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The potential effects of reducing food loss and waste: Impacts on the triple challenge and cost-benefits analysis

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This paper provides an analysis of the effects that a reduction of Food Loss and Waste (FLW) could have on food security, on environmental sustainability, and on the livelihoods of rural households. A cost estimate of implementing measures to reduce FLW, obtained from a comprehensive literature review, was introduced into the OECD's standard modelling framework (the Aglink-Cosimo model). The quantitative analysis shows that achieving SDG 12.3, and as such halving FLW by 2030, could reduce agricultural GHG emissions by 4% and lift 137 million people out of hunger by 2030. However, the analysis also identifies a potential loss in agricultural income due to reduced food demand, highlighting the need for policy makers to balance the associated benefits and costs when implementing their national FLW reduction strategies. Globally, FLW reduction targets ranging between 26% and 47% by 2030 would allow policy space for policy makers seeking to maximise social welfare or to minimise overall FLW.

JEL codes: D61, E17, Q11, Q18

Key words: Partial equilibrium model, Food security, Environmental impact

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Key findings

What did we do?

- Cost estimates of food loss and waste (FLW) reduction interventions were obtained from a literature review and introduced in the Aglink-Cosimo modelling framework. Ten scenarios targeting a FLW reduction of 5% to 50% by 2030 were run using the baseline of the *OECD-FAO Agricultural Outlook 2024-2033*.
- Potential impacts of reducing FLW on the environment, food security, and agricultural livelihoods, as well as some direct and indirect costs and benefits associated with FLW reduction targets were explored.
- There are several limitations associated with the present analysis including the assumptions that underpin the Aglink-Cosimo model and the assumptions regarding the choice and estimation of direct and indirect costs and benefits associated with FLW reduction interventions. Changing any of these assumptions could impact the results presented in this paper.

What did we learn?

- **Costs of reducing FLW:** Based on a review of literature, comprehensive cost estimates of FLW reduction interventions at different points in the food supply chain can be identified for developed countries, while data for developing countries is scarce. The median cost of reducing FLW is approximately USD 500 per tonne, but this figure varies widely depending on the agricultural product, supply chain stage, and intervention type. Additionally, econometric analyses confirm that the costs of reducing FLW increase as FLW levels decrease.
- **Impacts, synergies, and trade-offs associated with FLW reduction:** While agricultural incomes would be negatively affected by a fall in demand following a reduction in FLW, the positive impacts on the environment (e.g. greenhouse gas emissions and land use) and on food security are likely to be substantial. These effects would increase as the reduction targets become more ambitious. The scale of the impacts would also differ depending on whether all countries acted in a concomitant and coordinated manner or whether only the most developed economies are involved. This suggests a potential useful role for coordinated action at the international level.
- **Cost-benefit analysis of FLW reduction targets:** At the global level, considering some direct (value of saved food and costs associated with FLW reduction initiatives) and indirect (reduction in the externalities associated with GHG emissions and reduction in net agricultural income) costs and benefits associated with FLW reduction, a range of economically adjusted FLW reduction targets is estimated to be between 26% and 47% by 2030.

1. Introduction

The issue of food loss and waste (FLW) has received increased international attention since 2011 when the Food and Agriculture Organization of the United Nations (FAO) published estimates that about 30% of all food produced is either lost or wasted (FAO, 2011[1]). Reducing FLW is a critical part of the solution to the triple challenge of feeding a growing world population, ensuring the livelihoods of rural households, and delivering on climate and sustainability commitments (Deconinck and Giner, 2023[2]) (OECD, 2021[3]).

The United Nations Sustainable Development Goal (SDG) target 12.3 states that "by 2030 per capita global food waste at the retail and consumer levels should be halved and food losses along production and supply chains, including post-harvest losses should be reduced". Global progress on achieving SDG 12.3 is however slower than needed to achieve this goal (Lipinski, 2022[4]). In 2020, an estimated 13.3% of the world's food was lost after harvesting and before reaching retail markets (United Nations, 2022[5]). A further 17% of food is estimated to be wasted at the retail and consumer level (UNEP, 2021[6]). According to United Nations Environment Programme (UNEP), households worldwide wasted over one billion meals a day in 2022 (UNEP, 2024[7]).

The *OECD-FAO Agricultural Outlook 2024-2033* (hereafter the *Outlook*) (OECD/FAO, 2024[8]) estimates that between 20% and 25% of food by weight was lost or wasted along the food value chain over the 2021-2023 period, with poorer countries exhibiting higher levels of FLW. The higher share of FLW that is observed among least developed countries is explained by significant losses related to fruits and vegetables production.[1]

The OECD FLW policy stocktake (OECD, 2025[9]) sheds light on public strategies and associated policy instruments that specifically address FLW to achieve SDG target 12.3 with the objective of supporting more effective policymaking. The policy stocktake identifies avenues for improved public action in FLW monitoring, policy design and evaluation.

To ensure greater policy coherence, the report recommends that policymakers more effectively account for the livelihood, food security and environmental sustainability impacts of FLW policy initiatives, and costs to leverage synergies. It is indeed possible to attribute to FLW over a fifth of all greenhouse gas (GHG) equivalent emissions coming from agricultural production, of total land use, and of aggregate income associated to the agricultural sector (i.e. net value added) (OECD/FAO, 2024[8]) (Figure 1.1). In addition, the *Outlook* estimates that achieving SDG 12.3 could reduce CO_2 equivalent emissions associated to the agricultural sector by 4% and raise 153 million people out of hunger by 2030 (OECD/FAO, 2024[8]).

With the intention of informing evidence-based FLW policymaking, this paper complements the OECD FLW policy stocktake (OECD, 2025[9]) and builds on preliminary work on FLW undertaken as part of the *Outlook* (OECD/FAO, 2024[8]) to assess the triple challenge impacts of reducing FLW, and some associated direct and indirect costs and benefits. Part 2 discusses the scenario methodology. It provides information on new features of the Aglink-Cosimo modelling framework, reviews the relevant literature relative to the costs of different FLW-reducing interventions and presents the assumptions that are used in the scenario analysis. Part 3 presents the scenario results, with a focus on the triple challenge impacts and some costs and benefits associated with FLW reduction targets. Part 4 concludes.

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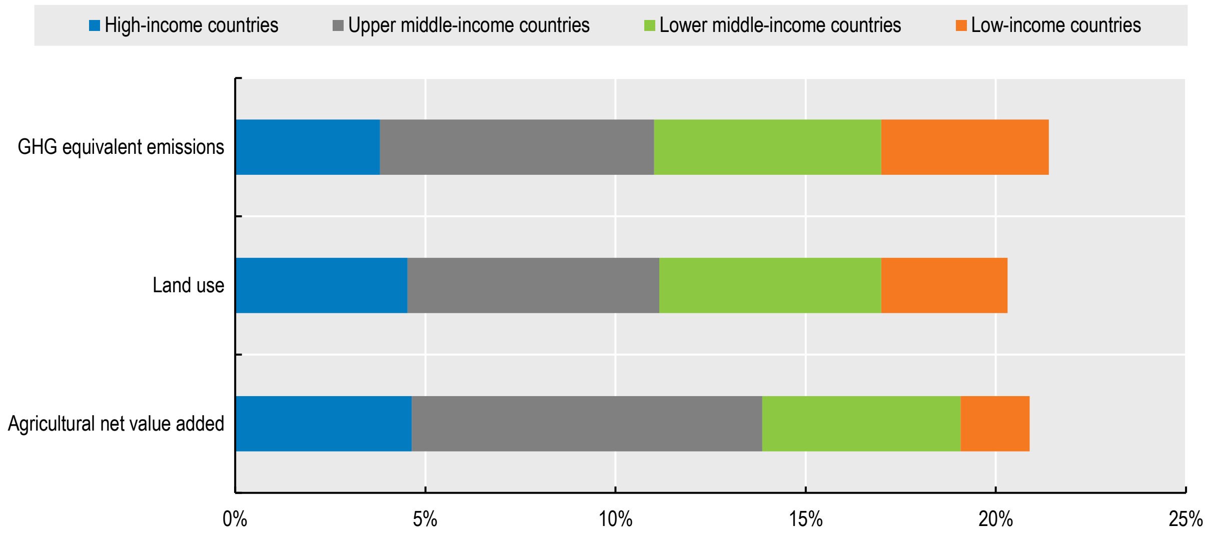
[1] Although FLW figures presented here are expressed in terms of quantity (i.e. measured in tonnes of food), they can also be analysed referring to its caloric content, which may yield different shares (e.g. because of different food products have different water and nutritional contents). For a consideration of the latter and further discussion on the initial state of FLW, see the *OECD-FAO Agricultural Outlook* (OECD/FAO, 2024[8]).

