Food and Agriculture
Organization of the
United Nations

Repurposing food and agricultural policies to deliver affordable healthy diets, sustainably and inclusively: what is at stake?

Background paper for *The State of Food Security and Nutrition in the World 2022*

FAO AGRICULTURAL DEVELOPMENT ECONOMICS
WORKING PAPER 22–05

ISSN 2521-1838

Repurposing food and agricultural policies to deliver affordable, healthy diets, sustainably and inclusively: what is at stake?

Background paper for *The State of Food Security and Nutrition in the World 2022*

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Rome, 2023

Required citation:

Glauber, J. & Laborde, D. 2023. *Repurposing food and agricultural policies to deliver affordable healthy diets, sustainably and inclusively: what is at stake?* Background paper for *The State of Food Security and Nutrition in the World 2022*. FAO Agricultural Development Economics Working Paper 22-05. Rome, FAO. https://doi.org/10.4060/cc4348en

ISSN 2664-5785 [Print]

ISSN 2521-1838 [Online]

ISBN 978-92-5-137641-6

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Abstract

The analysis presented in this report examines the impacts of repurposing food and agricultural fiscal support and border support on several key socioeconomic, nutritional and climate indicators. The impacts are estimated at the global level, as well as for various income groups and geographic regions. Scenarios include repurposing fiscal support to producer support targeted to high-priority foods (those where current levels of consumption are below that of recommended levels) and to consumer subsidies targeting high-priority foods.

Several conclusions are drawn from the analysis:

- The affordability of healthy diets improves under all repurposing scenarios, but repurposing fiscal subsidies towards consumer subsidies is far more effective in increasing the affordability of healthy diets than redistributing fiscal subsidies to producer fiscal support that is more targeted to high-priority foods.
- Impacts on the affordability of healthy diets are least in the high-income countries (HICs) and low-income countries (LICs). In the case of the HICs, the percent of population that can afford a healthy diet is already quite high. In the case of LICs, those countries have fewer fiscal subsidies to repurpose.
- The costs of healthy and actual diets are estimated to increase marginally in LICs under the consumer subsidies scenarios because of increased import demand in the rest of the world (due to consumer subsidies) whereas in the LICs, there are limited fiscal subsidies to repurpose.
- Repurposing scenarios that are targeted towards high-priority food groups have greater impact on healthy-diet affordability. In general, repurposing fiscal support towards consumer subsidies has the largest impact on the per capita consumption of food groups.
- Repurposing fiscal support towards consumer subsidies reduces total agricultural greenhouse gas (GHG) emissions, but those targeted towards producer support are estimated to increase GHG emission in low- and middle-income countries.
- Global farm income falls under all of the repurposing scenarios except for the targeted removal of border measures. Farm income falls across most income groups, with the largest impact seen in the HICs. The exception is the LICs, where fiscal subsidies are small and producer income is estimated to increase with increased global demand. Not surprisingly, farm income declines are largest for those scenarios where repurposed fiscal support is applied towards consumer subsidies.

Keywords: nutrition, healthy diets, agricultural support, vulnerability, sustainability, household income, poverty

JEL codes: D10, Q18, I32, O54

Acknowledgements

The authors would like to thank colleagues and friends for their contributions. In particular, we would like to thank Marco V. Sánchez, Cindy Holleman and Valentina Pernechele of the Food and Agriculture Organization of the United Nations (FAO) Agrifood Economics Division (ESA), for their comments and inputs and Abdullah Mamun, Senior Research Analyst at the International Food Policy Research Institute (IFPRI), for his work on the database used in this project, as well as all the members of the Ag-Incentives consortium.

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Finally, we would like to thank Dianne Berest for copyediting the paper and Daniela Verona (ESA, FAO) for her editorial and layout support, as well as publishing coordination.

1 Introduction

To end hunger and ensure access by all people to safe, nutritious and sufficient food all year round and end all forms of malnutrition (SDG targets 2.1 and 2.2) by 2030, nutritious foods must be widely available, and everybody should be able to afford and consume them in the amounts and combinations necessary to enjoy a healthy diet. Nonetheless, as shown in *The State of Food Security and Nutrition in the World 2022* (FAO *et al.*, 2022), we are not on track to meet these targets. After declining for decades, the prevalence of undernourishment (PoU) in the world has risen over the past five years. In 2020, the income of almost 3.1 billion people was insufficient to cover the least-cost version of a healthy diet. The COVID-19 pandemic has made the situation worse, as it contributed to economic recessions around the world. This has led to higher unemployment and lower earnings and incomes, which has negatively affected the quantity and quality of foods consumed by billions of people. Food prices and inflation have increased in the past year because of bottlenecks in supply chains, soaring transport costs and other disruptions caused by the COVID-19 pandemic, and now the war in Ukraine threatens to increase prices further and increase humanitarian needs in Ukraine and neighbouring countries. FAO simulations estimate that the global number of undernourished people could increase by 7.6 to 13.1 million people in 2022/23, with the most pronounced increases taking place in sub-Saharan Africa, followed by the Near East and North Africa (FAO *et al.*, 2022).

If we are to meet the targets of SDG 2 by 2030, we must transform our agrifood systems and ensure they are fit to deliver lower-cost, nutritious foods that make healthy diets more affordable for all, sustainably and inclusively – as highlighted in past editions of *The State of Food Security and Nutrition in the World* report (see, for example, FAO *et al.* [2021]). There are several entry points to do this, but the current recessionary context also means resources are not widely available – certainly not for many low- and middle-income countries – to massively invest in agrifood systems at this time. Furthermore, given the increase in hunger, food insecurity and malnutrition of the past years – even before the pandemic, the food and agricultural policies in place and the resulting incentives may no longer be delivering increasing marginal returns.

Deciding how food and agricultural policy support could be reformed to achieve better results will require an examination of the evidence on the trade-offs implied by different mixes of such reforms all along the food supply chain and in terms of consumer behaviour, in order to strike a proper balance across all dimensions of food security, nutrition and sustainable-development objectives. Policies will need to be repurposed in a way that: (i) improves agrifood system efficiency by providing healthy diets at the lowest cost, with fairness for all agrifood system actors; (ii) increases the availability and reduces the cost of nutritious foods, thus increasing the affordability of and access to healthy diets for all; and (iii) provides strong incentives to reduce GHG emissions and adapt to climate change, while using natural resources sustainably. Nonetheless, repurposing food and agricultural policy support will not be free of trade-offs; therefore, mitigation measures such as social protection may be needed to avoid unintended consequences, especially for those most vulnerable to the changes during the transition. Furthermore, country context matters. Repurposing food and agricultural policy support (and complementing policies within and outside agrifood systems) will need to be tailored to the unique structural characteristics of the countries, including their income status, natural resource endowments, net trade position, and food security and nutrition situation, as well as political economy considerations.

Recent studies (for example, FAO, UNDP and UNEP [2021]; Laborde *et al.* [2021]; and Laborde Debucquet *et al.* [2020]) have analysed the impacts of removing agricultural support on a variety of indicators measuring food security, nutrition and climate outcomes.[1] A key finding of these studies is that removing agricultural support may have important adverse trade-offs. For example, the FAO/UNDP/UNEP study found that if agricultural fiscal subsidies were eliminated globally, there would be a reduction in agricultural production, resulting in fewer inputs (for example, of previously subsidized agrochemicals) and land use (cropland and pastureland), helping to preserve nature and cutting emissions by an estimated 11.3 million tonnes of CO_2e by 2030 (FAO, UNDP and UNEP, 2021). However, this would likely hit consumers with higher food costs for a healthy diet and hurt farm incomes, especially for female-headed households and poorer households dependent on subsidies. The decline in farm income from a removal of agricultural subsidies, if not compensated, would push a small portion of the population in developing countries into extreme poverty, thus increasing the prevalence of undernourishment.

Gautam *et al.* (2022) examined redirecting agricultural support towards more public spending on research and development (R&D), and incentives for the development and adoption of green innovations. They concluded that assuming historical productivity gains, a redirection of support towards R&D could yield a 30 percent increase in production and a 30 percent reduction in emissions per unit of output. They acknowledge, however, that impacts could be smaller if marginal productivity gains are smaller than what was achieved over the past 60 years.

Similarly, Springmann and Freund (2022) found that removing agricultural subsidies could be economically and environmentally beneficial, but could negatively impact population health. In contrast, the authors found that redirecting all subsidies to the production of foods with beneficial health and environmental characteristics could improve population health and reduce GHG emissions, but have negative economic impacts. Improved health and economic benefits could be found if repurposing of subsidies was combined with a global restructuring of subsidy levels according to GDP or population levels, but that would imply a large shift of subsidies from richer to poorer countries. Based on the above studies, the scope of repurposing food and agricultural policies could encompass a wide range of options. While this study will discuss a number of potential directions, a key feature will be the focus on the affordability of healthy diets, as defined in the 2022 edition of *The State of Food Security and Nutrition in the World* (FAO *et al.*, 2022).[2] The model applied in this paper provides detailed quantification of several model-based scenarios designed explicitly to assess opportunities and challenges to use the repurposing of agricultural policy support to increase the affordability of healthy diets. The report will shed light on the relative effectiveness of achieving improved food security and nutrition outcomes through repurposing fiscal subsidies and border

[1] Other research, such as OECD (2021) and Searchinger *et al.* (2019) has discussed repurposing subsidies but have not quantified the impacts.

[2] Recent work by Hirvonen *et al.* (2020) examined the affordability of the diets based on the EAT–Lancet targets (Willett *et al.*, 2019) and found that improving diets is affordable in many countries but, for many people, would require some combination of higher income, nutritional assistance and lower prices.

measures towards more targeted food and agricultural policies, through targeted consumer subsidies or through redirecting fiscal subsidies towards general service expenditures. The paper also highlights the trade-offs between indicators and regional impacts.

The structure of the study is as follows: Chapter 2 presents the analytical framework of the study, including a discussion of the MIRAGRODEP modelling framework, the underlying data and the assumptions in the business-as-usual baseline. Chapter 3 examines the impact of removing agricultural fiscal support on food security, nutrition and sustainability. Chapter 4 and 5 consider several repurposing scenarios that target food and agricultural policies towards improved outcomes for food security, nutrition and sustainability. Chapter 6 considers trade-offs in more detail with an emphasis on the affordability of healthy diets. Chapter 7 discusses the impact on GDP in the repurposing scenarios. Conclusions are offered in Chapter 8.

2 Analytical framework

2.1 The MIRAGRODEP model

In its standard version, MIRAGRODEP is a recursive, dynamic competitive general equilibrium (CGE) model encompassing multiregions and multisectors. The core model is described in Bouët *et al.* (2022).

For the analysis described in this report, a CGE model has distinct advantages over partial equilibrium models focused on individual sectors or regions because it allows for the analysis of the effects of a policy change in an individual sector in a specific region (for example, the maize market in the Americas). This makes it possible to understand how that policy change affects not just maize production and consumption in the Americas, but also – through its link with trade – its global effects on the production and consumption of maize and other agricultural commodities. MIRAGRODEP also links the agriculture sector to the broader economy so that the impacts of policy changes in the agriculture sector on macroeconomic measures such as GPD, employment and balance of trade, can also be identified.

The model assumes perfect competition in each market. Even if this assumption could be considered strong, it reflects the long-term outcomes of competitive pressure on price transmissions and avoids relying on numerous "guesstimates" in order to calibrate a global model relying on alternative assumptions. In each country, a representative consumer maximizes a CES–LES (Constant Elasticity of Substitution–Linear Expenditure System) utility function, subject to an endogenous budget constraint, to generate the allocation of expenditures across goods and services. This functional form replaces the Cobb-Douglas structure of the Stone-Geary function (that is, LES) with a CES structure that retains the ability of the LES system to incorporate different income elasticities of demand, with those for food being typically lower than those for manufactured goods and services. The demand system is calibrated on the income and price elasticities estimated by Muhammad *et al.* (2017). Once total consumption of each good has been determined, the origin of the goods consumed is determined by another CES nested structure, following the Armington assumption of imperfect substitutability between imported and domestic products, among various groups of importers.

On the production side, demands for intermediate goods are determined through a Leontief production function that specifies intermediate input demands in fixed proportions to output. For the agriculture sector, we allow for explicit intensification by combining land and fertilizers through a CES function, to generate an "effective" land unit supply. Total value added is determined through a CES function of unskilled labour and a composite factor of skilled labour and capital. This specification assumes a lower degree of substitutability between the last two production factors. In agriculture and mining, production also depends on land and natural resources. Labour markets are differentiated by gender, assuming an imperfect substitution between male and female labour for each category of skills. Unskilled labour is imperfectly mobile between agricultural and non-agricultural sectors, according to a constant elasticity of transformation function. Land is also imperfectly mobile between agricultural sectors. Other natural resources, like fishing grounds or mining resources are sector-specific.

Capital in a given region, whatever its origin (domestic or foreign), is assumed to be obtained by assembling intermediate inputs according to a specific combination. The capital good is the same regardless of the sector. As stated previously, in this version, we assume that all sectors operate under perfect competition, there are no fixed costs, and price equals marginal cost.

The model dynamic is recursive: capital in year t+1 is based on capital of year t, increased by the previous year investment, and corrected for depreciation. Total factor productivity and labour supply follow an exogenous trend (see Muhammad *et al.* [2017] for details).

To assess the response to a policy change, the model includes three important assumptions: the external account closure, the government account closure, and the private account closure. The private account closure assumption concerns the savings–investment closure. The MIRAGRODEP model assumes that marginal propensity to save is constant such that variation in income leads to variation in savings, which brings a variation in investment to match savings. The external account closure concerns the assumption on the current account. In MIRAGRODEP, the real exchange rate is adjusted in such a way that the current account balance is stable as a percentage of global gross domestic product (GDP). The government or public account closure assumption concerns how the public balance is affected when subsidies are changed by the scenario. This study assumes that each government maintains its public balance constant and that, after a shock that reduces customs duties, an additional value added tax rate on final consumption (either negative or positive) is established in order to maintain real public expenses per capita constant, while the public budget balance is a constant percentage of GDP. With this assumption, the level of public services in each country is constant, and there is no variation in the public budget balance and no associated crowding-out effect on private investment. Still, there is a risk of increased welfare cost if a policy reform leads to increased public spending, that is, more spending on agriculture, or reduces consumption by private households, or both.

As for all models, the magnitudes of the results are highly dependent on the underlying assumptions of the model. Results should therefore be interpreted in a relative rather than absolute sense. For this reason, the emphasis in presenting the results is on the direction and relative magnitude of a given effect rather than the actual magnitude. As with any model, the results are best interpreted as indicative of the likely effects.

2.2 Data

The underlying database used for the analysis is pre-release 2 of the Global Trade Analysis Project (GTAP) v11 database for 2017, modified by International Food Policy Research Institute (IFPRI) for use in the MIRAGRODEP model. The standard structure of the GTAP database is described in Aguiar *et al.* (2019). The database includes 141 regions/countries and 65 products. It includes updated social accounting matrices for all individually specified countries and updated estimates of agricultural support measures based on measures of average domestic support provided by the Ag-Incentives database, adjusted to include the impacts on bilateral protection rates of major trade preferences.

We represent 23 countries/regions of the world in the model (see Annex 1). Some are composed of a single country, while some represent groups of countries with homogenous policies (such as the European Union), and others represent groups of countries with similar policies and/or agricultural specializations for which individual representation in the model would add computation time without altering significantly the situation in international markets. The final aggregation is built to balance the computational needs of the analysis and the level of heterogeneity among countries, both in terms of existing policies and consequences of the scenarios. For the sake of presenting various results, we group countries into various aggregates, either in terms of income level (World Bank classification) or regional groupings, as listed in Table 1.[3]

Table 1. Regional nomenclature and summary descriptive statistics, 2017

Region	Total support (Million USD)	Fiscal support (Million USD)	Nominal rate of protection (%)	Nominal rate of assistance (%)	Share in global support (%)			
					Agricultural value of production	Agricultural fiscal support	Agricultural producer support	Total support
World	633 697	243 224	6	16	100	100	100	100
BY INCOME GROUP								
High-income countries	304 742	123 296	9. 5	25.6	28	51	48	48
Upper-middle-income countries	304 639	83 070	10.5	18.6	46	34	56	48
Lower-middle-Income countries	23 064	36 458	-6.7	0.3	23	15	-4	4
Low-income countries	1 252	400	-3.4	0.2	3	0	-1	0
BY REGION								
Africa	1 470	718	-2.6	0.3	4	0	-1	0
Asia	378 763	119 314	8.2	17.9	57	49	63	60
Americas*	115 088	30 636	2.46	8.90	21	13	11	18
Latin America and the Caribbean**	18 755	6 857	1.2	3.1	10	3	3	3
Europe	135 171	91 439	4.96	24.09	16	38	26	21

Notes: Results for Central Asia, Western Asia, Oceania excluding Australia and New Zealand, and subregional breakdown in Europe are not included for the sake of relevance. * Americas includes high-income countries (HICs) in Latin America and the Caribbean (Chile, Panama, Trinidad and Tobago, and Uruguay), plus Canada and the United States of America. ** Latin America and the Caribbean includes all countries in this region except HICs which are included in the Americas group.

