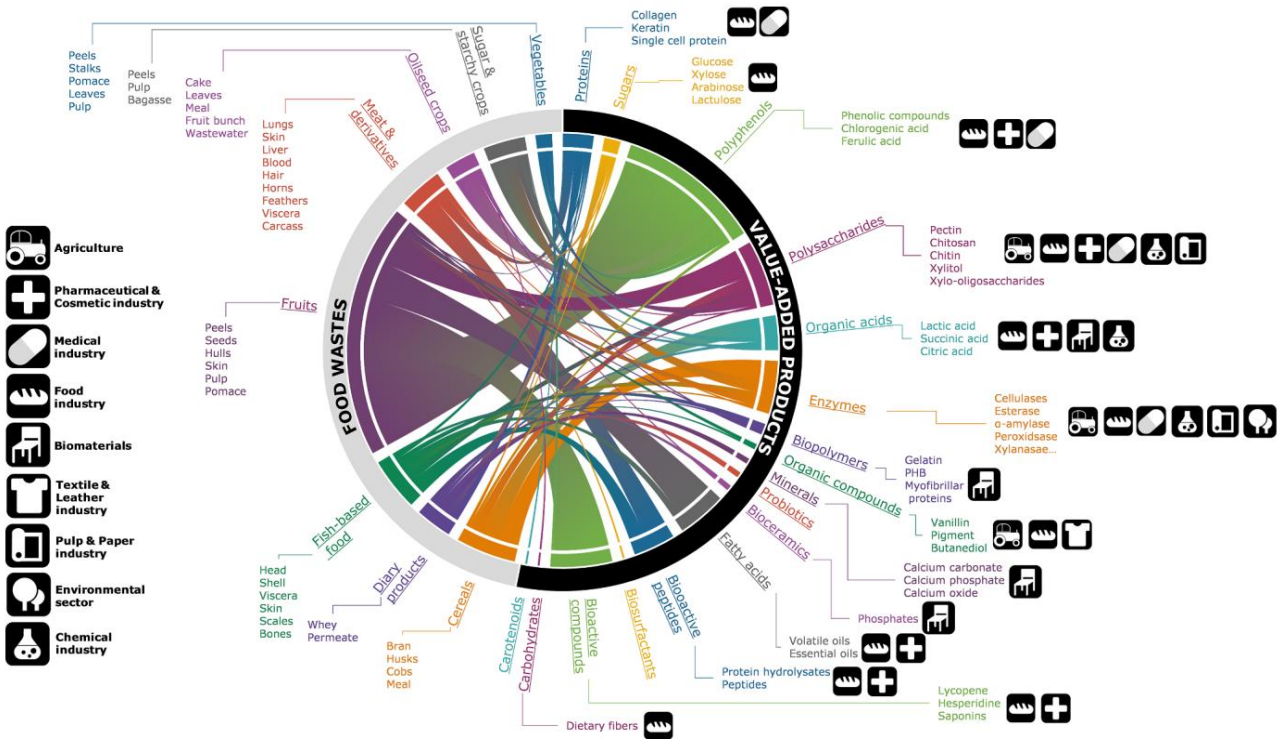
The **generation of biowaste** has been relatively **stable** since 2012 from households, industry and agriculture combined.

The **recovery rate**, corresponding to the share of biowaste recycled or used for energy recovery, had been steadily **increasing** from 2012 to 2018, but has since stabilised at around 90%.

Whereas biowaste recovery from industry and agriculture has remained stable this past decade, the biowaste recovery from households in the EU-27 has roughly doubled.



Food waste valorisation and Bioeconomy



Source: Caldeira, C., Vlysidis, A., Fiore, G., De Laurentiis, V., Vignali, G. and Sala, S., (2020). Sustainability of food waste biorefinery: A review on valorisation pathways, techno-economic constraints, and environmental assessment. Bioresource Technology, 312, p.123575. https://doi.org/10.1016/j.biortech.2020.123575