Figure 1.1. Share of global triple challenge variables associated to FLW by region, 2021-2023



Note: The 38 individual countries and 11 regional aggregates are classified into the four income groups according to their respective per capita income in 2018. The applied thresholds are: low: < USD 1 550, lower-middle: < USD 3 895, upper-middle: < USD 13 000, high: > USD 13 000.
Source: OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

2. Scenario methodology

2.1. The Aglink-Cosimo model

The main analytical tool used in this study is the Aglink-Cosimo model, an economic model designed to analyse the global supply and demand dynamics of agriculture. Managed jointly by the Secretariats of the OECD and the FAO, this model is employed to generate consistent baseline projections featured in the *OECD-FAO Agricultural Outlook* and for conducting policy scenario analyses.

Aglink-Cosimo is a recursive-dynamic, partial equilibrium model used to simulate medium-term developments of annual market balances and prices for the main agricultural commodities produced, consumed and traded worldwide. The Aglink-Cosimo country and regional modules cover the whole world. The OECD and FAO Secretariats in conjunction with country experts and national administrations are responsible for developing and maintaining the projections. Several key characteristics are as follows:

- *Exogenous non-agricultural markets:* Aglink-Cosimo is a partial equilibrium model for the main agricultural commodities, as well as biodiesel and bioethanol. Other non-agricultural markets are not modelled and are treated exogenously to the model. This means that the hypotheses regarding the trajectories of key macroeconomic variables are predetermined and do not account for feedback from developments in agricultural markets to the broader economy.
- *Competitive agricultural markets:* World markets for agricultural commodities are assumed to be competitive, with buyers and sellers acting as price takers. Market prices are determined through a global or regional equilibrium in supply and demand.
- *Non-spatial trade:* Domestically produced and traded commodities are viewed to be homogeneous and thus perfect substitutes by buyers and sellers. In particular, importers do not distinguish commodities by country of origin as Aglink-Cosimo is not a spatial model. Imports and exports are nevertheless determined separately, influenced by domestic price versus international price movements. For a given country/region, they may exist contemporaneously, due to non-price factors such as geography.

- *Recursive-dynamic markets:* market outcomes for one year influence those for the next years, notably through herd investment lags, due for example to biological factors affecting sizes or to changing dynamic expectations and behavioural responses. The *Outlook* provides a projection over ten years for purposes of forward-looking policy analysis and planning, but model projections are currently up to 2040 to assess long term implications.

The Aglink-Cosimo modelling framework is continuously enhanced to strengthen its ability to reflect future market developments and provide a more comprehensive analysis beyond the market outcomes.[2] As part of the continued efforts to develop its capacity to track impacts beyond market outcomes and gauge the effects of market developments on food systems, enhanced estimates for food intake were introduced in 2024. Food intake is estimated by integrating analytical methods that first remove food loss from the food available after harvest, and then removes food waste from food consumption.

FLW data incorporation into Aglink-Cosimo started in 2023 and the following three elements have been introduced:

- *Value chain losses* account for all losses occurred between the level at which production is recorded and retail (and not including retail). The source is FAO Food Balance Sheets (FBS) from FAOSTAT and FAO Food Loss and Waste Database.[3] The computation follows the methodology of FAO Global Food Loss Index (GFLI). This primarily includes losses during transformation and processing of primary commodities, storage and transportation.
- *Distribution waste* accounts for all food lost at retail distribution level. The main data sources for computing distribution loss values are caloric waste shares from FAOSTAT Food Security tables. Note that the food service sector is not included.
- *Household waste* accounts for all food waste occurred at household level. Data sources are primarily the Post Harvest Loss Information System (SIPPOC) data and FAO Food Loss and Waste Database. The data are then rescaled to align with global estimates from UNEP.

2.2. Introduction of the costs associated with FLW reduction initiatives in the Aglink-Cosimo model

Researchers at the Joint Research Centre (JRC) of the European Commission have already studied the effects of reducing FLW assuming different stylised cost scenarios in the absence of precise estimates (Britz et al., 2019[10]) (Britz, Dudu and Ferrari, 2014[11]) (Jafari et al., 2020[12]). Using a similar approach the *Outlook* features a stylised scenario that simulates the impact of halving food losses along supply chains and food waste at the retail and consumer levels by 2030 (SDG 12.3.) (OECD/FAO, 2024[8]).

Building on this work, a module introducing equations representing the costs of FLW reduction initiatives was developed in the Aglink-Cosimo modelling framework. These costs are assumed to finance FLW reduction initiatives via higher consumer prices. A detailed description of this module is presented in Annex A.

The costs associated with FLW reduction policies are often not reported by governments and food systems stakeholders. However, a review of the literature was undertaken to quantify the costs that might be implicit in different policy interventions aimed at reducing FLW for different stages of the food supply chain and in different countries (including, for example, the expenditures and/or the costs associated with the development and implementation of an intervention). Annex B provides the list of studies that were reviewed to derive costs estimates included in the Aglink-Cosimo modelling framework.

[2] The latest detailed documentation of Aglink-Cosimo model is available on the official website of the *OECD-FAO Agricultural Outlook*: www.agri-outlook.org, https://www.agri-outlook.org/documents/2024_Aglink%20Cosimo%20Brochure.pdf.

[3] Details on the FAO Food and Loss Database are available at https://www.fao.org/platform-food-loss-waste/flw-data/en.

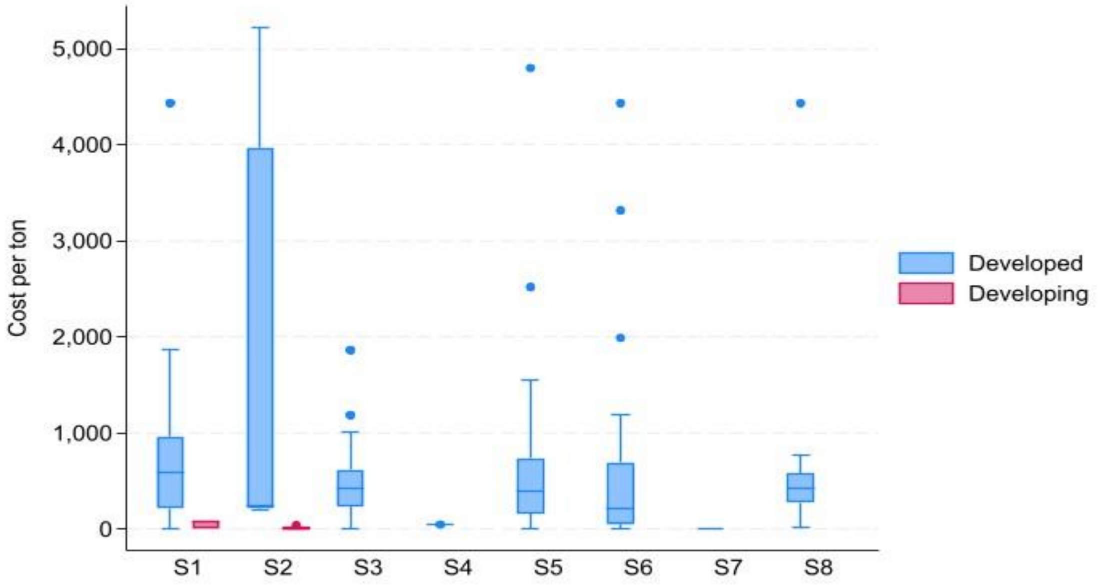
Most of the evidence regarding the costs of FLW reduction initiatives is available for developed countries. The main learnings of this literature review have been included in the OECD Stocktaking of FLW policies (OECD, 2025[9]) and are provided in Box 2.1.

Using information gathered in the literature review, cost estimates for FLW reduction initiatives were collected, normalised (expressed in terms of USD per tonne of FLW reduced) and assembled in a dataset. Figure 2.1 presents a description of the cost data across supply chain stages and level of development of the implementing country. Despite a large variance in the cost estimates, median values tend to centre around USD 500 per tonne of FLW reduced.

Specific initial costs were estimated econometrically for each of the Aglink-Cosimo countries and regions. These costs were included in the consumer price equation of the model, converted metrically to be expressed in terms of tonnes consumed, and adjusted to the price of each commodity relative to a general price index to generate effects of similar magnitude on the demand for each of them.

In addition, based on the information gathered in the literature, an econometric analysis was undertaken to assess the relationship between the cost of FLW reduction interventions and the levels of FLW. It was confirmed that costs of reducing FLW per tonne of reduced FLW appear to be lower when FLW is high (due to “low-hanging fruits”) and seem to increase when lower FLW levels have been achieved (when for example the remaining FLW reduction needs to come from processes that are difficult to improve, e.g. manufacturing line optimisation). Annex C provides more information on all these estimations.

Figure 2.1. Boxplot of costs of FLW reduction initiatives along the agro-food value chain



Note: Stages S1 through S8 correspond to primary agriculture, agricultural handling and storage, food processing and packaging, wholesale, retail, hospitality and food services, public food procurement, and private households, respectively. See Table A B.1 for further details. The dots represent outliers.
Source: OECD based on the literature review.