Source: Authors' elaboration, based on MIRAGRODEP model database.

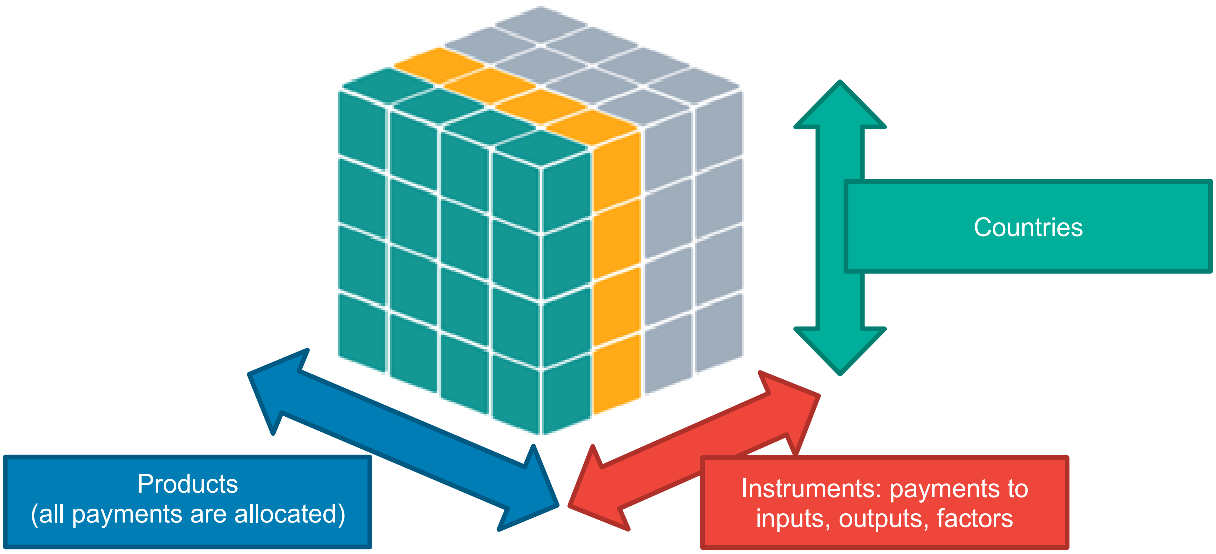
To calculate the impact of fiscal policies on GHG emissions, we utilize the GHG database developed by Laborde Debucquet *et al.* (2021), and updated with research by Tubiello *et al.* (2021), which maps GHG emissions to crop and livestock production, by region. In addition, the database is used to calculate GHG emissions due to land-use change, such as converting forestland to grazing land or cropland.

[3] While worldwide support for the food and agriculture sector accounted for almost USD 634 billion in 2017, on average it is around 630 billion a year over the period 2013–2018.

We represent farm policies through a set of detailed instruments: ad-valorem output subsidies, ad-valorem input subsidies, and various payments to production factors (subsidies to capital, labour and land),[4] based on the 2021 release of the Ag-Incentives database, which collects farm policy information from the Organisation for Economic Co-operation and Development (OECD), the World Bank, FAO and the Inter-American Development Bank (IDB). The resulting database covers close to 90 percent of world agricultural production in most years since 2005. A technical summary of the dataset is available in Annex 1 of FAO, UNDP and UNEP [2021]; non-product-specific spending is distributed among relevant products based on the agricultural value of production.

Figure 1 represents a data cube created for each country/region and for each year in the database. This setting allows the implementation of various constraints on any subset of the cube in this model. Adding values on the different dimensions of the data cube provides the values indicated in the Fiscal support column in Table 1.

Figure 1. Representation of the data on fiscal support to farmers in MIRAGRODEP



Source: Authors' own elaboration.

Other relevant agrifood system policies captured by the model include general services payments and consumer subsidies.[5] However, we do not remove any of these initial payments in any scenarios, while some can be augmented in some scenarios (see Section 3).

[4] The model could also accommodate ad-valorem per physical quantity, taxes and subsidies. However, in the baseline and scenarios detailed in this report, we use only ad-valorem representation of the various instruments. Sensitivity analysis has been conducted on this choice, and in the context of rising agricultural prices, as in our baseline, considering an ad-valorem instrument could reduce the relative impact of baseline policies.

[5] Such policies are aggregated from a number of sources, including the OECD agricultural support database.

2.1 Baseline assumptions

A baseline is constructed, which is aligned with the United Nations (UN) demographic projections and the updated International Monetary Fund (IMF) economic growth estimates (IMF, 2021), to bring the base year values (2017) to those of the actual years of simulation (2022–2026) and on to the comparisons between reference and simulated outcomes in 2030. Summary statistics for baseline projections are presented in Table 2.

Table 2. Baseline projections

Region	Annual growth rate 2019–2030 (%)					2030 level			
	GDP per capita	Agricultural value of production	Agricultural total factor productivity	Non-agricultural total factor productivity	Agricultural GHG emissions	Percent of population that is undernourished*	Percent of population for which a healthy diet is unaffordable	Healthy diets income gap	GHG emissions
World	3.5	1.4	1	2.6	1.5	6.7	35.8	17.5	10 538.0
BY INCOME GROUP									
High-income countries	2.2	1.2	0.8	1.7	0.6	0.7	0.9	0.0	2 288.7
Upper-middle-income countries	3.7	2.8	1.4	3.6	1.3	3.4	15.6	5.9	4 294.1
Lower-middle-income countries	4.1	3.1	0.7	3.1	2.1	9.7	62.1	31.5	3 245.8
Low-income countries	5.0	2.4	0.2	3.2	3.7	21.5	71.5	40.7	709.0
BY REGION									
Africa	4.8	1.3	0	2.2	3.1	19.4	77.0	45.6	1 588.9
Asia	3.9	2.7	1.4	3.3	1.6	4.2	32.8	13.9	5 395.6
Americas*	2.4	1.0	0.8	1.5	1.1	4.3	10.0	2.9	2 366.9
Latin America and the Caribbean**	2.5	0.9	1	1.7	1.3	6.7	14.9	4.6	1 541.8
Europe	2.0	1.3	1.3	2.1	0.4	0.2	0.9	0.1	1 186.2

Notes: * Americas includes high-income countries (HICs) in Latin America and the Caribbean (Chile, Panama, Trinidad and Tobago, and Uruguay), plus Canada and the United States of America. ** Latin America and the Caribbean includes all countries in this region except HICs which are included in the Americas group.

Source: Authors' own elaboration, based on MIRAGRODEP model database.

3 Impacts of removing agricultural support

This chapter examines the impacts of removing agricultural support measures on a number of indicators measuring food security and nutrition; equity, including regional impacts of the scenario on farm income and agricultural production; and climate measures, including changes in GHG emissions. Two scenarios are considered:

- **Removal of agricultural fiscal support**: All fiscal subsidies, including subsidies tied to inputs (such as fertilizer), outputs and factor payments are removed. Border measures (including tariffs, duties and export taxes) remain in place.
- **Removal of agricultural border measures:** All border measures affecting agricultural products are removed. Agricultural fiscal subsidies remain in place.

In both cases, the loss (for example, the removal of tariffs) or gains (such as the removal of subsidies) of public financial resources are compensated by endogenous changes in homogenous consumer taxes collected on every good and service in each region.

3.1 Presentation of the indicators

To gauge the impact of these scenarios we examine their impact on nine key indicators of food security and nutrition, equity and income, and climate.

Food security and nutrition indicators

- **Prevalence of undernourishment (PoU):** This indicator measures the percentage point change in the percent of population that is undernourished. Thus, a value of 0.30 means that the percent of the population of that region or economic group that is undernourished has increased by 0.30 percentage points (for example, from 10.0 percent to 10.3 percent). In this report, we use the "pseudo-PoU" approach embedded in the MIRAGRODEP framework, using a non-parametric measurement of undernourishment based on household surveys. It compares the average calories available for each household, based on its food purchases, compared to the minimal energy required by the household, considering its demographic composition. This approach differs from the parametric approach developed by FAO for the PoU indicators computed by the FAO statistics division. However, as shown during the collaborative efforts made by FAO and IFPRI to build the medium projections for PoU in *The State of Food Security and Nutrition in the World* report 2022 (see Figure 6 in FAO *et al.* [2022] for an illustration, and Annex 2 for a discussion), the two approaches generate highly correlated outcomes.
- **Affordability of a healthy diet:** This indicator measures the percentage point change in the percent of the population that can afford a healthy diet (Annex 3). Thus, a value of 0.30 means that the percent of the population of that region or economic group that can afford a healthy diet has increased by 0.30 percentage points (for example, from 10.0 percent to 10.3 percent).
- **Income gap in the affordability of a healthy diet:** This indicator measures the percentage point change in the average gap between the cost of a healthy diet and the food expenditures of the population that could not afford it, expressed in percentage terms of the cost of providing a healthy diet for everyone not able to afford it today. Thus, a value of 0.30 means that the cost of a healthy diet relative to the national average food

expenditure has increased by 0.30 percentage points (for example, from 10.0 percent to 10.3 percent).

Equity and income indicators

- **Population in extreme poverty (less than USD 1.9 per day)**: This indicator measures the percentage point change in the percent of population living in extreme poverty. Poverty measurement is based on a non-parametric approach using a microsimulation technique at the global level, as described in Laborde, Martin and Vos (2020).
- **Farm income**: This indicator measures the percent change in the real value added of the farm sector.
- **Agricultural production (volume):** This indicator measures the percent change in the volume of agricultural production.

Climate indicators

- **GHG emissions due to agricultural production in 2030:** This indicator measures the percent change in GHG emissions, where the GHG assessment follows the IPCC Tier 1 approach (see additional details in Laborde Debucquet *et al.* [2021]).
- **Land-use emissions due to land-use changes:** This indicator measures the percent change in emissions due to land use change (for example, the conversion of forests and rangeland to cropland), cumulative for the period 2025–2030.
- **Total GHG emissions from agriculture, including land-use changes:** This indicator measures the percent change in the total cumulative value of GHG emissions from agriculture over five years (2025–2030). Note that for this total value, both production and land emissions are cumulative over five years, and could not be directly compared with the first indicator (GHG emissions due to agricultural production in 2030).

3.2 Estimated impacts of agricultural fiscal support scenario

From Table 1, agricultural fiscal support is estimated to be over USD 243 billion in 2030. About half that amount is provided to producers in HICs, another one third to producers in upper-middle-income countries (UMICs), and about one sixth of that total is provided to producers in lower-middle-income countries (LMICs). By contrast, almost no fiscal support is provided to farmers in LICs.

Removing fiscal subsidies has negative effects on farm income and production in all but the LICs (Table 3). Not surprisingly, the largest effects on farm income and production are in the HICs, where farm income is estimated to fall in 2030 by 18 percent from baseline levels and agricultural production is estimated to fall by 1.5 percent. Farm income in UMICs and LMICs is estimated to fall by 5 percent and 2 percent, respectively, from baseline levels. The drop in global agricultural production is estimated to raise agricultural prices, resulting in a small increase in agricultural production (up 0.12 percent) and farm income (up 0.5 percent) in LICs.

Table 3. Impact of the removal of agricultural fiscal support, changes from the baseline, 2030

Region	Food security and nutrition			Equity			Climate		
	Prevalence of undernourishment	Affordability of a healthy diet	Income gap in the affordability of a healthy diet	Extreme poverty (less than USD 1.90 per day)	Farm income	Agricultural production (volume)	Agricultural production emissions	Land-use emissions	Total GHG emissions from agriculture
World	0.08	-0.15	0.14	0.05	-6.27	-0.64	-1.14	-1.26	-0.94
BY INCOME GROUP									
High-income countries	0.01	-0.04	0.00	0.01	-18.17	-1.48	-2.87	-2.82	-2.23
Upper-middle-income countries	0.06	-0.08	0.05	0.01	-5.07	-0.46	-0.76	-2.55	-1.00
Lower-middle-income countries	0.13	-0.28	0.31	0.13	-2.06	-0.33	-0.75	0.47	-0.47
Low-income countries	0.06	-0.08	0.06	-0.02	0.49	0.12	0.35	6.44	1.72
BY REGION									
Africa	0.07	-0.06	0.05	-0.04	0.33	0.09	0.27	3.04	0.78
Asia	0.09	-0.20	0.21	0.10	-5.15	-0.51	-0.93	-1.30	-0.86
Americas*	0.07	-0.16	0.06	0.01	-6.79	-0.75	-0.66	-4.31	-0.76
Latin America and the Caribbean**	0.11	-0.23	0.23	0.02	-1.74	-0.36	-0.37	-5.68	-0.53
Europe	0.01	-0.04	0.00	0.01	-24.68	-2.08	-4.95	-5.07	-3.80

Notes: * Americas includes high-income countries (HICs) in Latin America and the Caribbean (Chile, Panama, Trinidad and Tobago, and Uruguay), plus Canada and the United States of America. ** Latin America and the Caribbean includes all countries in this region except HICs which are included in the Americas group. Results for the policy scenario are reported as percentage point changes from the baseline scenario in 2030 for food security and nutrition indicators and extreme poverty, while results are reported as percentage change from the baseline scenario in 2030 for the other indicators.

Source: Authors' own elaboration, based on MIRAGRODEP model database.

The loss of farm income causes a 0.05 percentage point increase in the percent of global population with an income below the extreme poverty line. Most of that increase is expected to come in the LMICs (with a 0.13 percentage point increase), where a larger share of the population is below the poverty line than in UMICs and HICs. The percent of population below the extreme poverty line in LICs is estimated to decline marginally (a decrease by 0.02 percentage points).

Food security indicators worsen for all income groups under this scenario. The percent of population that is undernourished is expected to increase by 0.08 percentage points. This is due to both a decline in farm income in some LMICs in Asia and increased prices due to an estimated decline in production. The percent of the population that can afford a healthy diet is estimated to decline by 0.15 percentage points, with the largest declines in LMICs, where the percent of the population that can afford a healthy diet is expected to decline by 0.28 percentage points. Likewise, the affordability gap between the cost of a healthy diet and the food expenditures of the population that could not afford it increases by 0.14 percentage points globally.

The estimated decrease in agricultural production due to the removal of fiscal subsidies is expected to reduce total agricultural GHG emissions (including from land-use change) by 0.94 percent from baseline levels in 2030. Total agricultural GHG emissions fall by 2.23 percent in HICs, by 1 percent in UMICs and by 0.5 percent in LMICs. In LICs, increased agricultural production is expected to boost agricultural GHG emissions by 1.7 percent.

Removal of border measures increases agricultural imports, which can lower prices for consumers and producers in the importing countries, but raises prices for exporting countries as demand is boosted for their products. Removing agricultural support is estimated to cause global agricultural production to increase marginally, by about 0.02 percent (Table 4). Production in the HICs is expected to increase by 1.04 percent over baseline levels, but those increases are offset somewhat by estimated declines in the other income groups. The largest decline in farm income is estimated to be in the middle-income countries where, border support is more typically provided than fiscal subsidies. Likewise, the picture for farm income is also mixed. Removing border measures is estimated to increase farm income in the HICs by 7.98 percent but cause a reduction in the other income groups. Indeed, while producers in advanced economies will see a reduction in domestic prices for some commodities, the stronger level of production in middle- and low-income countries will provide them more export opportunities, especially on highly protected products (livestock). Globally, farm income is expected to rise by 0.28 percent over baseline 2030 levels. The percent of population in extreme poverty is estimated to be unchanged at the global level, with small increases in the LMICs (up 0.04 percentage points) offset by decreases in other income groups.

The percent of population that is undernourished is expected to decrease by 0.08 percentage points. This reflects, in part, the small increase in global farm income. Lower agricultural prices means that the affordability of healthy diets is estimated to increase and the income gap towards affording a healthy diet is estimated to shrink. Globally, the percent of the population for which a healthy diet is affordable is estimated to increase by 0.59 percentage points. Likewise, the income gap for households to be able to afford a healthy diet is estimated to decrease by 0.44 percentage points. The LMICs benefit the most from a removal of border measures. Lower prices through decreased border measures means the costs of a healthy diet declines. As a result, the percent of the population for which a healthy diet is more affordable is estimated to increase by 1.22 percentage points.