*"Are these bio-based products **sustainable** and **safe**?*

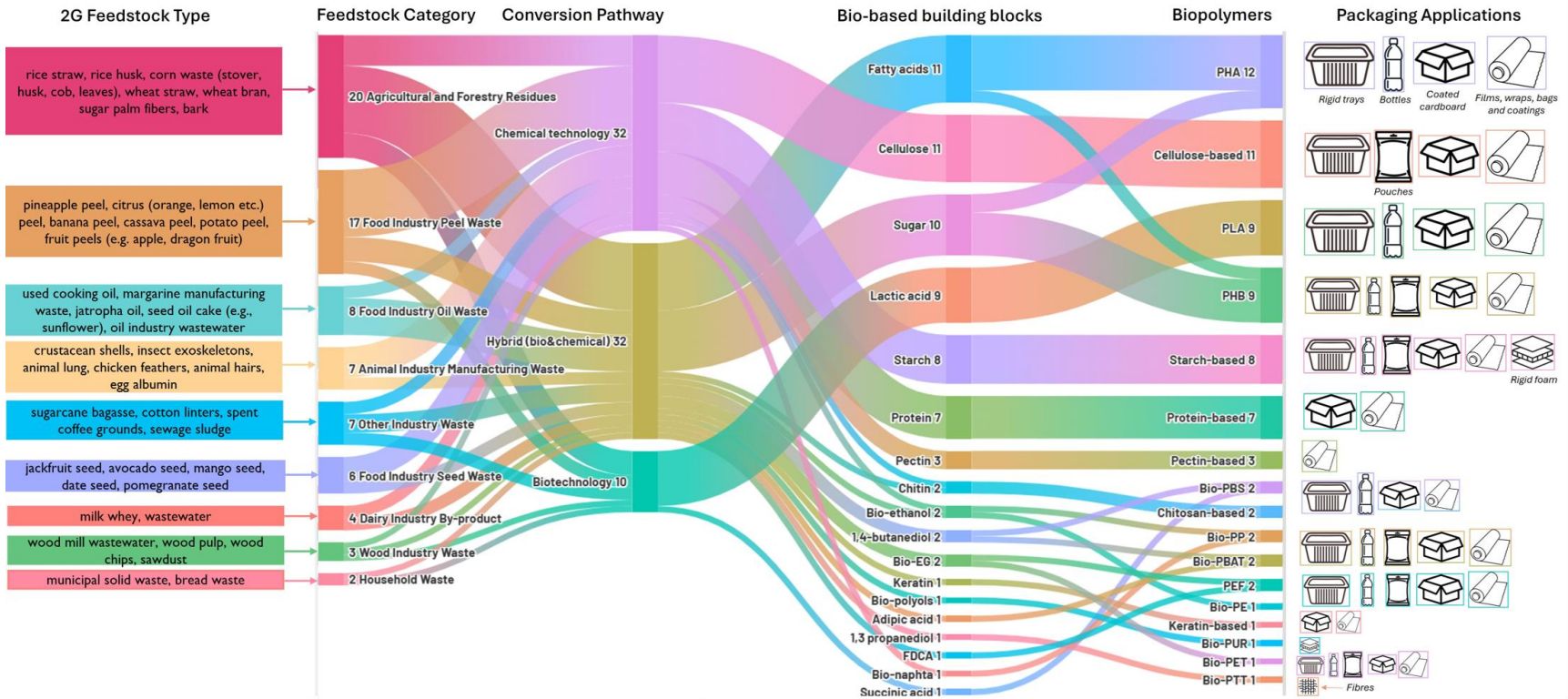
Life Cycle Assessment

- to **identify** and **address** potential **trade-off**
- to **test** the effects of different conditions on the overall performance
- to **compare impacts** of bio-based alternatives to conventional products

EU Bioeconomy Strategy lead markets

- **Bio-based chemicals**
- **Bio-based plastics and polymers**
- **Bio-based fertilisers and plant protection products**
- **Bio-based construction products**
- **Bio-based fibres and fabrics for the textile sector**

Focus on second-generation (2G) bio-based feedstock for EU plastic packaging



Alternatives

2G feedstock (derived from waste) show potential for EU packaging.

Food waste

The most common 2G feedstock is food processing waste.