Box 2.1. Information on costs of reducing FLW reported in the literature

Several not-for-profit and/or research organisations active in the field of FLW reduction have been exploring these costs. In the United States, ReFED, the not-for-profit organisation that the US EPA, the FDA, and the USDA have partnered with as part of the Federal Interagency Collaboration to Reduce Food Loss and Waste (FIFLAW), has been developing data and estimates on the costs and benefits of 40 different FLW-reducing interventions at different stages of the agro-food supply chain (ReFED, 2021[13]) (ReFED, 2016[14]). Their Solutions Database provides detailed and specific information regarding total food reduced (measured in tonnes), its implied costs, and other impact measures such as spillover effects on the environment, or on food security (both of which are always shown to be positive). Cost estimates vary greatly depending on the stage and/or the type of initiative, with some requiring as little as USD 0.16 per reduced tonne and others as much as USD 1 015.54 per diverted tonne (average of about USD 509 per tonne).

Similar estimates have been collected by the Joint Research Centre (JRC) of the European Commission for 43 different initiatives in EU countries (Caldeira, Sala and De Laurentis, 2019[15]). As in the ReFED studies, cost estimations show a large variance, ranging from EUR 19.44 to up to EUR 23 863.51 per reduced tonne of FLW (average of EUR 730 per tonne).

In the United Kingdom, in a report led by the World Resources Institute (WRI) and the Waste and Resources Action Programme (WRAP) on behalf of Champions 12.3, Hanson & Mitchell (2017[16]) analyse two programmes aimed at reducing food waste at the final consumption stage through different campaigns. The first programme reduced 1.1 million tonnes of food wasted at a cost of GBP 23.64 per tonne and at a benefit to cost ratio of 250:1, while the second programme saved 12 350 tonnes of food waste at a cost of GBP 13.64 per tonne and a benefit-cost ratio of between 8:1 and 91:1. The authors also provide an analysis of the profitability of almost 1 200 businesses in 17 different countries devoted to reducing FLW, with a median benefit to cost ratio close to 14:1.

In addition, the International Food Waste Coalition, a not-for-profit organisation set up to coordinate action to reduce FLW across Europe's hospitality and food services sector, presented, in 2022, information about 45 private-driven innovative initiatives aimed at reducing FW at the hospitality and food services stage in France, Germany, Netherlands, and the United States (IFWC, 2022[17]). With total investment costs ranging from EUR 0.47 million to EUR 8.83 million per year (average of EUR 2.89 million), these businesses can reduce FW by between 15% and 50% (with most of them reporting 50% reductions).

Recently, some studies are looking specifically at cost and impact of FLW reduction measures for certain low- or lower middle-income economies such as Colombia, South Africa, Brazil, Ghana, Tanzania, Kenya, or Nigeria (UNEP, 2024[18]) (FAO, 2019[19]) (Hanson and Mitchell, 2017[16]) (Flanagan, Robertson and Hanson, 2019[20])). Other studies from the academic literature report specific cost estimates, as well as environmental impacts, using the standardised methodology of life-cycle costing (LCC) or similar approaches, mostly focusing on the food processing and manufacturing stage (Martinez-Sanchez et al., 2016[21]) (Ferella et al., 2019[22]) (Vaneeckhaute et al., 2018[23]) (Hanson and Mitchell, 2017[16]) (Flanagan, Robertson and Hanson, 2019[20]).

Source: OECD (2025[9])

2.3. Scenario specification

To estimate the potential effects of reducing FLW on the triple challenge of food systems, two types of scenarios were run assuming different FLW reduction targets to be reached by 2030 either by all countries and regions (type 1) or by only high- and upper-middle income countries (type 2). The scenario specifications are presented in Table 2.1.

Table 2.1. FLW reduction scenario specifications

	Start year	Target year	Countries and regions	Target: FLW reduction with respect to start year
Type 1	2023	2030	All	5% to 50%
Type 2	2023	2030	Only high-income and upper middle-income	10% and 50%

Note: The 38 individual countries and 11 regional aggregates are classified into the four income groups according to their respective per capita income in 2018. The applied thresholds are: low: < USD 1 550, lower-middle: < USD 3 895, upper-middle: < USD 13 000, high: > USD 13 000.
Source: OECD.

The FLW reduction is assumed to be simultaneous in all countries concerned for all food products and is linearly extrapolated from start to target year. Each of the scenarios is compared to the *Outlook* baseline (OECD/FAO, 2024[8]), which represents the counterfactual situation. The *Outlook* assumes constant FLW shares for all food products and countries at their 2023 levels, and average weather conditions over the outlook period. The difference between the former and the latter provides the scenario's impacts.

Similar assumptions to the SDG 12.3 scenario analysis featured in the *Outlook* (OECD/FAO, 2024[8]) are maintained in this work:

- In countries where there is a high prevalence of undernourishment (above the critical threshold of 2.5%), households do not reduce their food demand as a response to FLW reduction but rather increase their calorie intake.
- Costs are transmitted to consumer prices.

3. Scenario results

3.1. Triple challenge impacts for different FLW reduction targets

Food systems face the triple challenge of providing food security and nutrition to a growing population, providing livelihoods to those along the food supply chain, and contributing to environmental sustainability (OECD, 2021[3]). The following indicators, available in the Aglink-Cosimo modelling framework, were chosen to shed light on different dimensions of the triple challenge (Table 1). While these indicators capture important aspects of the triple challenge, they only offer a partial view due to data and evidence gaps, a phenomenon which holds for food systems more broadly (Deconinck et al., 2021[24]).

Table 3.1. Indicators of the triple challenge

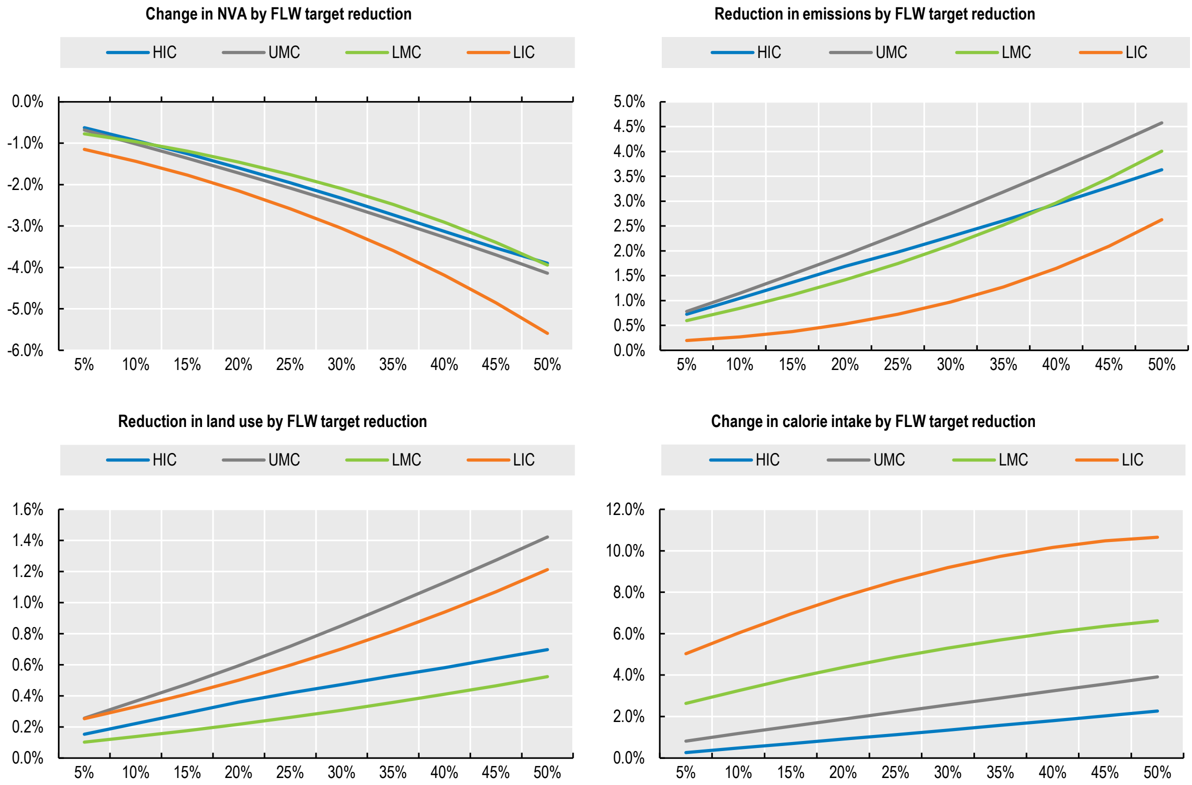
Challenge	Indicator	Definition
Food security and nutrition	Calorie intake	Global per capita calorie intake
	Undernourishment	Prevalence of Undernourishment (PoU)
Livelihoods	Agricultural net value added (NVA)	Index capturing aggregate income associated to the agricultural sector
Environmental sustainability	Direct emissions	Direct GHG emissions from the agricultural sector
	Land use	Land use change

Note: Other indicators related to environmental sustainability (e.g. biodiversity, water use) cannot be assessed with the Aglink-Cosimo modelling framework
Source: OECD.

Type 1 scenarios: Co-ordinated FLW reduction

This first set of results present the impacts on the indicators of the triple challenge presented above for the ten scenarios targeting a FLW reduction of 5% to 50% between 2023 and 2030. Figure 3.1 shows the impacts of reducing FLW globally expressed as the percentage difference between each scenario and the *Outlook* baseline in 2030 for each reduction target.