Table 4. Impact of the removal of border measures, changes from the baseline, 2030

Region	Food security and nutrition			Equity			Climate		
	Prevalence of undernourishment	Affordability of a healthy diet	Income gap in the affordability of a healthy diet	Extreme poverty (less than USD 1.90 per day)	Farm income	Agricultural production (volume)	Agricultural production emissions	Land-use emissions	Total GHG emissions from agriculture
World	-0.08	0.59	-0.44	0.00	0.28	0.02	-0.14	0.60	-0.01
BY INCOME GROUP									
High-income countries	-0.02	0.01	0.00	-0.01	7.98	1.04	2.08	10.00	3.05
Upper-middle-income countries	-0.06	0.23	-0.15	-0.03	-1.29	-0.30	-0.09	3.36	0.60
Lower-middle-income countries	-0.11	1.22	-0.91	0.04	-1.21	-0.23	-1.18	-10.68	-2.00
Low-income countries	-0.17	0.29	-0.34	-0.04	-0.41	-0.36	-2.50	-14.86	-5.03
BY REGION									
Africa	-0.13	0.33	-0.44	0.02	-0.22	-0.17	-2.94	-19.07	-5.70
Asia	-0.09	0.89	-0.60	0.00	-2.53	-0.57	-1.06	-3.55	-1.38
Americas*	-0.01	0.03	-0.01	-0.04	8.72	1.30	2.61	48.10	4.79
Latin America and the Caribbean**	-0.01	0.04	-0.02	-0.06	7.25	1.13	2.26	73.15	4.69
Europe	0.01	0.01	0.00	0.00	6.91	0.88	1.26	17.34	3.86

Notes: * Americas includes high-income countries (HICs) in Latin America and the Caribbean (Chile, Panama, Trinidad and Tobago, and Uruguay), plus Canada and the United States of America. ** Latin America and the Caribbean includes all countries in this region except HICs which are included in the Americas group. Results for the policy scenario are reported as a percentage point change from the baseline scenario for food security and nutrition indicators and extreme poverty, while results are reported as a percentage change from the baseline scenario for the other indicators.

Source: Authors' own elaboration, based on MIRAGRODEP model database.

Lastly, total agricultural GHG emissions are estimated to decline by almost 0.01 percent from baseline levels. Large declines are estimated for LMICs (down 2.0 percent) and LICs (down 5.03 percent). Increased agricultural production in the HICs is estimated to increase GHG emissions by about 3.05 percent from 2030 baseline levels.

4 Repurposing scenarios

We now consider repurposing agricultural support measures in order to reduce the prevalence of undernourishment, increase the number of people for whom a healthy diet is affordable, reduce the affordability gap for achieving a healthy diet, and reduce GHG emissions.

4.1 General discussion

In designing repurposing policies, a number of questions must be addressed, including the following:

- Should producer incomes be protected relative to the baseline? That is, if fiscal subsidies are removed, should individual producers be compensated through decoupled support? This would ensure that no one becomes worse off as a result of, repurposing but it would substantially increase budget costs. An alternative would be to target such compensation to low-income farmers (for example, through means testing). Such targeting would not fully compensate all farmers but would direct the compensatory payments in a more equitable manner.
- Should fiscal subsidies be kept budget-neutral at the country level relative to the baseline? This would likely create winners and losers, not just within countries but also across regions, as a change in fiscal subsidies in one country can impact trade and thus affect producer incomes in other regions.
- Should fiscal subsidies be kept budget-neutral for high-income countries while compensating producers in developing countries? As mentioned above, compensation may not be a credible option for poorer countries.

For the simulations that follow, compensation is assumed to be budget-neutral at the country level,[6] or group of countries (for instance, considering a constant European Union budget).

As the simulations presented in Chapter 3 showed, there are often trade-offs between performance indicators. A policy may have a positive impact on one goal (for example, a reduction of GHG emissions) while having a negative impact on another goal (for example, a decrease in farm income). Tinbergen (1952) stressed that an optimal policy was one that mapped a specific policy to a specific goal. But society often has multiple goals they attempt to achieve through a given set of policies. In the simulations that follow we try to understand the potential trade-offs but do not attempt to explicitly rank policies. When designing policy changes in the field of agrifood systems, not including specific regulations, four broad categories of policies can be considered, as follows:

- border measures: These include tariffs, taxes and duties that are applied towards imports and exports.
- producer fiscal subsidies: These include direct income support, such as input subsidies, production subsidies and subsidies tied agricultural factors such as land.
- consumer fiscal subsidies: These include payments or rebates to consumers that lower the effective purchase price of specific food items.

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[6] MIRAGRODEP lacks the modeling structure to analyze distributional issues based on farm size, so all analysis is done at the aggregate level of the country or country grouping, for instance the European Union.

- general government services: These include expenditures that support public goods, such as research and development, extension services and infrastructure.

Lastly, there is the question of targeting, considering the following aspects:

- Should incentives target producers or consumers? In repurposing agricultural fiscal subsidies we consider policies that would keep subsidies within the agriculture sector but redirect them to achieve certain goals (for example, making healthy diets more affordable). A second set of policies would redirect producer subsidies towards consumers to lower the costs of food purchases. A third set of policies removes border measures. Border measures affect both producers (of those commodities which receive border protection) and consumers (of products which receive border protection).
- What products should benefit? One option is to entirely decouple fiscal subsidies from production or consumption decisions. This would mean that production and consumption decisions would be affected only through income effects, in the sense that production and consumption are not linked to the subsidy itself. A second option would be to bias fiscal subsidies towards the production or consumption of specific products. For example, a producer of a nutritious product would be eligible for a subsidy, while a producer of a product high in energy but of minimal nutrition value would receive a far lower subsidy (or none at all). For border measures, we consider only a targeted scenario where border measures are reduced proportionate to how closely the baseline diet aligns with recommended dietary levels.

Under any option, there will be distributional issues as subsidies are redirected from one set of beneficiaries to another (see compensation discussion above).

Table 5 presents a scenario matrix for the simulations which follow. The simulations focus on the first three categories of policies and the trade-off in terms of targeting.

Table 5. Repurposing scenario matrix

		Degree of targeting towards product	
		Removing biased incentives	**Supporting nutritious products**
Targeting producers, consumers or both	Fiscal subsidies to producers	**Scenario 1a** Homogenous subsidy on farm gross income (same rate of subsidy across all farm commodities).	**Scenario 1b** Nutritious products are subsidized at ten times the average rate, and products of high energy density and minimal nutritional value are subsidized at half the average rate.
	Mixed approach: the role of border support and market price controls		**Scenario 1c** Border support is removed on nutritious products and not changed for products of high energy density and minimal nutritional value.
	Fiscal subsidies to consumers	**Scenario 2a** Consumer subsidies are provided at the same rate of subsidy across all food items.	**Scenario 2b** Nutritious products are subsidized at ten times the average rate, and products of high energy density and minimal nutritional value are subsidized at half the average rate.

Source: Authors' own elaboration.

In repurposing scenarios 1a and 1b, producer fiscal subsidies are redistributed among crop and livestock producers:[7]

- **Repurposing scenario 1a**: Fiscal support would be redistributed such that fiscal subsidies at the aggregate level would be unaffected, but all commodities would receive similar or same level of support on a percent of value of production (VoP) basis. No changes are made to border measures.
- **Repurposing scenario 1b**: Fiscal support would be redistributed such that fiscal cost remains constant, but that products where consumption levels are low relative to recommended dietary levels for that region would be subsidized at a higher rate than products where consumption levels are higher relative to the recommended dietary level.

In repurposing Scenario 1c, border measures are addressed.[8] Changes to border measures have direct impacts on prices for producers and consumers. Removal of border measures also has impacts on fiscal revenues (that is, lost tariffs and duties). Under this scenario, existing fiscal subsidies would remain in effect.

- **Repurposing scenario 1c**: Border measures would be reduced for products where consumption levels are low relative to recommended dietary levels for that region. Fiscal subsidies would be adjusted proportionately to account for lost tariff revenue, if any.

Scenarios 2a and 2b represent repurposing scenarios where producer subsidies are redistributed among consumers:

- **Repurposing scenario 2a:** Fiscal support would be redistributed towards consumer food subsidies. As with producer support, repurposed subsidies could be redistributed across food purchases equitably. Scenarios that target broad-based income subsidies to poorer households are not considered in this analysis.
- **Repurposing scenario 2b**: Redistributed fiscal subsidies would be targeted towards foods where consumption levels are low relative to recommended dietary levels for that region, which would be subsidized at a higher rate than products where consumption levels are higher relative to the recommended dietary level.

Subsidies for consumers are applied to the final consumption of goods (that is, food consumption by households), or to intermediate consumption by the food service industry (for instance, dairy products bought by restaurants).

Table 6 presents the level of targeting for each of the repurposing scenarios, according to whether foods are classified as high, medium or low priority. (The classification methodology is presented in Section 4.2).

[7] Producers in fisheries and aquaculture are not included due to data limitations.

[8] Fish products are an important component of diets. While they are included in Scenario 1c (border measures), they are excluded from scenarios 2a and 2b (consumer subsidies) to parallel the treatment of agricultural products in scenarios 1a and 1b (producer fiscal subsidies).

Table 6. Scenario parameters

Scenario	Targeted level of support based on nutritional category		
	High-priority foods	Medium-priority foods	Low-priority foods
Scenario 1a	Average level of fiscal subsidy	Average level of fiscal subsidy	Average level of fiscal subsidy
Scenario 1b	Ten times average level of support	Same level of support as in baseline	One-tenth of the average level of support
Scenario 1c	100 percent reduction in border support	50 percent reduction in border support	No change in border support
Scenario 2a	Average level of consumer subsidy	Average level of consumer subsidy	Average level of consumer subsidy
Scenario 2b	Ten times the average consumer subsidy	Average level of consumer subsidy	One-tenth of the average level of consumer subsidy

Source: Authors' own elaboration.

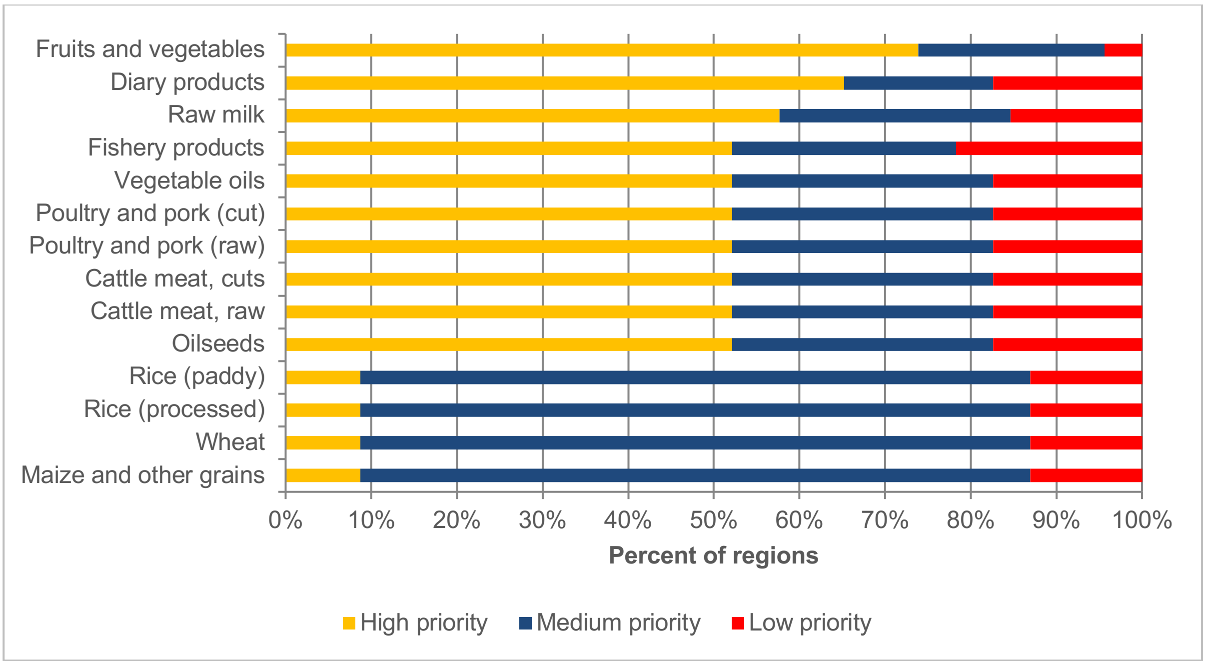
4.2 Classifying products in terms of nutritional deficiency

Classifying foods according to their nutritional value is critical in the scenario design. At the same time, there are no unique, objective, criteria for such classification. Finally, regional particularities, in terms of production practices, but also dietary habits and cultural preferences, should impact such definition.

For the purposes of the simulation analysis, agricultural products were classified based on the level of per capita consumption (adjusting for food loss) relative to the recommended diet for that country/region, as defined by FAO's food-based dietary guidelines used for the computation of the cost of healthy diets. Products whose average actual consumption level was less than 80 percent of the recommended level, were classified as high priority. Products whose actual level of consumption exceeded 120 percent of the recommended level of consumption, were characterized as low priority. And products with a per capita consumption of 80 and 120 percent of the recommended level, were characterized as medium priority.

Figure 2 shows the percent of regions for which a food group is classified as high, medium or low priority. Vegetables and fruits were identified as high or medium priority in over 95 percent of the regions analysed. Dairy and fishery products were also identified as key high- and medium-priority food groups. Low-priority food groups include vegetable oils in some regions. Grains, such as rice, wheat and maize, were classified most often as medium-priority food groups.

Figure 2. Classification of food groups based on per capita consumption relative to regional dietary guidelines



Source: Authors' own elaboration.

4.3 Impacts of the policy reforms across regions

Finally, scenarios are applied to all regions simultaneously. Initial policy heterogeneity will lead to heterogenous outcomes by region due to that region's unique set of policies and commodity mix, but also due to the indirect effects coming from third parties' reform. For example, a low-income country may have very limited fiscal subsidies to repurpose, but the impacts of global reform on that country's food security may be large, if such reform results in increased trade. Thus, indirect effects can have significant consequences (positive and negative) for a country even if the impact of repurposing their national or regional policies is minor.

4.4 Timing of introducing policy reforms

All the scenarios are assumed to be implemented in a linear way over the 2023–2028 period. Most policy impacts will be examined in 2030 to give sufficient time for policy changes to be implemented. Those impacts will be compared against baseline levels.

4.5 Consequences for the level of support

In Scenario 1c, for most countries, the combination of effects will lead to a slightly stronger reduction of support – compared to Scenario 1b – for products with high GHG emissions and low nutritional value, due to the reduction in budget space resulting from the loss of tariff revenue. At the same time, Scenario 1c will significantly reduce producer support for products with low GHG emissions and high nutritional value, compared to Scenario 1b, due to the direct effects of the loss of border support and the indirect impacts from lower tariff revenue. Globally, comparing net impact to the benchmark, for consumers, Scenario 1c leads to an unambiguous price reduction for low-GHG emitting, nutrient-rich foods.

5 Repurposing impacts on food security, nutrition and sustainability

This section presents the results of the five repurposing scenarios. In addition to the nine indicators discussed in Section 3, six more indicators are introduced that examine the impacts of repurposing scenarios on the cost of a healthy diet and on per capita consumption of broad food groups. Two measures are considered to measure the impact of the scenarios on the cost of healthy diets:

- **Cost of actual diet**: This indicator measures the percent change in the cost of the average diet based on the average national food expenditure.
- **Cost of a healthy diet**: This indicator measures the percent change in the cost of the healthy diet (as detailed in Annex 1).

In addition, four per capita consumption measures are examined:

- **Per capita consumption of dairy products:** This indicator measures the percent change in per capita dairy product disappearance, adjusted to account for food loss and waste.
- **Per capita consumption of animal fats and vegetable oils:** This indicator measures the percent change in per capita disappearance of fats and vegetable oils, adjusted to account for food loss and waste.
- **Per capita consumption of sugar and sweeteners:** This indicator measures the percent change in per capita disappearance of sugar and sweeteners, adjusted to account for food loss and waste.
- **Per capita consumption of fruits and vegetables:** This indicator measures the percent change in per capita disappearance of fruits and vegetables, adjusted to account for food loss and waste.

5.1 Impacts of repurposing support through homogenous producer fiscal subsidies

As indicated in Table 3, eliminating fiscal subsidies was estimated to result in a 6.3 percent decrease in global farm income. Redistributing fiscal support to provide equal subsidy rates across agricultural products is estimated to reduce farm income by about 1.2 percent from 2030 baseline levels (Table 7). The decline in farm income would occur across all country income levels and geographic regions, but would be most pronounced in the HICs where fiscal subsidies are largest and reflect lower cash receipts due to lower market prices. Agricultural production is estimated to increase in most income groups, except in the LICs where fiscal subsidies are minimal. The percent of the world population in extreme poverty would decrease marginally (0.02 percentage points). That percentage is estimated to fall in every income group except for the LICs (up 0.01 percentage points) and reflects the decline in farm income under the scenario.

Increased agricultural production levels are estimated to result in higher GHG emissions, up 0.49 percent globally. Total agricultural GHG emissions (including from the last use change) are estimated to increase over 1 percent in LICs.