Legend:

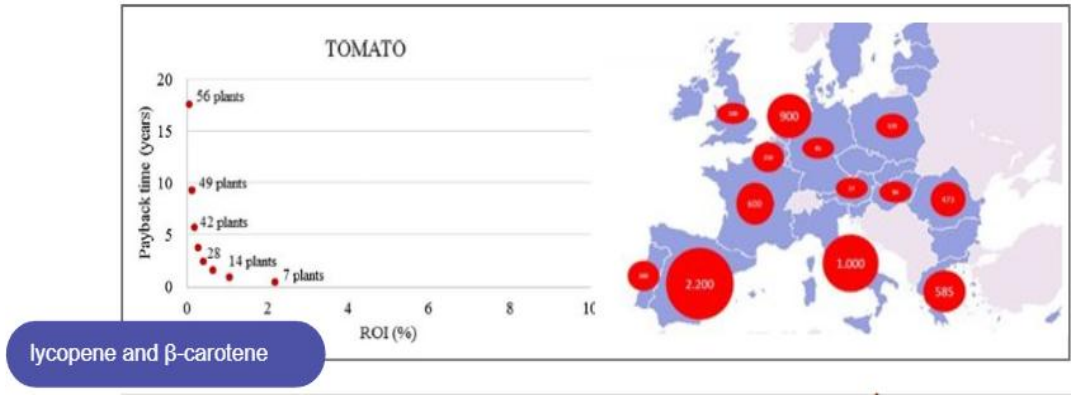
Rigid trays *Bottles* *Coated cardboard* *Pouches* *Films, wraps, bags and coatings* *Fibres*

Assessing opportunities and challenges at scale

Main challenges

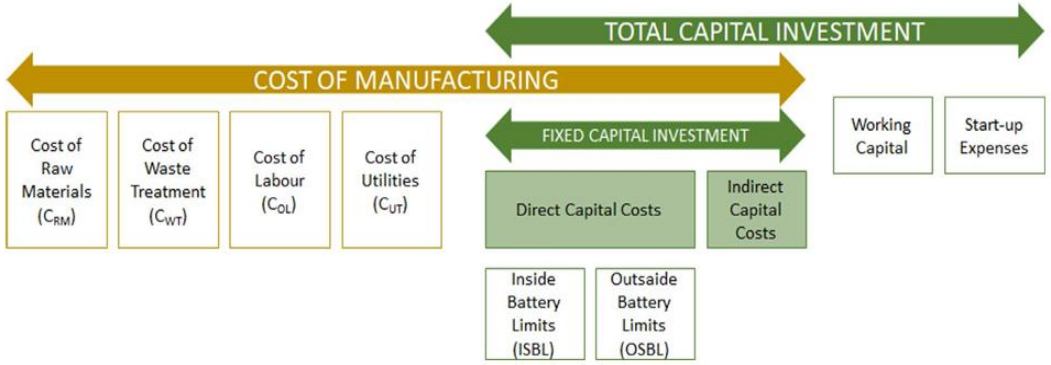
- Feedstock recalcitrance
- Feedstock availability
- Processes stabilisation
- Microorganisms' tolerance to inhibitors
- Regulatory fragmentation
- Costs
- Safety

Geographical considerations, security of supply, logistic



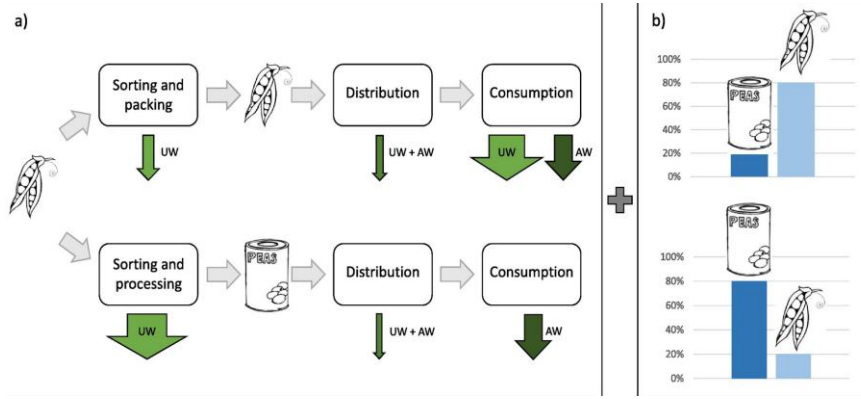
Source: Cristóbal, J., Caldeira, C., Corrado, S. and Sala, S., (2018). Techno-economic and profitability analysis of food waste biorefineries at European level. Bioresource Technology, 259, pp.244-252, https://doi.org/10.1016/j.biortech.2018.03.016