Figure 3.1. Impacts on the triple challenge indicators by FLW reduction target in 2030



Note: HIC, UMC, LMC, and LIC stand for high-, upper-middle-, lower-middle-, and lower-income countries, respectively. The 38 individual countries and 11 regional aggregates are classified into the four income groups according to their respective per-capita income in 2018. The applied thresholds are: low: < USD 1 550, lower-middle: < USD 3 895, upper-middle: < USD 13 000, high: > USD 13 000.
Source: OECD.

For all the indicators considered, the impacts (both positive and negative) increase as more ambitious reductions in FLW levels are targeted. This means that greater synergies and trade-offs can be expected if higher FLW reduction targets are achieved.

Regarding the implications of reducing FLW for the agricultural sector and farmers' livelihoods, the results suggest that there could be negative impacts on agricultural income. Reducing FLW would indeed reduce demand in most countries, which would drive agricultural producer prices and production down. If SDG 12.3 was to be achieved, agricultural net value added (NVA) would decrease by about 4% for all regions except in lower-income countries, which would see a larger drop of approximately 5.5%, mainly due to a drop in crop production.[4]

[4] Crops represent a larger share of agricultural production and FLW in lower-income countries.

When it comes to impacts on environmental sustainability indicators, reducing FLW has a high potential for reducing GHG emissions coming from agricultural production. Halving FLW by 2030 could potentially reduce agricultural GHG emissions by between 3% and 5%, depending on the level of economic development, with upper middle-income experiencing the largest spillover effects, followed by lower middle-, high-and lower-income countries.[5] Agricultural land use would also be expected to decrease under the different FLW reduction scenarios. In this case, however, the impacts are relatively smaller when compared to other triple challenge indicators. A 50% FLW reduction would imply, due to lower agricultural production needs, a 0.5% to 1.4% decrease in land use compared to the baseline by 2030.

Lastly, the results also reveal significant food security spillovers. Achieving SDG 12.3 would yield increases in calorie intake from 2% to almost 11% by 2030 depending on the region, with nutritional impacts being inversely related to the level of economic development. This is partly due to the assumption made regarding demand transmission of FLW reduction in countries with high prevalence of undernourishment, for which most of the food that is saved is assumed to stay in local markets and be consumed locally. The concave shape of the calorie intake curves in low- and lower middle-income countries can be attributed to the fact that, as FLW reduction targets become more ambitious, costs of reducing FLW start to increase more, which would cause consumer prices to rise and, consequently, have a higher disincentivizing effect on demand, all else being equal.

The positive calorie intake impacts mentioned above would also have an impact on the number of undernourished people. Reducing FLW by 10% and 50% could potentially lift 78 and 137 million people out of hunger, respectively.[6] This is another positive externality on the food security dimension of the triple challenge of food systems.

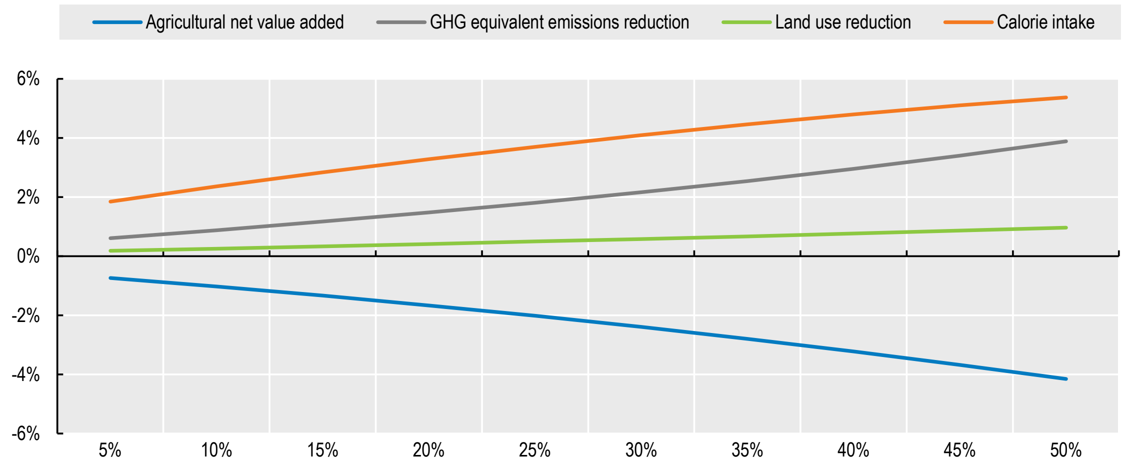
Figure 3.2 shows the global impacts for each of the main triple challenge indicators considered by level of FLW reduction target in 2030. In terms of trade-offs at the global level, the impact in terms of reduced agricultural income increases in almost the same proportion as the impact in terms of GHG reduction[7]. In a simple framework where the decision to reduce FLW depends exclusively on preferences regarding the three dimensions of the triple challenge of food systems, FLW reduction would only be unattractive for policymakers whose priority on ensuring agricultural livelihoods was sufficiently high for it to outweigh the environmental and food security benefits associated with FLW reduction. This rationale applies globally, but not necessarily in low-income countries, where agricultural income would see a relatively stronger decline.

[5] This result relating the environmental potential of FLW reduction and level of economic development could be indicative of an environmental Kuznets curve dynamic, according to which GHG emissions and other environmental issues follow an inverse U-shaped relationship with respect to economic performance (see Grossman and Krueger (1991[28]), World Bank (1992[34]), Beckerman (1995[29]), Arrow et al. (1995[30]). The classical rationale behind this is that, as economies start to emerge and grow, they make use of technologies and production processes that have greater detrimental impacts for the environment. It is not until a certain level of economic development is reached that countries would be able and willing to start reducing these negative effects.

[6] Note that this result is not far from the previous analysis in OECD/FAO (2024[8]), which estimated a reduction of 153 million people living in hunger as a consequence of halving FLW by 2030. The 16 million people difference between the latter and the results in this paper can be attributed to the implementation of the more refined cost structure of reducing FLW into the Aglink-Cosimo model and its effects on food demand.

[7] Similar findings regarding trade-offs are reported in De Jong et al. (2023[33]).for European Union countries using a model-based approach

Figure 3.2. Global impacts of FLW reduction targets in 2030

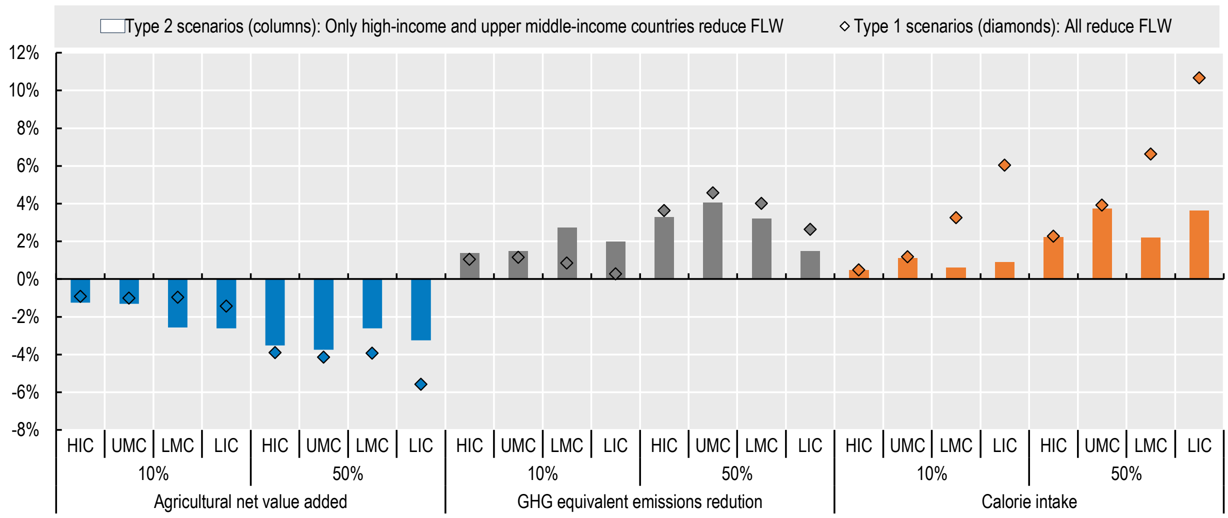


Source: OECD.

Type 2 scenarios: FLW reduction in high-income and upper-middle-income countries

Type 1 scenarios assume collective, coordinated political action to achieve concomitant FLW reduction targets by 2030. However, it is likely that FLW reduction policy action will be led by higher-income countries, given the policy commitments highlighted in the OECD FLW policy stocktake (OECD, 2025[25]) which discusses the ambition and the commitment of high-income and upper-middle income countries in achieving SDG 12.3. Type 2 scenarios were therefore run to quantify the potential impacts of FLW reduction in high-income and upper-middle-income countries. Results are presented in Figure 3.3.