The percent of global population that is undernourished is estimated to decline by 0.08 percentage points. The percent of the global population that can afford a healthy diet is estimated to increase by 0.35 percentage points. This increase is seen in every income group and for all geographic regions. The income gap between the cost of a healthy diet and the national average expenditures is estimated to decrease by 0.24 percentage points and that gap is estimated to decline across all income groups and regions.

Table 7. Impact of repurposing fiscal subsides to producers to support healthy diets, scenario 1a (homogenous fiscal subsidies), changes from the baseline, 2030

	Food security and nutrition			Equity			Climate		
Region	Prevalence of undernourishment	Affordability of a healthy diet	Income gap in the affordability of a healthy diet	Extreme poverty (less than USD 1.90 per day)	Farm income	Agricultural production (volume)	Agricultural production emissions	Land-use emissions	Total GHG emissions from agriculture
World	-0.08	0.35	-0.24	-0.02	-1.19	0.48	0.56	0.61	0.49
BY INCOME GROUP									
High-income countries	-0.01	0.16	-0.01	-0.05	-4.00	1.56	0.79	-4.19	-0.18
Upper-middle-income countries	-0.05	0.23	-0.10	0.00	-1.66	0.20	0.20	2.39	0.64
Lower-middle-income countries	-0.14	0.63	-0.49	-0.06	1.49	0.16	0.85	0.95	0.67
Low-income countries	-0.08	0.15	-0.17	0.01	-0.92	-0.24	0.56	2.85	1.03
BY REGION									
Africa	-0.04	0.11	-0.11	0.07	-1.01	-0.34	0.35	2.53	0.76
Asia	-0.11	0.50	-0.36	-0.07	-0.47	0.37	0.65	-0.45	0.27
Americas*	-0.05	0.26	-0.07	0.00	-2.20	0.03	0.37	16.40	1.35
Latin America and the Caribbean**	-0.07	0.39	-0.11	0.00	-1.70	-0.35	0.22	38.84	1.98
Europe	-0.01	0.15	-0.01	-0.03	-5.20	3.08	0.90	-7.76	-0.51

Notes: * Americas includes high-income countries (HICs) in Latin America and the Caribbean (Chile, Panama, Trinidad and Tobago, and Uruguay), plus Canada and the United States of America. ** Latin America and the Caribbean includes all countries in this region except HICs which are included in the Americas group. Results for the policy scenario are reported as percentage point change from the baseline scenario in 2030 for food security and nutrition indicators and extreme poverty, while results are reported as percentage change from the baseline scenario in 2030 for the other indicators.

Source: Authors' own elaboration, based on MIRAGRODEP model database.

The estimated decrease in agricultural prices under Scenario 1a is estimated to result in a 0.88 percent decline in the costs of average diets and a 1.85 percent decline in the cost of healthy diets (Table 8). When fiscal subsidies are distributed equitably across commodities, per capita consumption of fruits and vegetables is anticipated to increase by 1.1 percent. The impact on other food groups is more mixed, reflecting the shift in subsidies away from more heavily subsidized commodities like dairy.

Table 8. Impact of repurposing subsidies to producers to support healthy diets, scenario 1a (homogenous fiscal subsidies) on diet and consumption, percent changes from the baseline, 2030

Region	Dietary costs			Per capita consumption		
	Current diets	A healthy diet	Dairy products	Fats and oils	Sugar and sweeteners	Fruits and vegetables
World	-0.88	-1.95	-0.66	-0.19	-0.14	1.07
BY INCOME GROUP						
High-income countries	-1.07	-4.16	-0.59	-0.84	-1.20	1.56
Upper-middle-income countries	-0.83	-1.83	0.03	0.29	0.27	1.23
Lower-middle-income countries	-0.71	-1.44	-2.83	-0.52	0.27	0.58
Low-income countries	-0.58	-1.00	0.00	-0.18	-0.22	0.50
BY REGION						
Africa	-0.44	-0.79	0.26	-0.31	-0.22	0.36
Asia	-0.94	-1.87	-1.10	0.06	0.25	1.16
Americas*	-0.70	-2.33	-0.04	-0.25	0.08	1.17
Latin America and the Caribbean**	-0.54	-1.77	0.04	-0.08	-0.17	0.99
Europe	-1.26	-4.71	-0.91	-1.11	-2.08	1.85

Notes: * Americas includes high-income countries (HICs) in Latin America and the Caribbean (Chile, Panama, Trinidad and Tobago, and Uruguay), plus Canada and the United States of America. ** Latin America and the Caribbean includes all countries in this region except HICs which are included in the Americas group.

Source: Authors' own elaboration, based on MIRAGRODEP model database.

5.2 Impacts of repurposing support through targeted producer fiscal subsidies

We now consider Scenario 1b, which redistributes fiscal subsidies towards food groups that are under consumed relative to country dietary guidelines (Table 9 and Table 10). It is important to consider that most fiscal subsidies are provided in HICs and UMICs; thus, most of the direct impacts on farm income and production are expected to be felt in countries in those economic groups. Globally, farm income is estimated to decline by 0.94 percent and agricultural production is expected to increase by 0.27 percent (Table 9). As expected, farm income is estimated to decline by a greater amount in the HICs (down 3.3 percent) and UMICs (down 1.59 percent). Farm income is estimated to increase by almost 1.6 percent in LMICs but to decline by 0.8 percent in LICs. As in the previous scenario, the percent of the global population that is in extreme poverty is estimated to decline marginally (down 0.04 percentage points). Total GHG emissions are expected to increase by 1.5 percent, reflecting the increase in agricultural production.

The percent of the population that is undernourished is expected to decrease by 0.11 percentage points, and the decline is reflected in all economic groups and across all geographic regions. The percent of the global population for which healthy diets are affordable is expected to increase by 0.81 percentage points, while the income gap between the cost of a healthy diet and national food expenditures is expected to fall by 0.53 percentage points. Both of these impacts are more pronounced than under the previous scenario (where fiscal subsidies are equally distributed across commodities).

Table 9. Impact of repurposing subsidies to producers to support healthy diets scenario 1b (targeted fiscal subsidies), changes from the baseline, 2030

	Food security and nutrition			Equity			Climate		
Region	**Prevalence of undernourishment**	**Affordability of a healthy diet**	**Income gap in the affordability of a healthy diet**	**Extreme poverty (less than USD 1.90 per day)**	**Farm income**	**Agricultural production (volume)**	**Agricultural production emissions**	**Land-use emissions**	**Total GHG emissions from agriculture**
World	-0.05	0.81	-0.53	-0.04	-0.94	0.27	0.52	5.99	1.50
BY INCOME GROUP									
High-income countries	0.00	0.17	-0.01	-0.05	-3.29	1.53	-0.08	-2.52	-0.49
Upper-middle-income countries	-0.04	0.51	-0.19	0.00	-1.46	-0.19	1.46	7.16	2.64
Lower-middle-income countries	-0.08	1.52	-1.14	-0.09	1.59	0.10	-0.38	10.22	0.92
Low-income countries	-0.11	0.22	-0.26	-0.02	-0.80	-0.12	1.42	12.83	3.90
BY REGION									
Africa	-0.05	0.14	-0.15	0.06	-1.08	-0.32	1.00	10.72	2.86
Asia	-0.06	1.24	-0.83	-0.09	-0.31	0.00	0.90	5.41	1.90
Americas*	-0.07	0.45	-0.12	-0.01	-1.59	-0.04	0.61	23.54	1.98
Latin America and the Caribbean**	-0.10	0.67	-0.20	-0.01	-0.89	-0.26	-0.03	50.16	2.30
Europe	-0.01	0.17	-0.01	-0.03	-4.45	3.20	-1.95	-10.33	-2.90

Notes: * Americas includes high-income countries (HICs) in Latin America and the Caribbean (Chile, Panama, Trinidad and Tobago, and Uruguay), plus Canada and the United States of America. ** Latin America and the Caribbean includes all countries in this region except HICs which are included in the Americas group. Results for the policy scenario are reported as a percentage point change from the baseline scenario in 2030 for food security and nutrition indicators and extreme poverty, while results are reported as a percentage change from the baseline scenario in 2030 for the other indicators.

Source: Authors' own elaboration, based on MIRAGRODEP model database.

As with the preceding scenario, we now turn to examining how repurposing fiscal subsidies in a targeted manner affects dietary costs and per capita consumption (Table 10). The costs of actual diets and a healthy diet are both estimated to fall, but by targeting fiscal subsidies towards more high-priority foods, the cost of healthy diets are estimated to fall by proportionately more (almost 3 percent for the cost of healthy diets, versus a 0.6 percent drop in the cost of actual diets). Per capita consumption of fruits and vegetables increases by 1.5 percent at the global level and increases across all income groups and geographic regions.

Table 10. Impact of repurposing subsidies to producers to support healthy diets scenario 1b (targeted fiscal subsidies) on diet and consumption, percent changes from the baseline, 2030

Region	Dietary costs			Per capita consumption		
	Current diets	A healthy diet	Dairy products	Fats and oils	Sugar and sweeteners	Fruits and vegetables
World	-0.58	-2.97	-2.40	-0.94	-0.86	1.54
BY INCOME GROUP						
High-income countries	-0.85	-5.11	0.03	-1.47	-1.82	1.95
Upper-middle-income countries	-0.31	-2.33	-6.78	-1.73	-0.04	1.10
Lower-middle-income countries	-0.66	-3.19	0.78	1.19	-1.36	1.74
Low-income countries	-0.59	-1.29	-0.07	-0.57	-0.89	0.75
BY REGION						
Africa	-0.45	-0.94	0.05	-0.62	-0.51	0.49
Asia	-0.48	-3.14	-6.44	-0.61	-0.49	1.63
Americas*	-0.54	-3.52	0.00	-1.72	-1.13	1.79
Latin America and the Caribbean**	-0.52	-3.04	0.07	-1.72	-1.28	2.56
Europe	-1.02	-5.65	0.35	-1.62	-2.07	2.72

Notes: * Americas includes high-income countries (HICs) in Latin America and the Caribbean (Chile, Panama, Trinidad and Tobago, and Uruguay), plus Canada and the United States of America. ** Latin America and the Caribbean includes all countries in this region except HICs which are included in the Americas group.

Source: Authors' own elaboration, based on MIRAGRODEP model database.

5.3 Impacts of repurposing support through targeted border measures

We now consider the impacts of removing border measures on targeted foods that are designated as high priority (where actual consumption falls below 80 percent of recommended consumption levels for that region). As seen in Figure 2, in most regions, high-priority foods include fruits and vegetables, fish and dairy products. Removing border support for those commodities is estimated to decrease their prices in markets with high border protection. Increased imports mean higher domestic prices in exporting countries.

As shown in Table 11, removing and reducing border measures under Scenario 1c is estimated to have a small impact on global farm income (up 0.03 percent) and agricultural production (down 0.06 percent). For LICs and LMICs, where border measures account for a high share of total agricultural support, farm income effects are greater than the global average and are negative. Farm income in the LMICs is estimated to drop by 1.6 percent and in LICs by 0.6 percent. The impact on global poverty, as measured by the percent of population earning less than USD 1.90 per day, is estimated to be minimal at the global level. Small increases in LMICs are offset by declines in the other income groups.

Declines in global agricultural production contribute to an estimated 0.98 percent decline in global GHG emissions. Declines in GHG emissions are estimated to occur in all income groups except for the HICs (where agricultural production is estimated to increase by almost 0.4 percent).

Table 11. Impact of repurposing border measures to support healthy diets, scenario 1c (targeted border measures), changes from the baseline, 2030

	Food security and nutrition			Equity			Climate		
Region	Prevalence of undernourishment	Affordability of a healthy diet	Income gap in the affordability of a healthy diet	Extreme poverty (less than USD 1.90 per day)	Farm income	Agricultural production (volume)	Agricultural production emissions	Land use emissions	Total GHG emissions from agriculture
World	-0.08	0.64	-0.46	0.00	0.03	-0.06	-0.48	-3.86	-0.98
BY INCOME GROUP									
High-income countries	-0.01	0.00	0.00	-0.01	2.75	0.36	0.88	3.16	1.07
Upper-middle-income countries	-0.04	0.23	-0.14	-0.02	0.03	-0.13	-0.67	-3.52	-1.11
Lower-middle-income countries	-0.12	1.35	-0.97	0.03	-1.58	-0.29	-1.13	-12.14	-2.14
Low-income countries	-0.20	0.31	-0.37	-0.06	-0.81	-0.22	-0.50	-5.82	-1.81
BY REGION									
Africa	-0.12	0.33	-0.44	0.02	-0.33	-0.15	-2.08	-14.38	-4.25
Asia	-0.08	0.97	-0.64	0.00	-0.77	-0.27	-0.79	-4.20	-1.36
Americas*	-0.02	0.06	-0.02	-0.01	1.52	0.31	0.42	8.37	0.81
Latin America and the Caribbean**	-0.03	0.09	-0.03	-0.02	1.25	0.24	0.19	9.77	0.53
Europe	-0.01	0.00	0.00	0.00	3.99	0.45	0.91	4.37	1.28

Notes: * Americas includes high-income countries (HICs) in Latin America and the Caribbean (Chile, Panama, Trinidad and Tobago, and Uruguay), plus Canada and the United States of America. ** Latin America and the Caribbean includes all countries in this region except HICs which are included in the Americas group. Results for the policy scenario are reported as a percentage point change from the baseline scenario in 2030 for food security and nutrition indicators and extreme poverty, while results are reported as a percentage change from the baseline scenario in 2030 for the other indicators.

Source: Authors' own elaboration, based on MIRAGRODEP model database.

Removing border support for high-priority products such as fruits and vegetables, fish and dairy products is estimated to lower the percent of global population that is undernourished by 0.08 percentage points, with that percentage declining for all income groups and geographic regions. The percent of global population for which healthy diets are affordable is estimated to increase by 0.64 percentage points and the gap between the cost of healthy diets and average diets declines by almost 0.5 percentage points.

The costs of a healthy diet and of actual diets both decline under this scenario across all income groups, except for the HICs (Table 12). At the global level, the cost of actual diets are estimated to fall by 0.4 percent, while the cost of healthy diets are estimated to fall by over 1.7 percent. At the global level, the removal of border measures for high-priority foods is estimated to increase consumption of fruits and vegetables (up 0.5 percent), dairy products (up 0.4 percent) and fats and oils (up 2.9 percent).

Table 12. Impact of repurposing border measures to support healthy diets, scenario 1c (targeted border measure) on diet and consumption, percent changes from the baseline, 2030

Region	Dietary costs		Per capita consumption			
	Current diets	A healthy diet	Dairy products	Fats and oils	Sugar and sweeteners	Fruits and vegetables
World	-0.42	-1.73	0.36	2.94	-0.33	0.49
BY INCOME GROUP						
High-income countries	0.06	0.28	0.08	-0.30	-0.11	-0.20
Upper-middle-income countries	-0.38	-0.83	0.54	0.67	0.19	0.23
Lower-middle-income countries	-1.20	-3.43	0.68	9.80	-1.38	1.27
Low-income countries	-0.88	-1.69	1.70	22.39	-1.75	0.68
BY REGION						
Africa	-0.53	-1.58	1.82	9.99	-1.08	0.19
Asia	-0.84	-2.53	0.59	3.76	-0.38	1.17
Americas*	0.09	0.34	0.15	0.08	0.01	-0.36
Latin America and the Caribbean**	0.00	0.14	0.30	0.22	0.06	-0.37
Europe	0.19	0.51	-0.06	-0.44	-0.11	-0.18

Notes: * Americas includes high-income countries (HICs) in Latin America and the Caribbean (Chile, Panama, Trinidad and Tobago, and Uruguay), plus Canada and the United States of America. ** Latin America and the Caribbean includes all countries in this region except HICs which are included in the Americas group.

Source: Authors' own elaboration, based on MIRAGRODEP model database.

5.4 Impacts of repurposing fiscal subsidies with homogenous consumer subsidies

Scenario 2a considers redistributing fiscal subsidies from producers to consumers. Under this scenario, food is subsidized at an equivalent subsidy rate across all food categories.

Under Scenario 2a, farm income is estimated to fall by 4.2 percent from baseline levels (Table 13). The loss of fiscal support is partially offset by increased demand due to consumer subsidies. As a result, the drop in farm income under this scenario is less than the estimated 6.3 percent decline we saw from removing fiscal support with no repurposing (discussed in Section 3). Farm income declines across all income groups, except for the LICs, where farm income is estimated to increase by 1.1 percent. Agricultural production is estimated to fall by 0.23 percent from baseline levels, which results in an estimated 0.43 percent reduction in total agricultural GHG emissions (including land-use change). The percent of population living in extreme poverty is expected to increase by 0.08 percentage points globally and by as much as 0.16 percentage points in LICs.