Techno economic assessment



Source: Cristóbal, J., Caldeira, C., Corrado, S. and Sala, S., (2018). Techno-economic and profitability analysis of food waste biorefineries at European level. Bioresource Technology, 259, pp.244-252, https://doi.org/10.1016/j.biortech.2018.03.016

Implications of consumption choices



Source: De Laurentiis, V., Corrado, S. and Sala, S., (2018). Quantifying household waste of fresh fruit and vegetables in the EU. *Waste management*, *77*, pp.238-251. https://doi.org/10.1016/j.wasman.2018.04.001

Safe and Sustainable by Design (SSbD) Framework

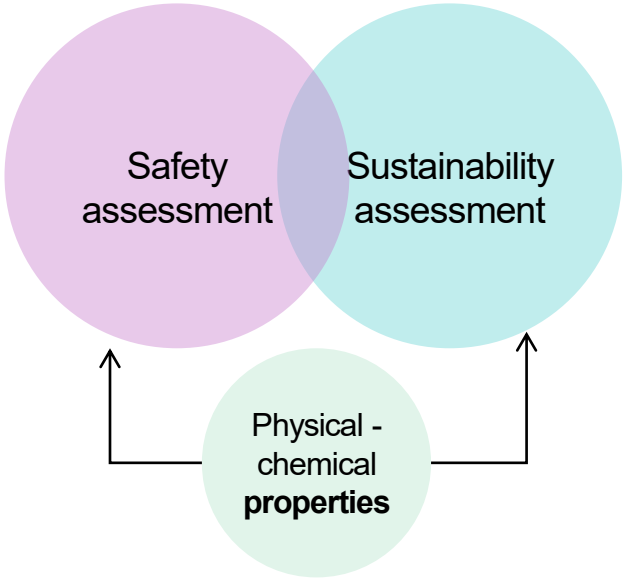


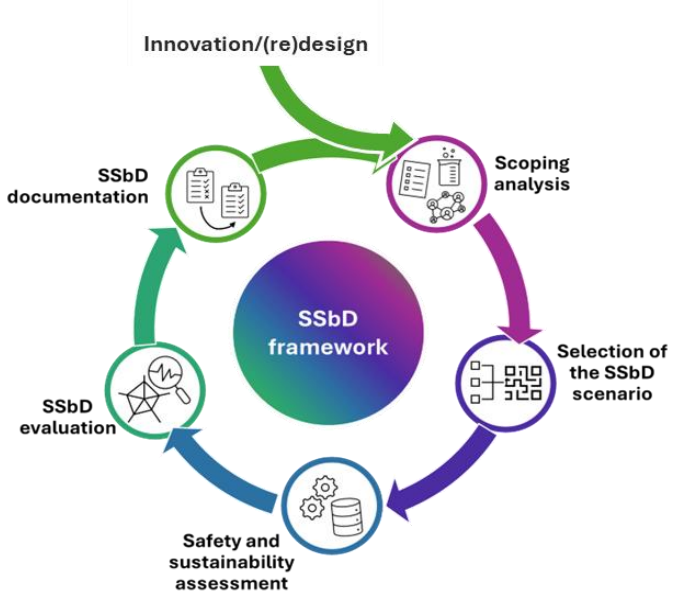
[Safe and sustainable by design]

COMMISSION RECOMMENDATION (EU) 2026/510

of 6 March 2026

on revising the European assessment framework for 'safe and sustainable by design' chemicals and materials





Why

Safety and sustainability need to be considered already when chemicals and materials are designed, not only once they reach the market.

Food-contact materials

LDPE food packaging

What

A voluntary framework for chemicals and materials innovation, combining safety and sustainability across the life cycle.
It accounts for possible trade-offs in:
- using alternative feedstock, including secondary and tertiary biomass
- using alternative processes

How

Through an iterative and tiered process that evolves with innovation maturity and data availability.

Thank you

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