Figure 3.3. Change in triple challenge indicators depending on which regions reduce FLW



Note: HIC, UMC, LMC, and LIC stand for high-, upper-middle-, lower-middle-, and lower-income countries, respectively. The 38 individual countries and 11 regional aggregates are classified into the four income groups according to their respective per-capita income in 2018. The applied thresholds are: low: < USD 1 550, lower-middle: < USD 3 895, upper-middle: < USD 13 000, high: > USD 13 000.
Source: OECD.

Compared to type 1 scenarios, the effects observed on the triple challenge indicators when only high- and upper middle-income countries pursue FLW reductions (type 2 scenarios) depend on the target that is set.

For instance, if the FLW reduction is set at 10% by 2030, impacts when all countries engage in FLW reduction tend to be smaller in magnitude than when only high and upper-middle-income countries reduce FLW (except for calorie intake which is always higher when poorer countries also reduce FLW themselves). On the other hand, when the target is as ambitious as that of SDG 12.3 (i.e. 50% reduction), higher impacts are found when all countries reduce their FLW.

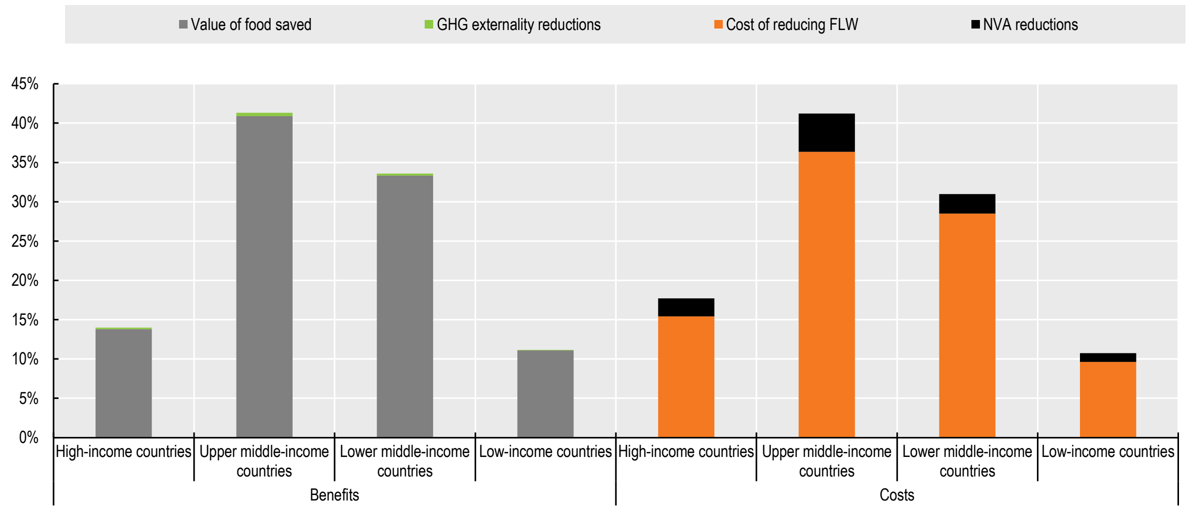
3.2. Cost-benefit analysis of FLW reduction targets

Composition of costs and benefits

A possible approach to setting FLW reduction targets can be based on the economic feasibility of such measures, i.e. direct and indirect costs and benefits associated with FLW reduction. The cost-benefit analysis run as part of this work only considers direct costs (cost of FLW reduction interventions) and benefits (value of food saved) and some indirect costs (reduction in agricultural incomes) and benefits (e.g. reductions in GHG externalities) associated with the triple challenge facing food systems (Deconinck and Giner, 2023[2])[8]. Besides the value of food saved and the direct cost of reducing FLW, negative impacts on agricultural NVA are considered as additional indirect costs (or negative benefits), and reductions in the social cost of GHG emissions as additional benefits. To quantify the latter, the social cost of carbon estimate in Nordhaus (2017[25]) was used, which amounts to 31 constant international USD per tonne of emitted CO_2 in 2015 with a real growth rate of 3% annually. Figure 3.4 shows the composition and regional distribution of the benefits and costs considered as a proportion of total world values.

Direct costs and benefits account for the bulk of the total estimates, with indirect impacts on agricultural income and GHG emissions accounting for a small proportion. Moreover, the regional distribution indicates that upper-middle and lower-middle income countries are expected to bear most of the global costs of reduction (both in terms of policy investments and direct interventions as well as reductions in agricultural incomes) but at the same time would be able to exploit and receive the most benefits.

Figure 3.4. Contribution of benefits and costs by type and income level as a share of world total (average 2023-2030)



Note: The 38 individual countries and 11 regional aggregates are classified into the four income groups according to their respective per capita income in 2018. The applied thresholds are: low: < USD 1 550, lower-middle: < USD 3 895, upper-middle: < USD 13 000, high: > USD 13 000.
Source: OECD.

[8] True cost accounting (see FAO (2023[31]) and Lord (2023[32]) for a food systems application) could be used to quantify such costs and benefits.

Cost-benefit considerations and economically adjusted FLW reduction targets

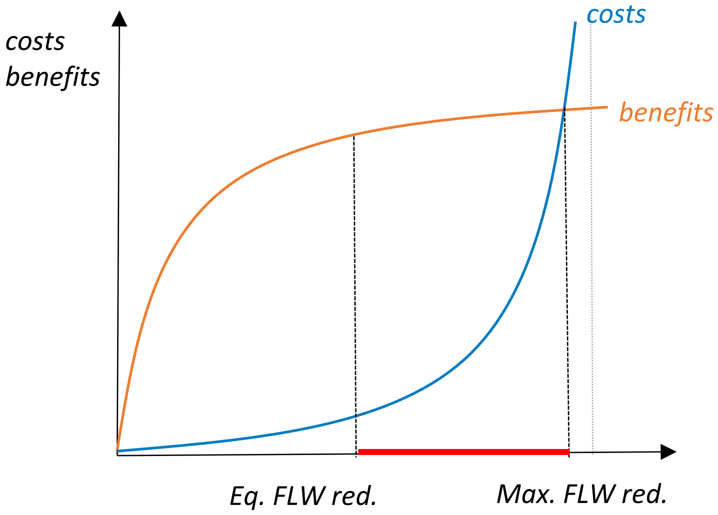
Figure 3.5 presents a theoretical framework representing costs and benefits associated with FLW reduction. Both costs and benefits increase when higher FLW reduction levels are achieved.

Policymakers could seek to maximise social welfare. They would seek to reduce FLW as long as benefits increase faster than costs and stop reducing once the difference between both is largest. This represents an *economic equilibrium* reduction target since there would be no economic incentives to move away from it (although there could still be political incentives to keep setting more ambitious targets).

Policymakers could also seek to achieve the maximum level of FLW reduction that does not imply social welfare losses for the economy, i.e. looking for the *maximum* FLW reduction before total costs start to exceed social benefits (i.e. when both are equal and the net effect on welfare is zero).

Considering all the above, from an economic (not necessarily political) standpoint, policymakers should at least try to reduce FLW as long as welfare effects keep increasing (minimum FLW reduction target) but may not go as far as making the reduction more costly to society than the benefits that could be obtained from it (maximum FLW reduction target). The reduction targets that lay between those two extremes define a *range of economically adjusted FLW reduction targets*.

Figure 3.5. Costs and benefits curves of reducing FLW



Note: Red segment in the horizontal axis represents the estimated range of economically adjusted FLW reduction targets.
Source: OECD.

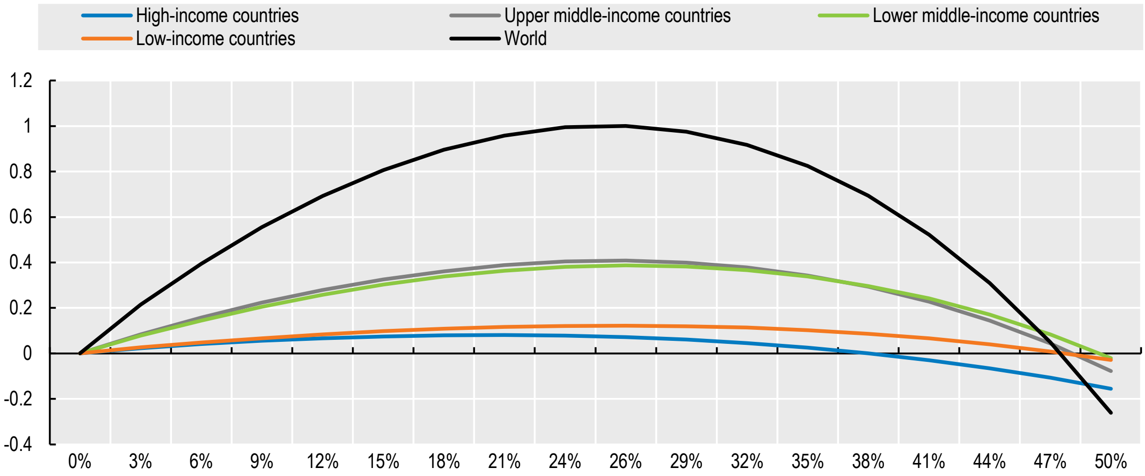
The costs and benefits structure that justifies the above theoretical approach would yield an inverse U-shaped social welfare curve that is validated by the scenario results. Figure 3.6 shows the modelled welfare effects that different targets produce for different regions. The level of reduction at the maximum point of each curve corresponds to the *economic equilibrium* and that for which the curve crosses the horizontal axis at the 0 value to the *maximum attainable*.