Table 13. Impact of repurposing fiscal subsidies from producers to consumers to support healthy diets, scenario 2a (homogenous consumer subsidies), percent changes from the baseline, 2030

Region	Food security and nutrition			Equity			Climate		
	Prevalence of undernourishment	Affordability of a healthy diet	Income gap in the affordability of a healthy diet	Extreme poverty (less than USD 1.90 per day)	Farm income	Agricultural production (volume)	Agricultural production emissions	Land use emissions	Total GHG emissions from agriculture
World	-0.10	0.38	-0.21	-0.08	-4.18	-0.23	-0.59	-0.42	-0.43
BY INCOME GROUP									
High-income countries	-0.02	0.13	-0.01	-0.05	-16.01	-0.93	-1.93	-1.88	-1.44
Upper-middle-income countries	-0.07	0.50	-0.14	-0.03	-2.59	0.00	-0.15	-1.95	-0.51
Lower-middle-income countries	-0.15	0.01	-0.38	-0.15	-0.63	-0.13	-0.42	1.47	-0.12
Low-income countries	-0.11	-0.01	-0.05	-0.16	1.09	0.26	0.39	8.00	2.12
BY REGION									
Africa	-0.03	-0.01	-0.03	-0.12	0.81	0.23	0.34	4.44	1.12
Asia	-0.12	0.58	-0.32	-0.09	-2.73	-0.09	-0.35	-1.08	-0.46
Americas*	-0.11	0.32	-0.09	-0.05	-4.73	-0.33	-0.13	-0.29	-0.11
Latin America and the Caribbean**	-0.16	0.47	-0.15	-0.07	0.14	-0.01	0.01	0.61	0.04
Europe	-0.01	0.12	-0.01	-0.02	-22.54	-1.42	-3.86	-3.96	-2.88

Notes: * Americas includes high-income countries (HICs) in Latin America and the Caribbean (Chile, Panama, Trinidad and Tobago, and Uruguay), plus Canada and the United States of America. ** Latin America and the Caribbean includes all countries in this region except HICs which are included in the Americas group. Results for the policy scenario are reported as a percentage point change from the baseline scenario in 2030 for food security and nutrition indicators and extreme poverty, while results are reported as a percentage change from the baseline scenario in 2030 for the other indicators.

Source: Authors' own elaboration, based on MIRAGRODEP model database.

The percent of global population that is undernourished is estimated to fall by 0.10 percentage points under this scenario. The percent of population who can afford a healthy diet is estimated to increase by almost 0.4 percentage points and the gap in affordability between a healthy diet and the national average expenditure is estimated to drop by 0.2 percentage points.

Under Scenario 2a, the costs of actual diets and healthy diets are estimated to decline from baseline levels by 2 percent and 1.8 percent, respectively (Table 14), with declines seen across income groups and regions, except for the LICs and Africa. This is due, in part, to the fact that LICs have little fiscal subsidies to distribute. Thus, increased demand in other income groups (where consumer subsidies are larger) results in increased demand for imports from LICs, which raises prices. Likewise, per capita consumption of food groups generally increases under the scenario, except for LICs where per capita consumption levels for fats and oils, sugar and sweeteners, and fruits and vegetables are estimated to decline. Globally, however, per capita consumption is estimated to increase across all food groups.

Table 14. Impact of repurposing fiscal subsidies from producers to consumers to support healthy diets, scenario 2a (homogenous consumer subsidies) on diet and consumption, percent changes from the baseline, 2030

Region	Dietary costs		Per capita consumption			
	Current diets	A healthy diet	Dairy products	Fats and oils	Sugar and sweeteners	Fruits and vegetables
World	-1.98	-1.76	1.79	2.84	2.23	0.31
BY INCOME GROUP						
High-income countries	-3.02	-4.02	1.76	4.33	4.95	0.55
Upper-middle-income countries	-1.91	-2.39	1.40	2.49	1.63	0.64
Lower-middle-income countries	-0.72	-0.69	3.12	2.27	0.77	-0.17
Low-income countries	0.25	0.31	0.16	-1.03	-0.53	-0.17
BY REGION						
Africa	0.23	0.29	-0.02	-1.08	-0.83	-0.22
Asia	-1.88	-2.01	2.13	2.95	1.40	0.56
Americas*	-2.06	-1.82	0.97	0.69	2.92	-0.04
Latin America and the Caribbean**	-0.79	-0.65	0.58	-0.13	1.57	-0.38
Europe	-3.69	-4.75	2.58	6.14	7.04	0.88

Notes: * Americas includes high-income countries (HICs) in Latin America and the Caribbean (Chile, Panama, Trinidad and Tobago, and Uruguay), plus Canada and the United States of America. ** Latin America and the Caribbean includes all countries in this region except HICs which are included in the Americas group.

Source: Authors' own elaboration, based on MIRAGRODEP model database.

5.5 Impact of repurposing fiscal subsidies towards targeted consumer subsidies

Scenario 2b considers the impacts of repurposing fiscal subsidies towards consumer subsidies that target consumption of high- and medium-priority foods. Under this scenario, global farm income is estimated to fall by 3.7 percent and global agricultural production is estimated to fall by 0.2 percent (Table 15). Farm income in HICs is estimated to experience the largest relative drop, down 13.8 percent relative to the baseline. Farm income is estimated to fall in the UMICs and LMICs as well. Farm income in the LICs is estimated to increase by 1.6 percent. The global percentage of the population in extreme poverty is estimated to decrease by 0.06 percentage points, in part, reflecting increased farm income in the LICs.

Table 15. Impact of repurposing fiscal subsidies from producers to consumers to support healthy diets, scenario 2b (targeted consumer subsidies), changes from the baseline, 2030

	Food security and nutrition			Equity			Climate		
Region	Prevalence of undernourishment	Affordability of a healthy diet	Income gap in the affordability of a healthy diet	Extreme poverty (less than USD 1.90 per day)	Farm income	Agricultural production (volume)	Agricultural production emissions	Land use emissions	Total GHG emissions from agriculture
World	-0.05	0.77	-0.44	-0.06	-3.74	-0.20	-0.61	1.07	-0.18
BY INCOME GROUP									
High-income countries	-0.05	0.15	-0.01	-0.06	-13.84	-0.71	-1.85	-0.57	-1.16
Upper-middle-income countries	-0.04	0.84	-0.25	-0.04	-2.35	-0.02	-0.02	-1.40	-0.31
Lower-middle-income countries	-0.05	1.14	-0.85	-0.08	-0.85	-0.16	-0.67	5.77	0.21
Low-income countries	-0.14	0.05	-0.14	-0.22	1.61	0.36	0.30	8.85	2.26
BY REGION									
Africa	-0.03	0.03	-0.10	-0.15	1.13	0.30	0.33	5.39	1.31
Asia	-0.04	1.13	-0.66	-0.04	-3.02	-0.18	-0.42	-0.10	-0.28
Americas*	-0.12	0.81	-0.26	-0.10	-1.49	-0.02	0.00	5.75	0.38
Latin America and the Caribbean**	-0.18	1.21	-0.40	-0.13	2.63	0.30	0.14	9.93	0.55
Europe	-0.03	0.17	-0.01	-0.03	-21.56	-1.25	-4.00	-2.15	-2.64

Notes: * Americas includes high-income countries (HICs) in Latin America and the Caribbean (Chile, Panama, Trinidad and Tobago, and Uruguay), plus Canada and the United States of America. ** Latin America and the Caribbean includes all countries in this region except HICs which are included in the Americas group. Results for the policy scenario are reported as a percentage point change from the baseline scenario in 2030 for food security and nutrition indicators and extreme poverty, while results are reported as a percentage change from the baseline scenario in 2030 for the other indicators.

Source: Authors' own elaboration, based on MIRAGRODEP model database.

Lower agricultural production is associated with lower GHG emissions. As such, total agricultural GHG emissions are estimated to decline by 0.18 percent under this scenario.

The percent of global population that is undernourished is estimated to fall by 0.05 percentage points, declining across all income groups and regions. Under the scenario, the percent of population that can afford a healthy diet is estimated to increase by almost 0.8 percentage points and the percent gap between the costs of healthy diets and average diets is estimated to fall by 0.44 percentage points.

With consumer subsidies targeted towards high-priority food items, the cost of a healthy diet is estimated to fall by 3.34 percent (Table 16). The cost of actual diets is estimated to fall as well, down 1.51 percent from baseline levels. Because fiscal subsidies are relatively small in the LICs, consumer subsidies are also negligible under the scenario and are not sufficient to offset the rise in agricultural prices. Thus, the costs of actual and healthy diets are estimated to rise, by 0.44 percent and 0.20 percent, respectively.

Per capita consumption levels of dairy products, fats and oils, and fruits and vegetables are all estimated to increase globally, though there are regional differences due to differences in determining high-priority food items. The estimated impacts are largest for per capita consumption of fats and oils, particularly in Asia. This largely reflects lower per capital consumption levels of fats and oils in Asia compared to other countries (particularly, HICs).

Table 16. Impact of repurposing fiscal subsidies from producers to consumers to support healthy diets, scenario 2b (targeted consumer subsidies) on diet and consumption, percent changes from the baseline, 2030

Region	Dietary costs		Per capita consumption			
	Current diets	A healthy diet	Dairy products	Fats and oils	Sugar and sweeteners	Fruits and vegetables
World	-1.51	-3.34	2.95	25.27	-0.04	0.41
BY INCOME GROUP						
High-income countries	-2.46	-6.89	0.74	-5.11	5.24	0.86
Upper-middle-income countries	-1.33	-3.98	6.36	46.09	-1.52	-0.06
Lower-middle-income countries	-0.61	-2.07	1.59	14.82	-2.90	0.59
Low-income countries	0.44	0.20	0.41	-1.83	-1.05	-0.10
BY REGION						
Africa	0.35	0.23	0.22	-1.61	-1.26	-0.21
Asia	-1.42	-3.60	6.33	42.13	-2.44	0.03
Americas*	-1.23	-5.69	0.94	-1.60	0.56	0.78
Latin America and the Caribbean**	-0.54	-3.07	1.87	1.67	-0.79	1.94
Europe	-3.46	-6.24	0.78	-4.98	9.60	2.26

Notes: * Americas includes high-income countries (HICs) in Latin America and the Caribbean (Chile, Panama, Trinidad and Tobago, and Uruguay), plus Canada and the United States of America. ** Latin America and the Caribbean includes all countries in this region except HICs which are included in the Americas group.

Source: Authors' own elaboration, based on MIRAGRODEP model database.

6 Visualizing trade-offs

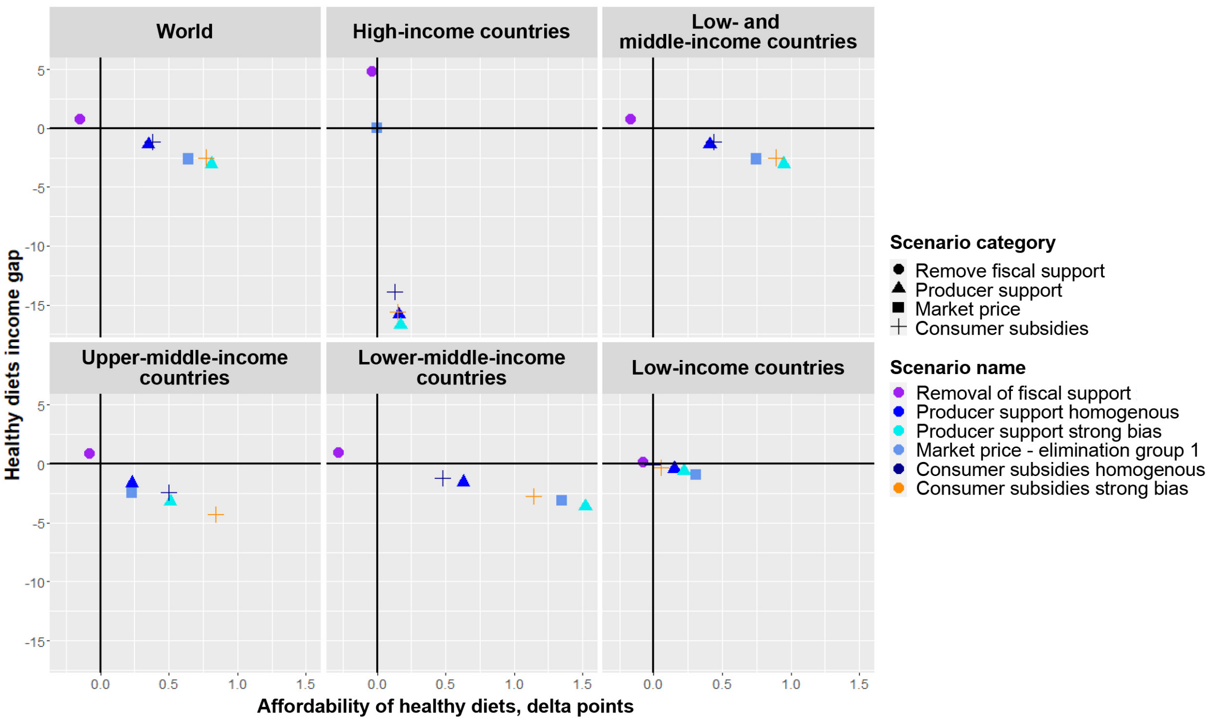
In this section, we discuss previous results through the lens of trade-offs, focusing on global impacts and impacts on specific income groups. Of key interest is the affordability of healthy diets and the cost of healthy diets. In the first set of figures, we analyse how the five repurposing scenarios affect the percent of population for which a healthy diet is affordable. Those results are compared to the impacts on other key indicators of food security, farm income, and climate. For comparison, we also include the scenario where fiscal support is removed (but not repurposed).

In the second set of figures, the focus shifts to the cost of a healthy diet relative to these indicators.

6.1 Undernourishment vs affordability of a healthy diet

Figure 3 shows the percentage point change in the percent of the population for which healthy diets are affordable and compares that to the percentage point change in the gap between the cost of a healthy diet and national average dietary cost. An increase in healthy diet affordability means a greater share of the population can afford a healthy diet. A decrease in the healthy-diet income gap means the gap between the costs of a healthy diet and the costs of the national average diet has declined. Figure 3 shows the impact for the five repurposing scenarios plus the scenario in which all subsidies have been removed. Separate figures are given for the world and various income groups.

Figure 3. Healthy diet income gap versus affordability of a healthy diet



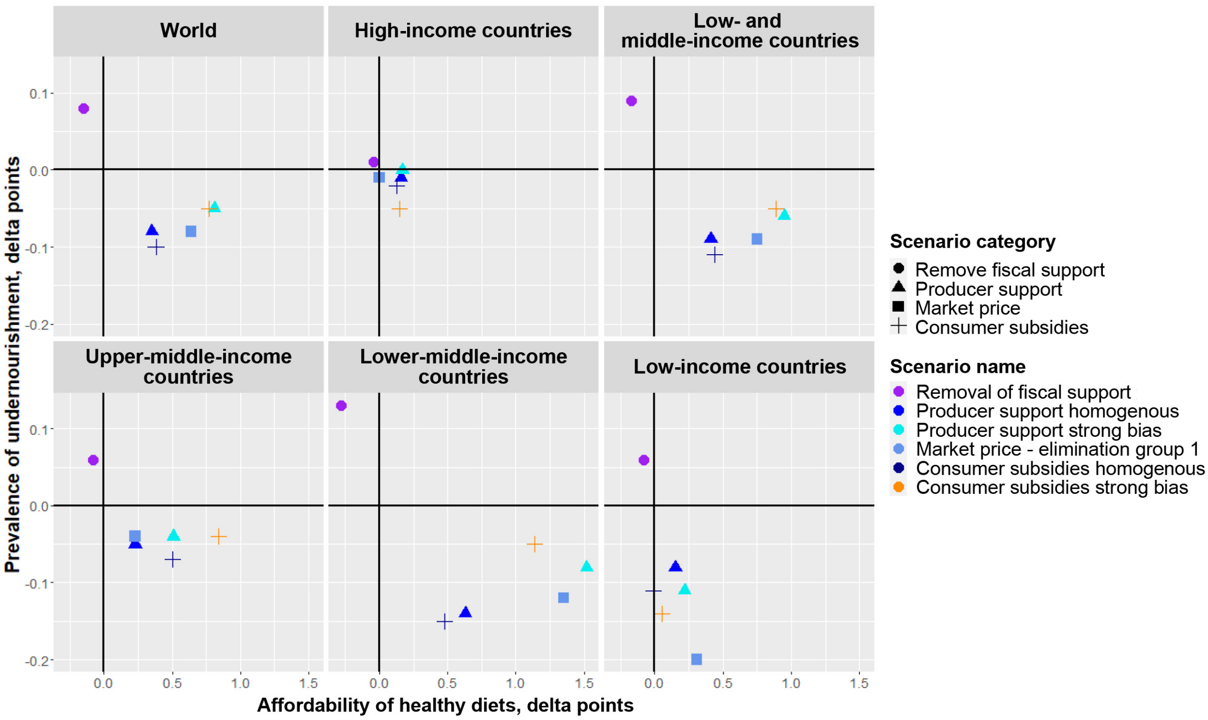
Source: Authors' own elaboration, based on MIRAGRODEP model database.

In general, healthy diet affordability and the healthy diet income gap are negatively correlated. That is, as the cost of healthy diets declines relative to that of national average diets, the percent of population for which healthy diets are affordable increases. The impact on healthy diet affordability is generally higher in the LMICs and UMICs. In these countries, fiscal subsidies are larger than in LICs, so repurposing has larger impacts. The impact on healthy diet affordability in HICs is small simply because the percent of population for whom healthy diets are unaffordable is small.

Lastly, the two scenarios that are biased towards high-priority foods (scenarios 1b and 2b) have the largest impacts on healthy diet affordability.

Figure 4 examines the trade-offs between healthy diet affordability and the prevalence of undernourishment. The percent of population that is undernourished is also negatively correlated with the affordability of healthy diets.

Figure 4. Prevalence of undernourishment versus affordability of a healthy diet



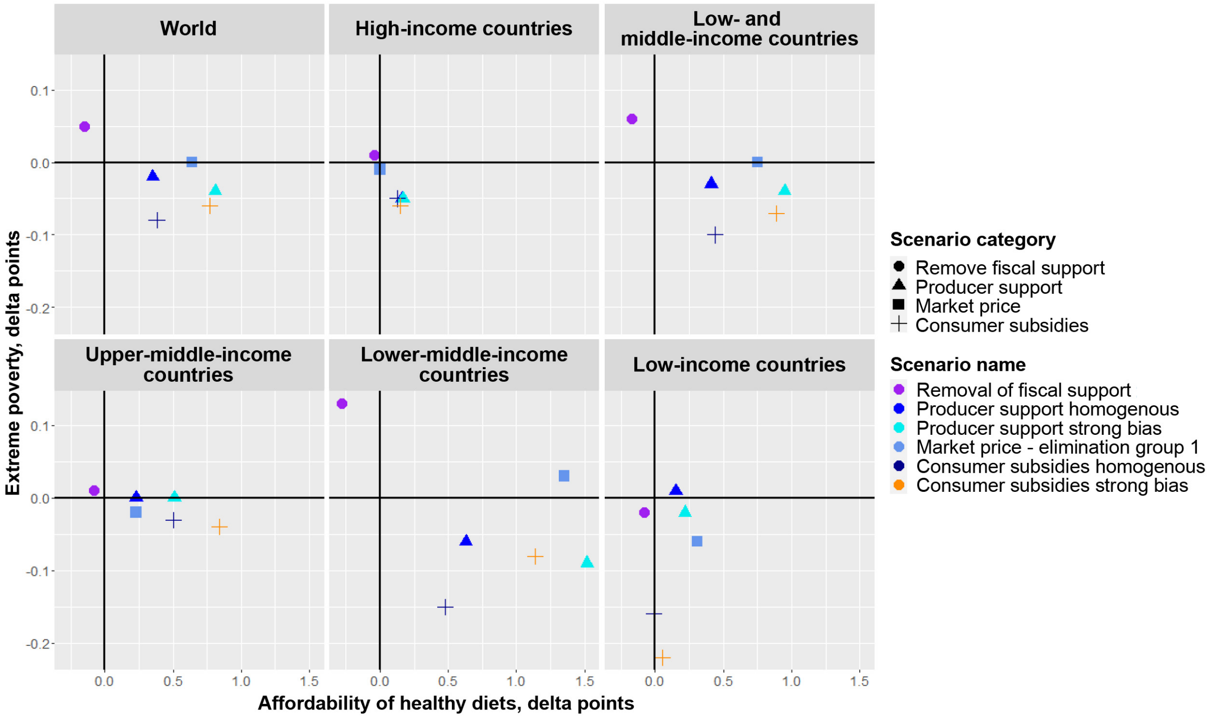
Note: In this report, the “pseudo-PoU” approach embedded in the MIRAGRODEP framework is used, using a non-parametric measurement of undernourishment based on household surveys.

Source: Authors’ own elaboration, based on MIRAGRODEP model database.

In our simulated analyses, under all scenarios, the percent of population that is undernourished drops, as does the percent of population for which healthy diets are unaffordable. In most income groups, consumer subsidies tend to be more effective in reducing the prevalence of undernourishment. The exception is LICs, where targeted border measures (Scenario 1c) are estimated to be more effective. As noted above, this result is, in part, due to the fact that LICs provide most agricultural support through border measures (rather than fiscal support).

Figure 5 examines the affordability of healthy diets relative to the percent of population in extreme poverty. The prevalence of poverty is estimated to decline in most scenarios at the global level, but redirecting fiscal subsidies towards targeted producer subsidies is generally less effective in reducing the prevalence of extreme poverty than targeted consumer subsidies. Targeted border measures (Scenario 1C) is estimated to increase the prevalence of extreme poverty in the LMICs due to the decline in farm income in those countries (Figure 6).

Figure 5. Prevalence of extreme poverty versus affordability of a healthy diet



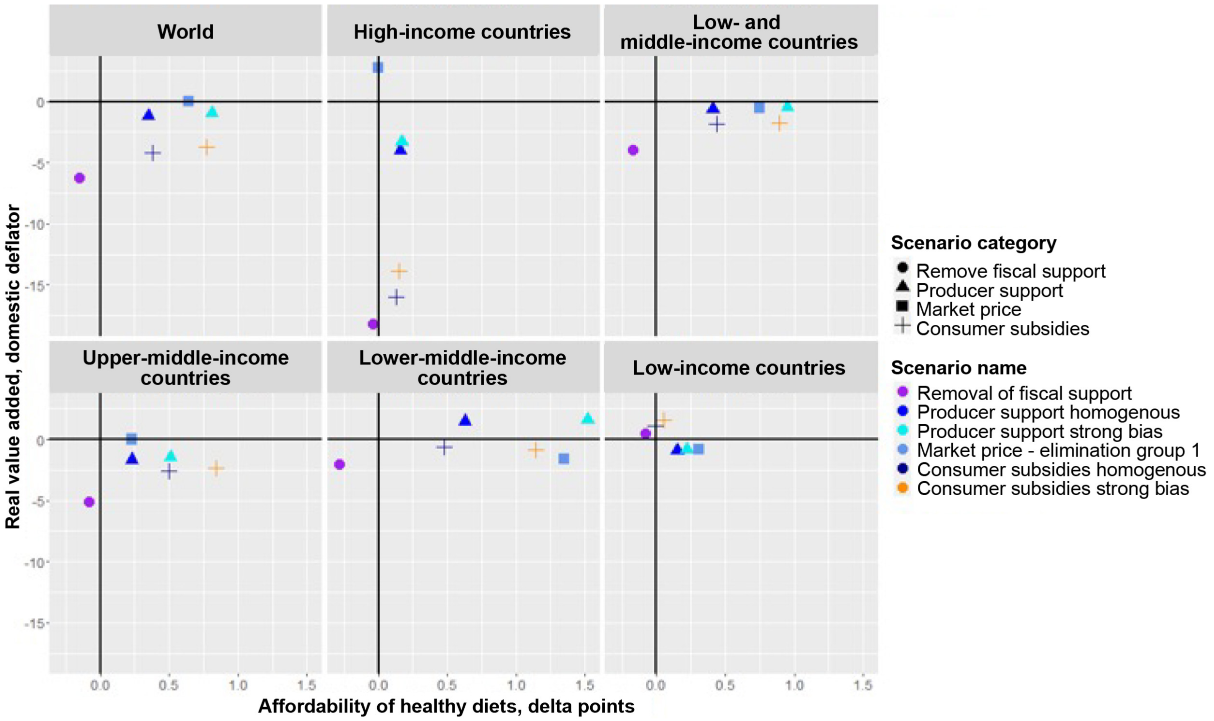
Note: In this report, the "pseudo-PoU" approach embedded in the MIRAGRODEP framework is used, using a non-parametric measurement of undernourishment based on household surveys.

Source: Authors' own elaboration, based on MIRAGRODEP model database.

Repurposing agricultural fiscal support is estimated to lower farm income across most scenarios and income groups (Figure 6). The impacts are highest in HICs, with consumer subsidy repurposing scenarios (scenarios 2a and 2) estimated to have larger impacts than producer support scenarios (scenarios 1a and 1b). Impacts are lowest for the LICs, which have fewer fiscal subsidies to repurpose. Farm income in LMICs is estimated to increase marginally under the producer support scenarios but decline under the consumer support scenarios.

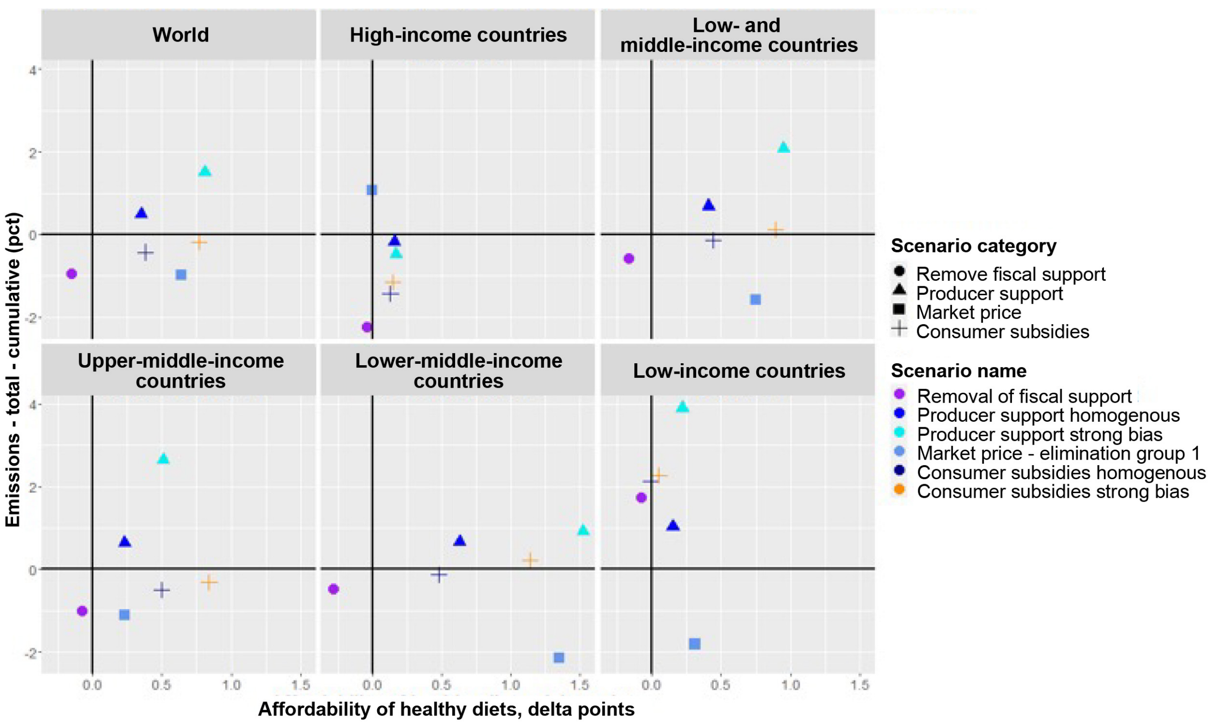
Figure 7 examines the trade-offs between healthy diet affordability and the level of agricultural GHG emissions (including from land-use change) under the various scenarios. Here, the picture is more mixed than under the previous indicators. In general, GHG emissions are estimated to decline in the HICs over all scenarios, with policies that repurpose fiscal subsidies towards consumer subsidies having greater reduction in GHG emissions than those repurposing towards producer subsidies. In low- and middle-income countries, repurposing policies towards producer support (scenarios 1a and 1b) is estimated to increase GHG emissions.

Figure 6. Farm income versus affordability of a healthy diet



Source: Authors' own elaboration, based on MIRAGRODEP model database.

Figure 7. GHG emissions versus affordability of a healthy diet



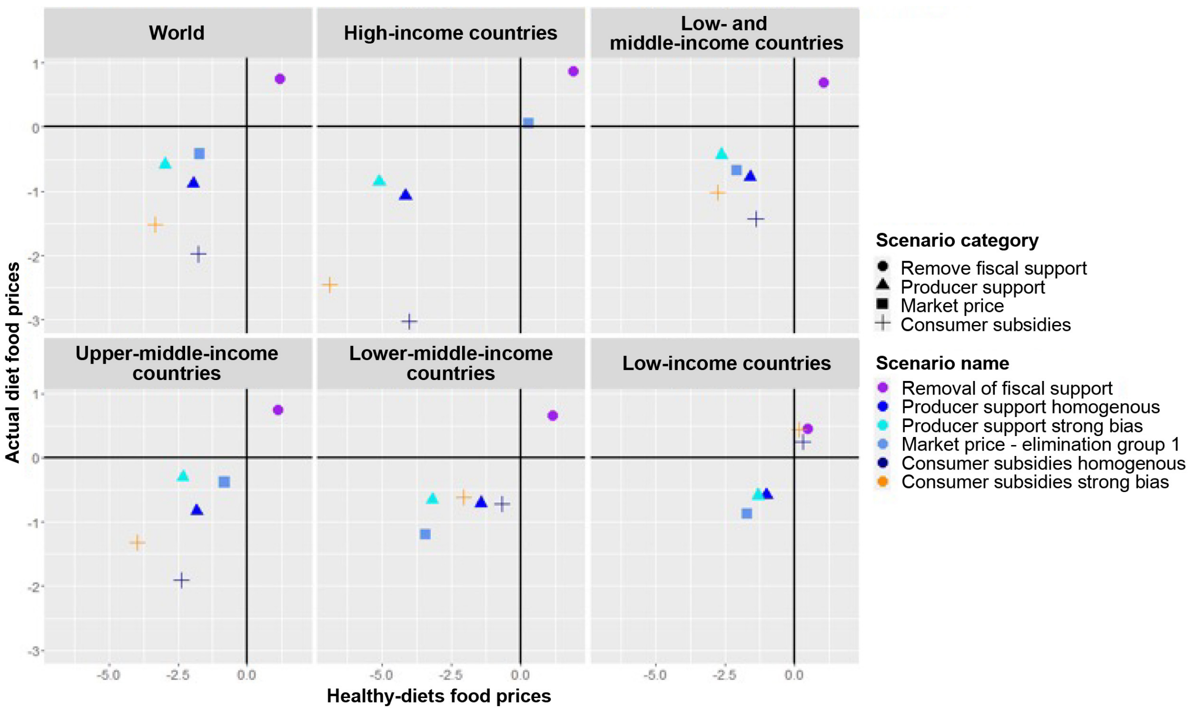
Source: Authors' own elaboration, based on MIRAGRODEP model database.

6.2 Farm income vs cost of a healthy diet

Figure 8 through to Figure 12 examine trade-offs with the cost of a healthy diet. Under most scenarios, the cost of a healthy diet is estimated to decline, with the largest declines coming from the scenario that repurposes fiscal subsidies towards targeted consumer subsidies (Figure 8). Paradoxically, the costs of healthy and actual diets are estimated to increase marginally in LICs under the consumer subsidies scenarios because of increased import demand in the rest of the world arising from consumer subsidies, whereas in the LICs there are limited fiscal subsidies to repurpose for consumer subsidies.

Note that the cost of actual diets is highly correlated to the cost of a healthy diet; but, generally, the cost of a healthy diet also declines in relative terms to the cost of actual diets. (This is why the affordability gap between healthy and actual diets declines in percentage terms over most scenarios).