The estimated *ranges of economically adjusted FLW reduction targets* were calculated for each region represented in the Aglink-Cosimo modelling framework.[9] Figure 3.7 presents the ranges in terms of targeted share of FLW for each region as well as that corresponding to SDG 12.3 and the initial FLW share.

[9] This is done by assessing social welfare for each region progressively for each of the ten scenarios in which all countries reduce FLW from 5% to 50%, ascending in the level of reduction of the scenarios. Once each region reaches a maximum in welfare, the level of FLW specific to that period is set as the economic equilibrium that delimits the lower bound of the range of policy effectiveness. Similarly, when social welfare reaches its first negative value for each region, the level of FLW of the directly preceding period is taken as the upper bound of the range, i.e. the maximum attainable FLW.

Figure 3.6. Social welfare and FLW reduction by region

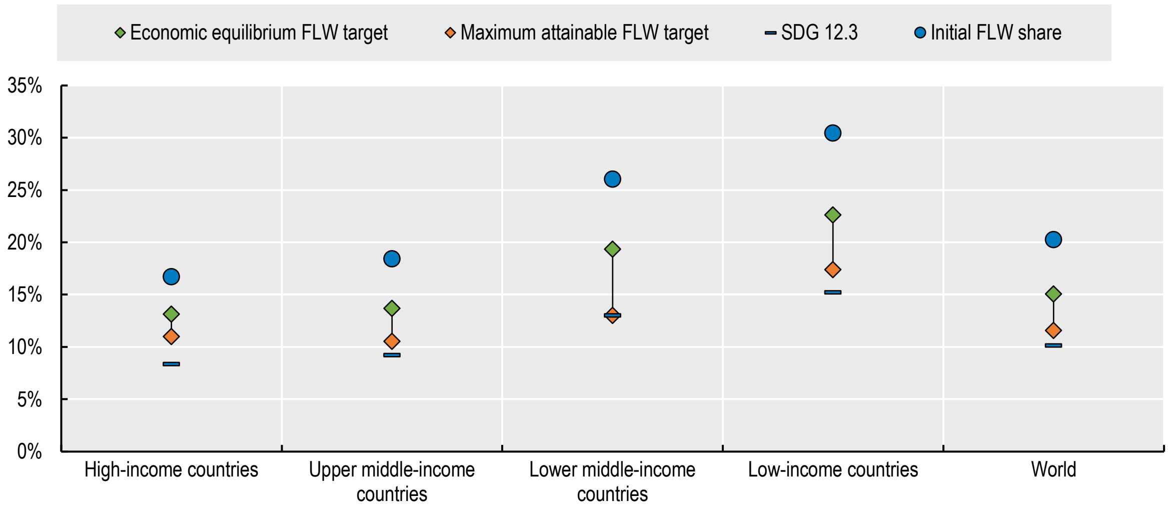
Expressed as an index relative to the *maximum equilibrium* reduction target for the world



Note: The 38 individual countries and 11 regional aggregates are classified into the four income groups according to their respective per-capita income in 2018. The applied thresholds are: low: < USD 1 550, lower-middle: < USD 3 895, upper-middle: < USD 13 000, high: > USD 13 000. These results were obtained from a more granular analysis which takes 17 periods between start and target year. Benefits include the monetary value of food saved and the social cost of carbon that is reduced. Costs include those associated to direct interventions or policies and agricultural NVA reductions.
Source: OECD.

Figure 3.7. Estimated ranges of economically adjusted FLW reduction targets by region

Targets in 2030 expressed as FLW shares



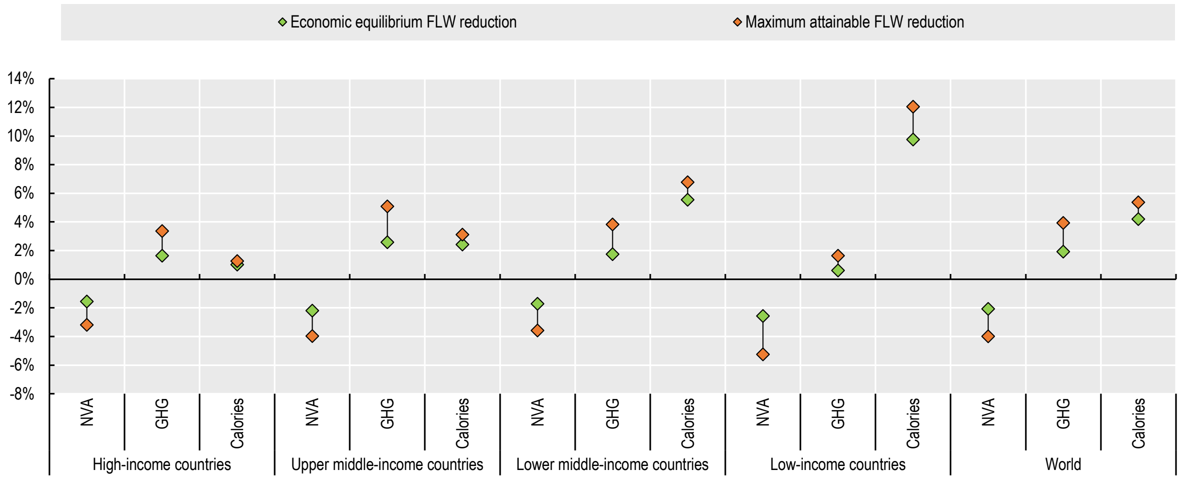
Note: The 38 individual countries and 11 regional aggregates are classified into the four income groups according to their respective per-capita income in 2018. The applied thresholds are: low: < USD 1 550, lower-middle: < USD 3 895, upper-middle: < USD 13 000, high: > USD 13 000.
Source: OECD.

The estimated ranges appear as wider when the initial share of FLW is bigger and with the level of economic development. The main reason for this is that developed countries start with higher estimated initial FLW reduction costs and lower benefits in terms of the economic value of food saved than lower income countries, mainly because their initial FLW levels are relatively lower.

According to these findings, the estimated *range of economically adjusted FLW reduction targets* at the global level is estimated between 26% and 47%, which would result in 12% to 15% of food produced being either lost or wasted in 2030 (compared to 20% in 2023). Reducing the costs associated with FLW reduction initiatives, thanks to innovative policy practices or more exchanges of good practice, could contribute to shifting the estimated *range of economically adjusted FLW reduction targets*.

Figure 3.8 explores the impacts of reducing FLW along the estimated range of *economically adjusted* FLW reduction targets by 2030 for the set of triple challenge indicators analysed in this paper by region.

Figure 3.8. Triple challenge impacts at the estimated range of economically adjusted FLW reduction targets



Note: NVA: net value added; GHG: greenhouse gas emission. The 38 individual countries and 11 regional aggregates are classified into the four income groups according to their respective per-capita income in 2018. The applied thresholds are: low: < USD 1 550, lower-middle: < USD 3 895, upper-middle: < USD 13 000, high: > USD 13 000.
Source: OECD.

3.3. Limitations

There are several limitations associated with the analysis presented in this paper. This includes the assumptions on which the analysis is based on, such as: (1) the assumptions that underpin the Aglink-Cosimo model and the *Outlook* baseline, (2) the cost estimates and associated empirical analysis, (3) the choice and estimation of indirect costs and benefits. Changing any of these assumptions could impact the results presented in this paper including the estimated ranges of economically adjusted FLW reduction targets.

Box 3.1 describes a comparable approach adopted by Food Innovation Australia as part of the National Food Waste Strategy Feasibility Study and highlights the importance of transparency regarding the assumptions inherent to the scenario analysis.

In the European Union, a framework for the evaluation of food waste prevention actions was developed and applied (Caldeira, Sala and De Laurentis, 2019[15]) which goes beyond the cost-benefit analysis presented here. It is structured around six criteria for the evaluation of food waste prevention actions: Quality of the action design, Effectiveness, Efficiency, Sustainability of the action over time, Transferability and scalability, Intersectoral cooperation. The criterion on efficiency is largely comparable to the benefit cost analysis presented here. Lehn and Schmidt (2023[26]) applied this framework to the conversion of surplus food into processed food products This study showed that this conversion is economically feasible and results in a reduction of the carbon footprint.

Box 3.1. Australia's feasibility study

Food Innovation Australia (FIAL) and their modelling approach

In 2021, The Food and Agribusiness Growth Centre of Food Innovation Australia (FIAL) published the National Food Waste Strategy Feasibility Study. Among other results, the report shows a scenario analysis that is produced from a modelling exercise of the Australian agri-food market. Probably one of the most relevant insights of this study is its focus on economic feasibility and cost-benefit analysis, which shares many similarities with the present paper.