Figure 8. Cost of actual diets versus cost of a healthy diet

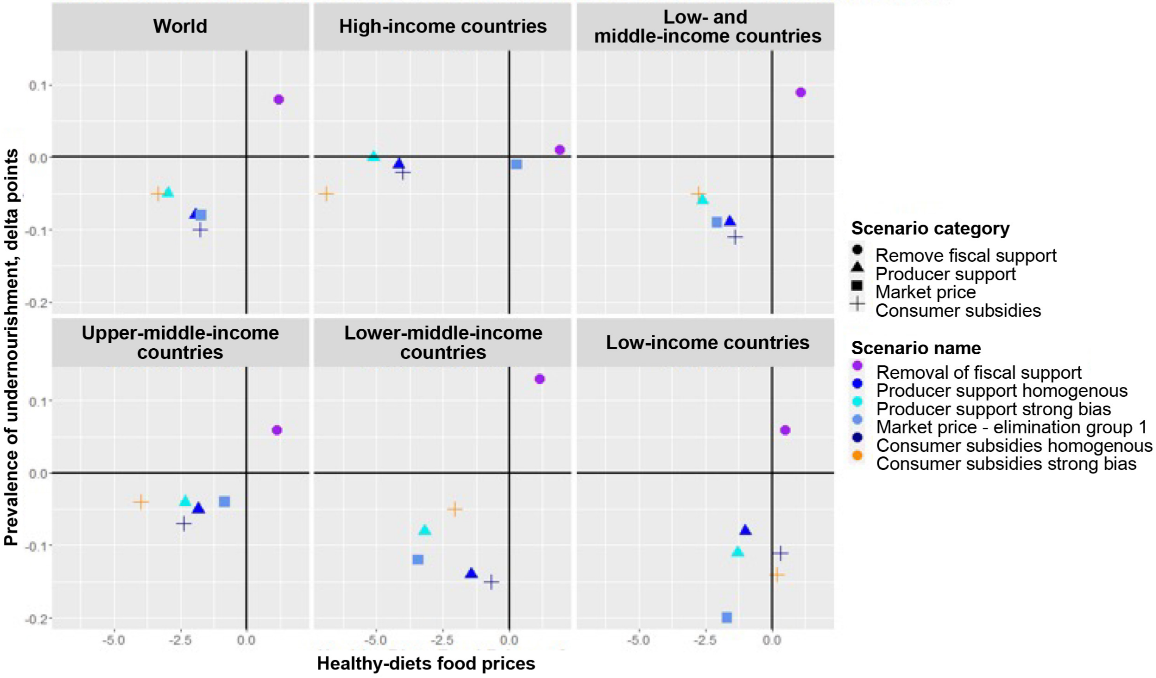


Source: Authors' own elaboration, based on MIRAGRODEP model database.

As with the affordability of healthy diets, the prevalence of undernourishment is generally correlated with the costs of healthy diets, but the effectiveness of the various scenarios differs across income groups (Figure 9). In middle-income countries, the prevalence of undernourishment is estimated to decline more under homogenous producer and consumer subsidies than with subsidies targeted towards high-priority foods; but under all scenarios, the prevalence of undernourishment is estimated to decline.

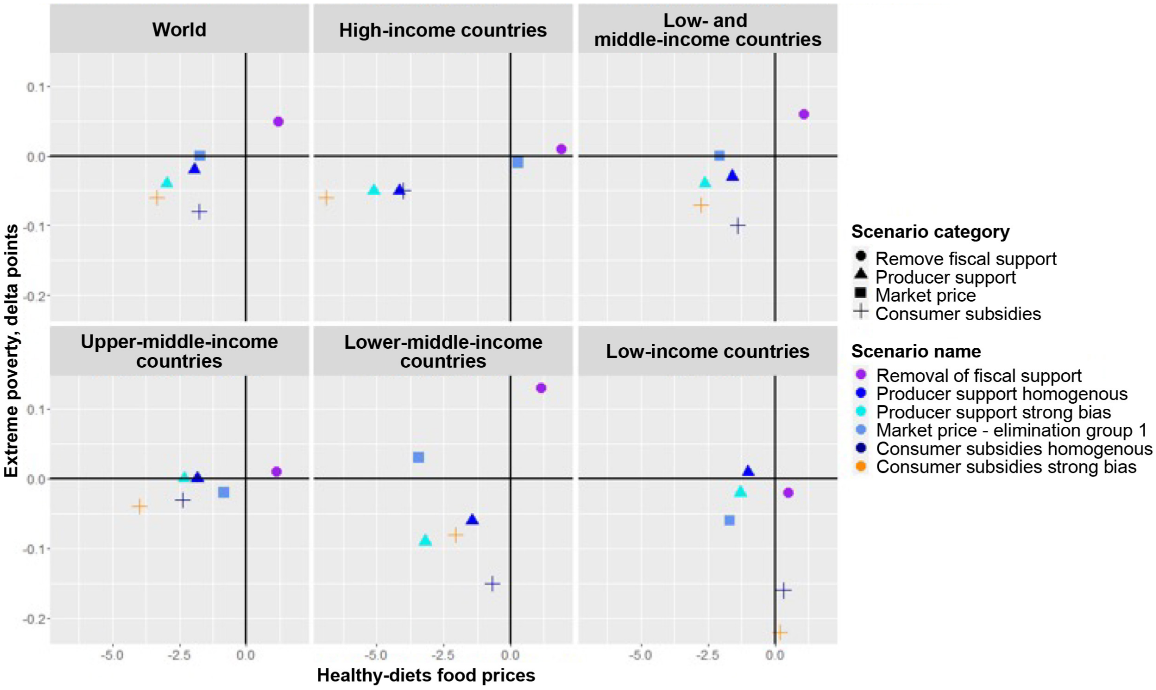
Consumer subsidies (scenarios 2a and 2b) have the largest proportionate impact on the percent of population in extreme poverty, a result that is generally consistent across all income groups (Figure 10). At one level, consumer subsidies are essentially in-kind income support, so their impact in reducing extreme poverty tends to be more effective than repurposing support through producer subsidies.

Figure 9. Prevalence of undernourishment versus cost of a healthy diet



Source: Authors' own elaboration, based on MIRAGRODEP model database.

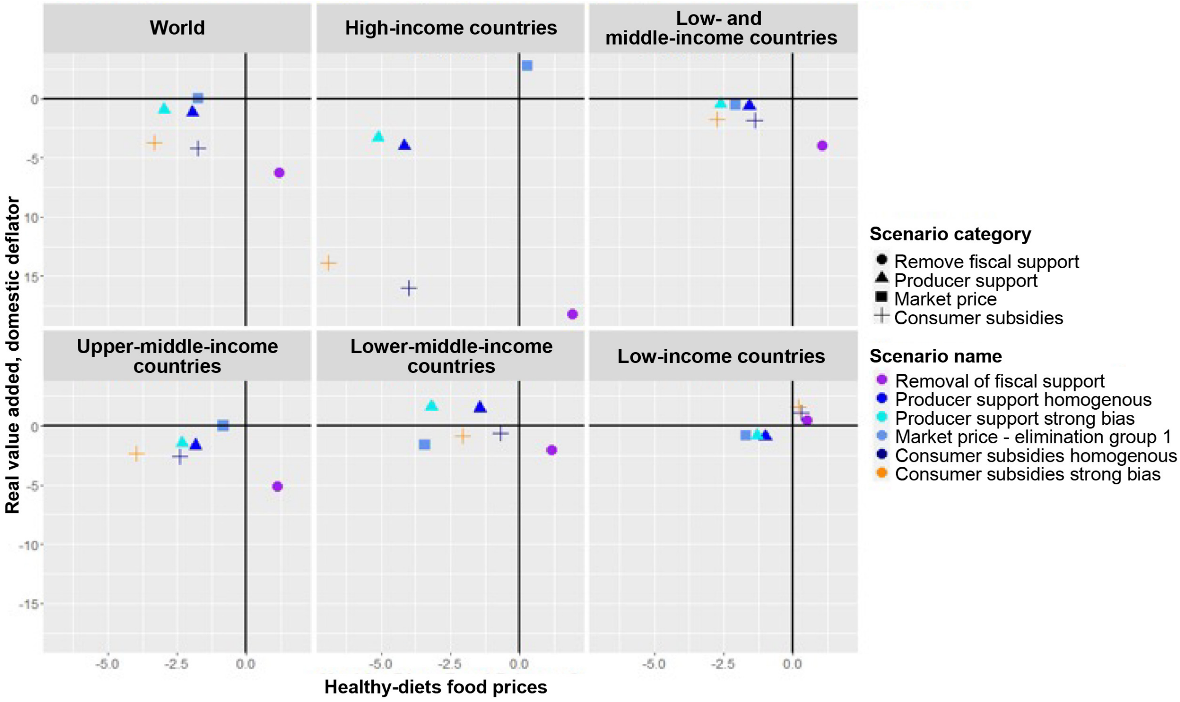
Figure 10. Prevalence of extreme poverty versus cost of a healthy diet



Source: Authors' own elaboration, based on MIRAGRODEP model database.

Figure 11 shows the trade-offs of the cost of healthy diets with farm income. Again, farm income declines under all scenarios at the global level, though impacts vary by income group. Globally, the greatest impacts are under the consumer scenarios, particularly in the HICs, where farm income is estimated to decline by more than 13.5 percent.

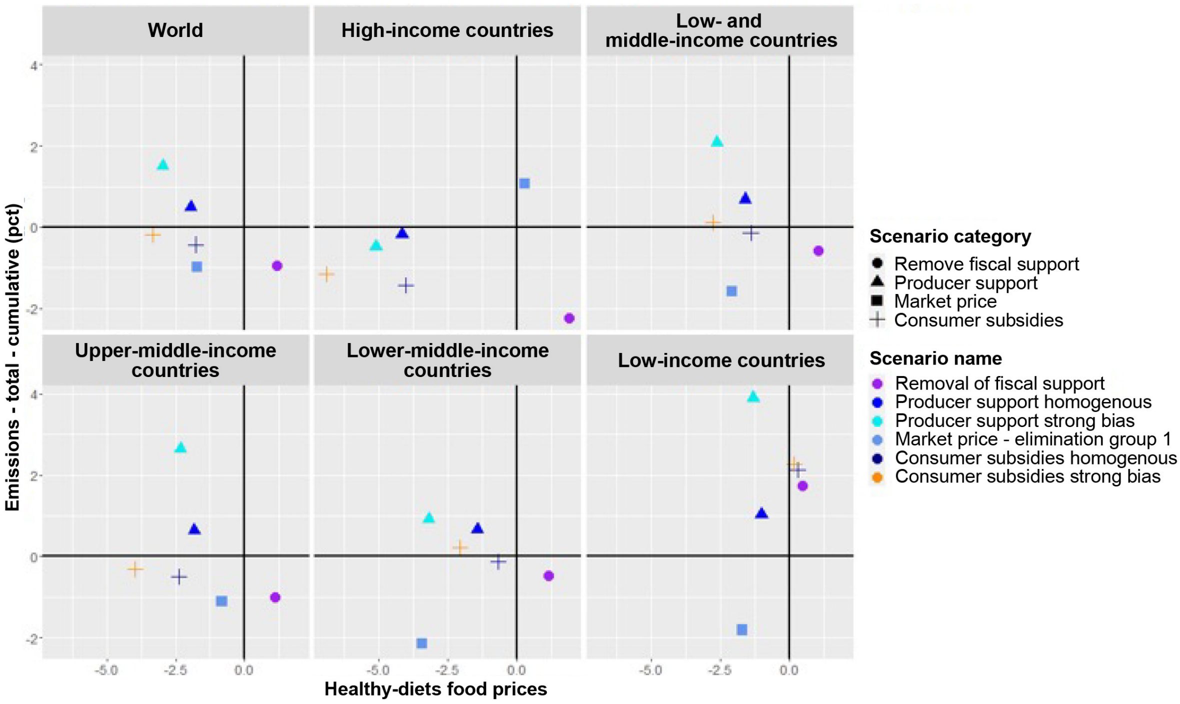
Figure 11. Farm income versus cost of a healthy diet



Source: Authors' own elaboration, based on MIRAGRODEP model database.

Lastly, Figure 12 shows the trade-offs between the cost of healthy diets and GHG emissions. As discussed in Figure 7, GHG emissions decline under the repurposing scenarios where fiscal funds are shifted to consumer subsidies but increase at the global level under the producer scenarios.

Figure 12. GHG emissions versus cost of a healthy diet



Source: Authors' own elaboration, based on MIRAGRODEP model database.

7 Repurposing and economic recovery

Given the current global economic context, the repurposing of support must also consider scenarios that, while healthy diets must become more affordable and the foods that form them must be produced more sustainably, many economies also need sustained economic recovery.

The scenarios discussed until now also capture economy-wide impacts (reflected in the GDP). Targeting support to high-priority foods will not necessarily limit or spur GDP, as this depends on how distortions in the economy play out. In fact, targeting support to high-priority foods to reduce the cost of healthy diets could lead to specialization of production towards those commodities, along with the evolution of world prices and the trade position on specific commodities, which could lead to GDP losses. In the end, we are confronted with an empirical question that the scenarios presented here help to respond.

The impact on GDP in the repurposing scenarios can be seen in Table 17. Here GDP measures the change in production volume (assuming fixed baseline prices). Reducing price incentives through border measures for agricultural products in regions where consumption is low relative to nutritional guidelines is estimated to increase GDP unambiguously across income groups and regions. Gains are estimated to be largest in LMICs and LICs where border measure support is often highly distortive.

Repurposing fiscal subsidies to producers towards commodities in regions where consumption is low relative to recommended dietary levels, results in efficiency losses for UMICs, particularly in Asia where large levels of support would be moved to less-efficient production outcomes. As a result, GDP is estimated to fall in this region. In LICs, efficiency loss is minimal, because there is little fiscal support to repurpose; however, those countries see GDP gains due to higher agricultural prices and increased exports.

Reallocating fiscal subsidies from producers towards consumers of agricultural products the consumption of which is low relative to nutritional guidelines tends to benefit all country income groups and LAC countries in particular. In this case, across geographic regions, the exception is LICs, which lose marginally as most of them tend to be net food importing countries facing higher prices.

Table 17. Impact of changes on GDP in the repurposing scenarios, 2030 (percentage change with respect to the baseline)

Region	Repurposing border measures			Repurposing fiscal subsidies to producers			Repurposing fiscal subsidies from producers to consumers		
World	0.05	-0.06	0.10	0.05	-0.06	0.10	0.05	-0.06	0.10
BY INCOME GROUP									
High-income countries	0.01	0.01	0.11	0.01	0.01	0.11	0.01	0.01	0.11
Upper-middle-income countries	0.09	-0.15	0.08	0.09	-0.15	0.08	0.09	-0.15	0.08
Lower-middle-income countries	0.06	-0.22	0.08	0.06	-0.22	0.08	0.06	-0.22	0.08
Low-income countries	0.22	0.10	0.09	0.22	0.10	0.09	0.22	0.10	0.09
BY REGION									
Africa	0.14	0.11	-0.10	0.14	0.11	-0.10	0.14	0.11	-0.10
Asia	0.08	-0.15	0.05	0.08	-0.15	0.05	0.08	-0.15	0.05
Americas*	0.02	-0.01	0.09	0.02	-0.01	0.09	0.02	-0.01	0.09
Latin America and the Caribbean**	0.05	0.00	0.24	0.05	0.00	0.24	0.05	0.00	0.24
Europe	0.01	0.01	0.23	0.01	0.01	0.23	0.01	0.01	0.23

Notes: * Americas includes high-income countries (HICs) in Latin America and the Caribbean (Chile, Panama, Trinidad and Tobago, and Uruguay), plus Canada and the United States of America. ** Latin America and the Caribbean includes all countries in this region except HICs which are included in the Americas group. Results for the policy scenario are reported as a percentage point change from the baseline scenario in 2030 for food security and nutrition indicators and extreme poverty, while results are reported as a percentage change from the baseline scenario in 2030 for the other indicators.

Source: Authors' own elaboration, based on MIRAGRODEP model database.

8 Conclusions

A number of conclusions can be drawn from the analysis.

- **Global farm income falls under all the repurposing scenarios,** except for the targeted removal of border measures. Farm income falls across most income groups, with the largest impact seen in the HICs. The exception is the LICs, where fiscal subsidies are small and producer income is estimated to increase due to increased global demand. Not surprising, farm income declines are largest for those scenarios where repurposed fiscal support is applied towards consumer subsidies.
- **The affordability of a healthy diet improves under all repurposing scenarios**, but repurposing fiscal subsidies towards consumer subsidies is far more effective in increasing the affordability of healthy diets than redistributing fiscal subsidies to producer fiscal support that is more targeted to high-priority foods.
- **Impacts on the affordability of a healthy diet are least in high-income and low-income countries**. In the case of the HICs, the percent of population that can afford a healthy diet is already quite high. In the case of LICs, those countries have less fiscal subsidies to repurpose.
- The cost of a healthy diet and the cost of a current diet are estimated to increase marginally in LICs under the consumer subsidies scenarios because of increased import demand in the rest of the world (due to consumer subsidies); whereas in the LICs, there are limited fiscal subsidies to repurpose.
- **Repurposing scenarios that are targeted towards high-priority food groups have greater impact on healthy diet affordability**. In general, repurposing fiscal support towards consumer subsidies has the largest impact on the per capita consumption of food groups among the scenarios examined.
- **Repurposing fiscal support towards consumer subsidies reduces total agricultural GHG emissions**, but those polices that repurpose fiscal support towards producer subsidies are estimated to increase GHG emission in low- and middle-income countries.