One of the main technical advantages in FIAL's report compared to the OECD Secretariat's approach is the possibility of modelling different interventions along all stages of the food value chain, something that is currently not possible with the Aglink-Cosimo model.

However, in contrast to our results presented above, they find that halving the FLW by 2030 to SDG 12.3 would not only be economically feasible but also able to generate important social welfare effects: "The analysis of the recommended scenario shows that it is feasible to deliver a 50% reduction in total food waste by the 2030 deadline. The results demonstrate that not only is it possible to halve Australia's food waste by 2030 but there are very significant economic benefits, at the national, business and household level in doing so" (FIAL, 2021[27]). Such discrepancy in results can be explained by the different ways in which both costs and benefits have been modelled.

Cost estimates

Like this paper, FIAL (2021[27]) includes costs associated to FLW-reducing interventions in the feasibility analysis using estimates obtained from a literature review which contains many common references to those presented in Section 2 (e.g. JRC (2019[15]) and ReFED (2016[14]). However, there are four main differences in the latter's approach with respect to the OECD Secretariat's approach:

- The cost values of the initiatives, many of which are estimates for other countries, are inputted directly into the model.
- Nothing seems to indicate that the introduction of these costs in the model has any effect on demand or supply, which could be obviating how these costs are borne by the market.
- Indirect costs like potential negative effects on agricultural income are not considered, which may underestimate the true cost of reducing FLW.
- Reduction costs are assumed constant, i.e. a cost structure as that specified by Figure 2.2 is not considered. It is precisely the latter that leads FIAL (2021[27]) to conclude the attainability of SDG 12.3, since assuming constant costs per tonne and constant or increasing unit benefits implies that net benefits will necessarily increase whenever the latter is higher than the former and there will always be incentives to continue reducing FLW. However, the empirical evidence seems to indicate an increasing cost structure in FLW reduction, as shown in Section 2 of this study.

Benefit estimates

As in this paper, FIAL (2021[27]) considers direct benefits measured as the value of avoided food waste but also avoided social cost of carbon and even the avoided cost of landfill. Another point in common is the distribution of total benefits, as the Australian report also estimates that the value of food saved would be the main component of total benefits (95%), with the effects on the social cost of carbon and the avoided cost of landfill only accounting for a small proportion of them.

This feasibility report by FIAL and its contrast with the findings in this paper provide an important insight for FLW reduction scenario analysis, as it may not necessarily be robust to different modelling approaches, mostly when it comes to costs.

4. Conclusions

Reducing FLW globally represents an important policy lever to contribute to ensuring greater food security and environmental sustainability of food systems. This paper studies the potential effects and feasibility of achieving different FLW reduction targets. Different FLW reduction scenarios were run and compared to a baseline scenario using the Aglink-Cosimo modelling framework. The analysis includes the estimation of a cost structure of FLW reduction interventions for different countries and regions. A cost-benefit analysis was undertaken to estimate a range of FLW reduction targets that could reflect different policymaking priorities.

A literature review highlights the growing focus on the costs associated with FLW reduction interventions. Overall, more detailed cost estimates across various stages of the food supply chain are available for developed countries, while there is a significant lack of data from developing regions. Median reduction costs centre around USD 500 per tonne, with large variation across estimates, supply chain stages and type of intervention. These costs are also found to increase as FLW is reduced.

The scenario analysis shows that, while ambitious FLW reduction targets can lower agricultural income (due to lower food demand), they can also significantly contribute to reducing agricultural GHG emissions and land use, and improving food security, especially in lower-income countries. However, the scale of these synergies and trade-offs may vary depending on whether FLW reduction is pursued globally or primarily by more developed countries.

A cost-benefit analysis shows that, globally, FLW reduction targets ranging between 26% and 47% by 2030 would allow policy space for policymakers seeking to maximise social welfare or to minimise overall FLW. The estimates could change if the costs associated with FLW reduction initiatives were lower or if other additional indirect benefits were considered.

Efforts to reduce FLW are strong, and this scenario analysis shows there are many incentives to do so. At the national and international levels, the choice of targets for FLW reduction and the commitment to meet these targets depends on the priorities and preferences of governments and food systems stakeholders. This type of modelling exercise can help policymakers make more informed policy decision.

Despite the above policy insights, further research is needed to improve the analysis of FLW reduction initiatives and efforts. More and better evidence is needed regarding the costs of reducing FLW to reduce the existing uncertainty around certain types of interventions, especially those targeting the agricultural production stage and in developing countries. Additionally, future research could conduct a sensitivity analysis of these results, including an examination of impacts of additional hidden or indirect externality costs and benefits (e.g. health improvements that arise because of food security gains or biodiversity gains). The robustness of the analytical approach could be tested using other agricultural models.

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Annex A. Introduction of the costs of FLW reduction interventions into the Aglink-Cosimo model

As was the case in OECD/FAO (2024[8]), FLW reduction is assumed to be transmitted to demand of food. Consequently, cost estimates are introduced as higher consumer prices by adjusting the latter as costs per tonne of reduced FLW that is consumed (rather than costs per tonne reduced) and a multiplier factor which accounts for consumer prices relative to an overall food price index so they can be differentiated by commodity.

Formally, costs are introduced into the model through the additive tax term (TAX^{add}) that is found in the consumer price (CP) equation as follows:

$$cost_{r,t} = cost_{r,t-1} + \hat{\beta}_1 \times \left(\frac{FLW_{r,t} - FLW_{r,t-1}}{FLW_{r,t-1}}\right) \times 100$$

$$TAX_{r,c,t}^{add} = cost_{r,t} \times \left(FLW_{r,2023} - FLW_{r,t}\right) \times \frac{CP_{r,c}}{\left(\frac{\sum_C FO_{r,c} \times CP_{r,c}}{\sum_C FO_{r,c}}\right)}$$

Where $cost$ represents the costs of reducing one tonne of FLW in country or region r and year t; FLW is the total share of food that is lost or wasted; and FO is total food consumption (in kilotons) of commodity c.

Annex B. Literature review and costs estimates

Table A B.1. Studies covered in the literature review

Publication type	Reference	S.1	S.2	S.3	S.4	S.5	S.6	S.7	S.8	Developed countries	Developing countries
Academic paper	Britz et al. (2014)	X	X	X	X	X	X	X	X	Yes	
	Jafari et al. (2020)	X	X	X	X	X	X	X	X	Yes	
	Martinez-Sanchez et al. (2016)	X	X	X				X	X	Yes	
	Ferella et al. (2019)		X							Yes	
	Vaneeckhaute et al. (2018)		X							Yes	
	Slorach et al. (2019)			X					X	Yes	
	Edwards et al. (2018)			X					X	Yes	
Gray literature	Britz et al. (2019)			X						Yes	
	ReFED (2016); centralised composting	X	X	X		X				Yes	
	ReFED (2016); centralised anaerobic digestion	X	X	X		X				Yes	
	ReFED (2016); co-digestion	X	X	X		X				Yes	
	ReFED (2016); consumer education campaign					X			X	Yes	
	ReFED (2016); manufacturing line optimization			X						Yes	
	ReFED (2016); manufacturing byproduct utilization			X						Yes	
	ReFED (2016); imperfect & surplus produce channels	X	X							Yes	
	ReFED (2016); donation education	X	X	X		X	X		X	Yes	
	ReFED (2016); standardised data labels			X						Yes	
	UNEP (2024)	X	X	X	X	X	X	X	X	Yes	Yes
	OR DEQ (2017)			X		X		X	X	Yes	
	FAO (2019)										Yes
	Hanson & Mitchell (2017); UK								X	Yes	
	JRC (2019); surplus food redistribution	X		X		X	X			Yes	
	JRC (2019); surplus food redistribution					X				Yes	
	JRC (2019); surplus food redistribution					X				Yes	
	JRC (2019); surplus food redistribution					X				Yes	
	JRC (2019); surplus food redistribution					X				Yes	
	JRC (2019); awareness/educational campaign						X			Yes	
	JRC (2019); awareness/educational campaign						X			Yes	
	JRC (2019); awareness/educational campaign	X								Yes	
	JRC (2019); imperfect product sale						X			Yes	
	JRC (2019); process innovation			X		X	X			Yes	
	Flanagan et al. (2019)										Yes
Private initiatives	Hanson & Mitchell (2017); RoW			X	X	X	X		X	Yes	Yes
	IFWC (2022); demand forecasting tool						X	X		Yes	
	IFWC (2022); demand forecasting tool						X			Yes	
	IFWC (2022); demand forecasting tool						X			Yes	
	IFWC (2022); measuring and reporting					X	X			Yes	
	IFWC (2022); measuring and reporting						X			Yes	
	IFWC (2022); measuring and reporting						X			Yes	

Notes: Stages codes: S.0 : all stages, S. 1. Primary agricultural production (on farm), S. 2. Agricultural handling and storage (post-harvest) S. 3. Food processing and packaging S. 4. Wholesale S. 5. Retail S. 6. Hospitality and food services S. 7. Public food procurement, including public schools S. 8. Private households.
Source: OECD.

Annex C. Methodological approach to estimating costs of reducing FLW and preliminary results

Relationship between the cost and the level of FLW

When studying the costs and effects of reducing FLW through different interventions it is worth noting that the former might not necessarily be constant as the latter is reduced. In fact, it could well be that, as different policies start to contribute to the reduction in the share of food that is lost or wasted, the low-cost initiatives that may be initially relatively abundant (the so-known "low hanging fruits") could start to run out, leaving only availability for more costly ones if lower levels of FLW want to be further reduced. Consequently, the hypothesis is that cost per tonne of FLW reduction will increase with an increasing level of reduction.

Taking advantage of the data collected from the literature review, this relationship was tested. This is formally done by estimating the regression equation below through OLS:

$$cost_{i,t} = \beta_0 + \ \beta_1 \log FLW_{i,t} + \gamma' X_{i,t} + \alpha_i + \tau_t + \varepsilon_{i,t}$$

Where $cost_{i,t}$ represents the cost of reducing one tonne of FLW (in USD) for country i at year t; $FLW_{i,t}$ is the average share of FLW (obtained from the FAO Food Loss and Waste database);[10] $X_{i,t}$ is a vector of covariates including food supply chain stage dummies, a binary variable taking value 1 if the initiative was private-driven and 0 otherwise, the log of GDP per capita (in real terms and adjusted to purchasing power parity, obtained from World Bank data), and fixed effects controlling for the source where the reference of each cost estimate was taken from; α_i and τ_t are country and time fixed effects, respectively; and $\varepsilon_{i,t}$ is the error term.

Note that finding a value of $\beta_1 < 0$ would imply that costs of reducing FLW increase as countries reduce their levels and approach to zero. The main motivation for performing this empirical exercise is so that it can be included in the Aglink-Cosimo modeling framework to adjust costs recursively every year as FLW is reduced more and more. Table A C.1 below shows the OLS results.

[10] In cases where data was not available for a given year, the value of the nearest available year or the average between the two nearest surrounding years were taken as the reference.

Table A C.1. Determinants of FLW reduction costs

	(1)	(2)	(3)	(4)
VARIABLES	Cost per tonne	Cost per tonne	Cost per tonne	Cost per tonne
Log FLW	-0.547***	-25.19***	-27.24***	-18.99***
	(1.11e-05)	(3.208)	(3.917)	(4.540)
Stage 1		187.8	237.2	237.2
		(254.8)	(234.1)	(234.1)
Stage 2		-541.1**	-378.5	-378.5
		(229.2)	(261.6)	(261.6)
Stage 3		-86.02	-120.1	-120.1
		(255.5)	(238.5)	(238.5)
Stage 4		-2,194*	-1,437	-35,180***
		(1,246)	(1,379)	(11,867)
Stage 5		120.5	107.6	107.6
		(225.8)	(222.1)	(222.1)
Stage 6		-139.5	-94.12	-94.12
		(206.9)	(204.7)	(204.7)
Stage 7		-1,958***	-2,120***	-2,059***
		(254.8)	(311.1)	(308.1)
Stage 8		-510.0**	-337.8	-337.8
		(204.2)	(204.9)	(204.9)
Private sector			212.0	212.0
			(168.9)	(168.9)
Log GDP per capita				56.95***
				(20.98)
Constant	2,525***	-5,631***	-6,705***	-35,460***
	(524.0)	(1,046)	(1,496)	(11,181)
Observations	89	89	89	89
R-squared	0.861	0.879	0.884	0.884
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Source FE	Yes	Yes	Yes	Yes

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Source: OECD.

Some key messages from these results are: (1) countries with higher values of FLW are correlated with lower costs of reduction, suggesting increasing costs as FLW shares are reduced, with a 1% decrease in the latter being associated with about USD 19 per tonne of additional costs; (2) costs do not seem to differ significantly across different stages of the supply chain (except for the wholesale and public procurement stages) or between public- and private-driven initiatives; and (3) the model accounts for more than 88% of the variation in costs. It should however be noted that the sample size (89 data points) is small. Initial cost estimates for Aglink-Cosimo regions

Besides this adjustment coefficient that increases costs as FLW is reduced, initial values of costs per tonne are needed for all the different countries and regions that are included in the Aglink-Cosimo model. These are calculated as the predicted values obtained from a simpler regression that was estimated using GDP per capita and a dummy variable taking a value of one if the region is developing and zero otherwise as explanatory variables while controlling for year and source fixed effects.[11] The sample that was used also excludes some outlier observations that may bias the predictive results.[12] The GDP per capita data that was used to predict the values is that from Aglink-Cosimo for the year 2023 (right before any initiative has been put in place and any FLW has been reduced, i.e. it represents an implicit cost).

The initial cost estimates normalised as USD per tonne of FLW diverted for every Aglink-Cosimo region are presented in Table A C.2:[13] These costs can only be presented as averages and not product specific due to the small sample size.

Table A C.2. Predicted estimates of average costs of reducing FLW (USD/tonne)

Region	Cost per tonne (USD)	Region	Cost per tonne (USD)	Region	Cost per tonne (USD)
AFL	97.04	UKR	73.47	CHN	212.55
CAN	526.68	EUE	440.78	IND	118.85
USA	545.74	AUS	534.42	IDN	154.86
ARG	5.02	NZL	518.88	KOR	507.58
BRA	172.57	OCE	387.74	MYS	213.71
CHL	214.70	ANL	101.95	PAK	60.40
COL	165.81	AFN	176.52	PHL	151.38
MEX	203.04	EGY	85.93	THA	189.67
PRY	168.68	ETH	11.19	VNM	146.51
PER	180.13	NGA	72.77	ASA	256.72
SAC	181.85	ZAF	401.33	ASL	118.97
EUN	514.52	AFS	142.54	NEO	207.86
GBR	520.87	JPN	514.75	IRN	200.07
NOR	542.69	KAZ	410.35	SAU	254.77
CHE	571.32	ISR	531.70	TUR	109.33
RUS	179.70	ASC	408.33		

Source: OECD.

Cost and benefits as a function of FLW reduction

As mentioned in the previous Annex, interventions aimed at reducing FLW are likely to imply costs. Nevertheless, it is also rather evident that the latter would also yield benefits. The most obvious example for this is that reducing the amount of food that would be lost or wasted saves economically valuable goods. It is also important to note (as is discussed in the main text) that additional hidden benefits and costs like those attributed to the minimization of negative externalities or the potential economic spillover and trade-offs that may impact different sectors of the economy would also be expected to arise from reducing FLW.

[11] Regions considered as "developing" or "developed" follows the Aglink-Cosimo classification, see OECD/FAO (2024[8]).

[12] These outliers tended to come from volunteering initiatives found in JRC (2019[15]) which included as total costs the number of hours worked by individuals who volunteered multiplied by each country's minimum hourly wage as a reference opportunity cost of time measure.

[13] Note that an implicit assumption in this approach is that costs are the same for all products, that is, it is equally costly for a given country to reduce a ton of FLW of any commodity.

Despite all these considerations, both costs and benefits can formally be defined as functions of FLW reduction ($F\dot{L}W$)[14] in the following way: $c(F\dot{L}W)$ and $b(F\dot{L}W)$, respectively. The basic assumptions regarding the functional form of these expressions would be: $\frac{\partial c}{\partial F\dot{L}W} > 0$; $\frac{\partial^2 c}{\partial F\dot{L}W^2} > 0$; $\frac{\partial b}{\partial F\dot{L}W} > 0$.[15] Where costs are convex and assumed to increase asymptotically in FLW reductions towards the maximum value that would represent zero level of FLW, while benefits are only assumed to increase in the reduction of FLW.[16]

For costs to exhibit such relationship with respect to FLW reduction, the first assumption specified above necessarily implies that policymakers and social planners will always choose the cheapest available reduction intervention or policy for any given level of FLW (i.e. they will start with the “low-hanging fruits” before investing in more costly interventions). This ensures that the cost curve is monotonically increasing in FLW reduction.

[14] This notation for FLW reduction implies $F\dot{L}W = -\Delta FLW$.

[15] Technically, an additional assumption regarding the second derivative of costs and benefits with respect to $F\dot{L}W$ is necessary: $\frac{\partial^2 c}{\partial F\dot{L}W^2} > \frac{\partial^2 b}{\partial F\dot{L}W^2}\ \forall\ 0 \leq F\dot{L}W \leq 1$. This means that marginal benefits are assumed to grow less than the marginal costs as FLW is reduced for the entire domain of FLW reduction. This is a necessary condition for equilibria to arise. It is innocuous.

[16] Note that, although most results from the Aglink-Cosimo scenario analysis seem to suggest that benefits tend to increase linearly in FLW reduction, concave benefit curves may be possible in some cases. If this was also to be included as an assumption to this theoretical framework, it would imply the following: $\frac{\partial^2 b}{\partial F\dot{L}W^2} < 0$. Figure C.1 was set to exemplify this model following the aforementioned functional form. This additional assumption, however, does not alter the results of the theoretical derivation in this section and would not add further explanatory power. For this reason, it was not included as a necessary assumption.