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Annexes

Annex 1. Regional aggregation and disaggregation of MIRAGRODEP used in this study

Table A1. Geographical mapping between Global Trade Analysis Project (GTAP) 11 regions and model aggregation

Region code in the model	GTAP regions	Income classification for displaying results
HIC_Oceania	Australia, New Zealand, Rest of Oceania (American Samoa, Cook Islands, Fiji, French Polynesia, Guam, Kiribati, Marshall Islands, Federated States of Micronesia, Nauru, New Caledonia, Niue, Northern Mariana Islands, Palau, Papua New Guinea, Pitcairn, Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu, United States Minor Outlying Islands, Vanuatu, Wallis and Futuna Islands)	High-income countries
CHINA	China; China, Hong Kong SAR	Upper-middle-income countries
HIC_Asia	Bahrain, Brunei Darussalam, Israel, Japan, Kuwait, Oman, Qatar, Republic of Korea, Saudi Arabia, Singapore, Taiwan, United Arab Emirates	High-income countries
LMIC_Asia	Bangladesh, Cambodia, Lao People's Democratic Republic, Nepal, Pakistan, Philippines, Sri Lanka, Viet Nam, Rest of Southeast Asia (Myanmar, Timor-Leste), Rest of Former Soviet Union (Turkmenistan, Uzbekistan), Rest of East Asia (China, Macao SAR; Democratic People's Republic of Korea)	Lower-middle-income countries
UMIC_Asia	Armenia, Azerbaijan, Georgia, Indonesia, Iran (Islamic Republic of), Jordan, Kazakhstan, Malaysia, Thailand, Türkiye, Rest of Western Asia (Iraq, Lebanon, Occupied Palestinian Territory, Syrian Arab Republic, Yemen)	Upper-middle-income countries
INDIA	India	Lower-middle-income countries
LIC_Asia	Tajikistan, Rest of South Asia (Afghanistan, Bhutan, Maldives)	Lower-middle-income countries
USA	United States of America	High-income countries
MEXICO	Mexico	Upper-middle-income countries
UMIC_America	Argentina, Colombia, Costa Rica, Dominican Republic, Ecuador, Guatemala, Jamaica, Paraguay, Peru, Venezuela (Bolivarian Republic of), Rest of North America (Bermuda, Greenland, Saint Pierre and Miquelon), Rest of South America (Falkland Islands [Malvinas], French Guiana, Guyana, South Georgia and the South Sandwich Islands, Suriname), Rest of Central America (Belize), Rest of the World (Antarctica, Bouvet Island, British Indian Ocean Territory, French Southern Territories)	Upper-middle-income countries

Region code in the model	GTAP regions	Income classification for displaying results
LMIC_America	Bolivia (Plurinational State of), El Salvador, Honduras, Nicaragua, Rest of Caribbean (Anguilla, Antigua and Barbuda, Aruba, Bahamas, Barbados, British Virgin Islands, Cayman Islands, Cuba, Dominica, Grenada, Haiti, Montserrat, Sint Maarten [Dutch part], Saint Kitts and Nevis, Saint Lucia, Saint Vincent and Grenadines, Turks and Caicos Islands, United States Virgin Islands)	Lower-middle-income countries
BRAZIL	Brazil	Upper-middle-income countries
HIC_Europe	Austria, Belarus, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxemburg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom of Great Britain and Northern Ireland, Rest of European Free Trade Association (Iceland, Liechtenstein)	High-income countries
UMIC_Europe	Albania, Bulgaria, Belarus, Russian Federation , Rest of Europe (Andorra, Bosnia and Herzegovina, Faroe Islands, Gibraltar, Guernsey, Holy See, Isle of Man, Jersey, Monaco, Montenegro, North Macedonia, San Marino, Serbia)	Upper-middle-income countries
LMIC_Europe	Ukraine, Rest of Eastern Europe (Republic of Moldova)	Lower-middle-income countries
UMIC_Africa	Botswana, Egypt, Morocco, Namibia, Tunisia, Rest of North Africa (Algeria, Libya, Western Sahara)	Upper-middle-income countries
LMIC_Africa	Cameroon, Côte d'Ivoire, Ghana, Kenya, Nigeria, Senegal, United Republic of Tanzania, Zambia, Zimbabwe, Rest of Central Africa (Central African Republic, Chad, Congo, Equatorial Guinea, Gabon, Sao Tome and Principe), South Central Africa (Angola, Democratic Republic of the Congo), Rest of South African Customs Union (Eswatini, Lesotho)	Lower-middle-income countries
BENIN	Benin	Lower-middle-income countries
LIC_Africa	Burkina Faso, Guinea, Madagascar, Malawi, Mozambique, Rwanda, Tonga, Uganda, Rest of Western Africa (Ascension, Saint Helena and Tristan da Cunha; Cabo Verde; Gambia; Guinea-Bissau; Liberia; Mali; Mauritania; Niger; Sierra Leone), Rest of Eastern Africa (Burundi, Comoros, Djibouti, Eritrea, Mayotte, Seychelles, Somalia, Sudan)	Low-income countries
ETHIOPIA	Ethiopia	Low-income countries
HIC_Africa	Mauritius	High-income countries
SOAFRICA	South Africa	Upper-middle-income countries

Source: Aguiar, A., Chepeliev, M., Corong, E. & van der Mensbrugghe, D. 2022. The Global Trade Analysis Project (GTAP) Data Base: Version 11. *Journal of Global Economic Analysis* 7(2). https://jgea.org/ojs/index.php/jgea/article/view/181

Table A2. Sectoral mapping between GTAP 11 sectors and model aggregation

Sector code in the model	GTAP sectors	Food group classification (for policy prioritization)
pdr	PDR	Rice, paddy
Wheat	WHT	Wheat
Maize	GRO	Maize and other grains
VegFruits	V_F	Fruits and vegetable
Oilseeds	OSD	Oilseeds
c_b	C_B	Sugar
Fibers	PFB	Non food
OthCrops	OCR	Other crops and stimulants
ctl	CTL, WOL	Cattle, raw
oap	OAP	Poultry and pork, raw
rmk	RMK	Milk, raw
Forestry	FRS	Non food
Fisheries	FSH	Fisheries
Energy	COA, OIL, GAS, P_C, ELY, GDT	Non food
Primary	OXT	Non food
MeatCattle	CMT	Poultry and pork, cut
MeatPorkPoul	OMT	Poultry and pork, raw
vol	VOL	Vegetable oils
mil	MIL	Dairy products
pcr	PCR	Rice, processed
Sugar	SGR	Sugar
Food	OFD	Food, miscellaneous
BevTobacco	B_T	Non-food
Manu	TEX, WAP, LEA, LUM, PPP, BPH, RPP, NMM, I_S, NFM, FMP, MVH, OTN, ELE, EEQ, OME, OMF	Non-food
chm	CHM	Non-food
SERV	WTR, CNS, CMN, OFI	Arial
TRD	TRD, WHS	Non-food
AFS	AFS	Food services
TRAN	OTP, WTP, ATP	Non-food

Source: Aguiar, A., Chepeliev, M., Corong, E. & van der Mensbrugghe, D. 2022. The Global Trade Analysis Project (GTAP) Data Base: Version 11. *Journal of Global Economic Analysis* 7(2). https://jgea.org/ojs/index.php/jgea/article/view/181

Annex 2. Modification of the MIRAGRODEP model to simulate policy repurposing

The MIRAGRODEP model used in this paper is based on MIRAGRODEP 2.0 as described in Bouët *et al.* (2022). In the following paragraphs, we use the notations introduced in this documentation as well as its equation numbering. This version of the model is combined with the *ex post* GHG accounting approach presented in Laborde Debucquet *et al.* (2021) and the microsimulation to track poverty and food consumption changes explained in Laborde, Martin and Vos (2020). The computation of affordability of healthy diet indicators is done in post solve stage and covered in Annex 3.

In addition, a few modifications have been done to better capture some economic responses, such as intensification, or to allow scenario implementation (endogenous support rate).

Structural modification: allowing for intensification or extensification

To allow for production intensification, or deintensification, in the agriculture sector, we allow the direct combination of inputs (chemical products and fertilizers for crops, and feed products for livestock) with land in the production tree. This approach has been introduced previously in the MIRAGE-BioF model (see Laborde and Valin, 2012).

Therefore, a few questions are modified, in particular equation (5), describing the demand of land in the production tree. Equation 5 is replaced by the demand for the aggregate “land and inputs”:

$$TEIC_{j,r,t} = a_{j,r}^{TEIC} VA_{j,r,t} \left(\frac{PVA_{j,r,t}}{PTEIC_{j,r,t}} \right)^{\sigma_j^{VA}}$$

With

$a_{j,r}^{TEIC}$	Land coefficient (CES - Value added) with inputs share
$PTEIC_{j,r,t}$	Price of land (including taxes) and substitutable inputs

The demand for land is now defined by a CES aggregate of land and farm inputs:

$$TE_{j,r,t} = a_{j,r}^{TE} TEIC_{j,r,t} \left(\left(PGFI_{j,r,t} - 1 \right) \times TE_{Productivity,j,r,t} + 1 \right)^{\sigma_{j,r}^{TEIC} - 1} \left(\frac{PTEIC_{j,r,t}}{PTE_{j,r,t}} \right)^{\sigma_{j,r}^{TEIC}}$$

$a_{j,r}^{TE}$	Land coefficient (CES - value added)
$\sigma_{j,r}^{TEIC}$	Substitution between land and key inputs
$TE_{Productivity,j,r,t}$	Land productivity factor
$PICTE_{j,r,t}$	Price of intermediate consumption bundle for sector j (including taxes)
$PTE_{j,r,t}$	Price of land (including taxes)

And the demand for the input bundle is given by

$$ICTE_{j,r,t} = a_{j,r}^{ICTE} TEIC_{j,r,t} \left(\frac{PTEIC_{j,r,t}}{PICTE_{j,r,t}}\right)^{\sigma_{j,r}^{TEIC}}$$

$a_{j,r}^{ICTE}$ Intermediate consumption scale coefficient (CES - Intermediate consumption) for land bundle

A new price equation is introduced

$$PTEIC_{j,r,t}TEIC_{j,r,t} = PTE_{j,r,t}TE_{j,r,t} + PICTE_{j,r,t}ICTE_{j,r,t}$$

Since various inputs (such as different crops for feed) could be considered, $ICTE_{j,r,t}$ will also be distributed among various feed/chemical inputs based on a CES function.

These changes also implied that equation 9 is modified as follows:

$$PVA_{j,r,t}VA_{j,r,t} = PL_{j,r,t}L_{j,r,t} + PTEIC_{j,r,t}TEIC_{j,r,t} + PRN_{j,r,t}RN_{j,r,t} + PQ_{j,r,t}Q_{j,r,t}$$

Importantly, it also means that the $VA_{i,r,t}$ variable does not reflect the true value added of the sector anymore and should be interpreted correctly. This leads to new definition indicators when generating results.

Scenario implementation

During simulations, and depending on the scenarios and sectors, the values of export taxes $\mathrm{taxEXP}_{i,r,s,t}$, and import duties $\mathrm{DD}_{i,r,s,t}$ are brought to zero. The same approach is followed for the taxes on the taxes on outputs $\mathrm{taxP}_{i,r,t}$, or the taxes on inputs $\mathrm{taxicc}_{i,j,r,t}$, but only when they are negative in the base year, that is, representing subsidies.

A variable $ValueFiscalSupport_{i,r,t}$ equal to all the fiscal support (output, factor and input subsidies) received by a given agricultural sector is also defined. This value is endogenous and evolves in the baseline, even when individual rates remain fixed. It serves as the “budget” to conduct policy experiment when addressing repurposing scenarios.

Importantly, some subsidy and tax rates endogenous to the simulations must be established. First, the tax on the factors of production:

$$\mathrm{taxFval}_{f,i,r,t} = taxfvalREF_{f,i,r,t} - subFBias_{i,r} * \mathrm{subFvalH}_{r,t}$$

with

$\mathrm{taxFval}_{f,i,r,t}$ the endogenous tax rate on factor of production costs

$taxfvalREF_{f,i,r,t}$ the exogenous tax rate on factor of production costs, fixed to baseline value. Note that during the scenarios, this value will also be set to zero to represent the phasing out of past policies in agriculture in the case that $taxfvalREF_{f,i,r,t}$ is negative.

$subFBias_{i,r}$ the product bias. It could take various values, including, but not limited to: 0 – the product could not be subsidized (for instance, a non-food product); 1 – the product receives the average level of support, 10 – the product receives 10 times the average level of support.

Similarly, we introduce the possibility of an endogenous food subsidy:

$$\mathrm{taxcc}_{i,r,t} = taxccREF_{i,r,t} - subFBias_{i,r} * \mathrm{FoodSubsidy}_{r,t}$$

with

$\mathrm{taxcc}_{i,r,t}$ the endogenous tax rate on final consumption

$taxccREF_{i,r,t}$ the exogenous tax rate on final consumption, fixed to baseline value.

$subFBias_{i,r}$ the product bias. It could take various values, including, but not limited to: 0 – the product could not be subsidized (for instance, a non-food product); 1 – the product receives the average level of support; 10 the product receives 10 times the average level of support.

During the repurposing scenarios, the value of fiscal support, $ValueFiscalSupport_{i,r,t}$, in each region *r* is fixed to its baseline value, adding one constraint by region and year, or, more exactly, removing one free variable by region and year. When the repurposing scenario targets the supply side response, the homogenous subsidy rate $\mathrm{subFvalH}_{r,t}$ is made endogenous and will balance the number of equations and variables.

When the repurposing scenario focuses on consumer subsidies, it is the variable $\mathrm{FoodSubsidy}_{i,r,t}$ that plays a similar role.

Annex 3. Assessing the evolution of the affordability of healthy diets with the MIRAGRODEP model

The notion of healthy diet affordability has been introduced in several publications. The cost and affordability of a healthy diet are now standard reported indicators in *The State of Food Security and Nutrition in the World* report. The basic methodology can be summarised as follows: 1) identify the least-cost of a healthy diet for each country, based on observed consumer prices and a set of nutrition, sociocultural and palatability criteria, 2) compute the daily cost in purchasing power parity (ppp) dollars, and 3) compare this cost with the food expenditures in ppp USD of the population, considering that each household is spending 63 percent of its income on food products. Using observed prices and income distribution, this approach makes it possible to determine the percent of the population that can afford a healthy diet for the base year. Fundamentally, this could be seen as defining a new, nutrition-sensitive poverty line applied to a food-expenditure distribution.

This annex explains how we adapt this approach to the MIRAGRODEP modelling framework to build projections (baseline) and assess policy changes (scenarios) in a context where both the prices of the different food items and the income distribution change.

Notations

The following sets and elements are defined:

- c the commodity index on the set of commodities C, used in the costing of healthy diet approach. d is an alias of c;
- g a given food group, defined as a partition of the set of commodities C, used in the cost of diet approach;
- i the sector index on the set of sectors I, used in the MIRAGRODEP model. j is an alias of i. In some cases, an element of *i* can be identical to *c* (such as rice) or covered by a group of commodities;
- r the country index on the set of countries R.

Assuming the consumption of a vector of food products $\underline{x}_r^c$ initially purchased at price p_r^c, the cost of the base year healthy diet is defined by:

- $\underline{Diet}_r^0 = \sum_c p_r^c \cdot \underline{x}_r^c$

Let's define the share of each commodity in this minimal budget: $sh_r^c = \frac{p_r^c \cdot \underline{x}_r^c}{\sum_d p_r^d \cdot \underline{x}_r^d}$.

The vector $\underline{x}_r^c$ and its associated cost could be used to define a nutrition-poverty line $\underline{Diet}_r^{base}$. Using the food expenditures distribution (actual or based on Engel's curve), and the $\underline{Diet}_r^{base}$. we can define the share of the population with a food budget insufficient to buy the optimized diet: $NutritionPoorZ_r = \int_0^{\underline{Diet}_r^{base}} g(z)dz$. This is a minimal, adjusted-income, nutrition-poverty line.

In *The State of Food Security and Nutrition in the World* exercise, a default value of 63 percent is used to measure the share of income spent on food. So, $z = \mu * y$ with y being the income distribution and $\mu = 0.63$. This strong assumption does not capture the observed heterogeneity in terms of the share of food expenditures in total income across and within countries, but allows a simpler international comparison based on the observed average of food expenditures across poor populations in low-income countries.

Integration in the MIRAGRODEP modelling framework

Through the changes in market equilibrium, the MIRAGRODEP CGE model provides relative changes in prices $\hat{p}_r^i$, for sector *i* and country *r*, and in income at the country level, but also at the household level $\hat{y}_r^h$ where *h* is the household index, through its microsimulation modules (see Laborde *et al*. [2020b] for details).

This makes it possible to capture: (i) how the prices of food products evolve and the cost of the minimal diet, and (ii) how the income and food expenditure distributions are impacted by the shock due to changes in wages, output prices (such as farm prices), etc. These changes impact both average income and the distribution of income.

Initial calibration and required data

The first step is to apply the previous definition to the MIRAGRODEP modelling framework and provide a proper calibration approach for the key parameters. First, based on *The State of Food Security and Nutrition in the World 2022*, we know the share of population that could afford a healthy diet in the base year, and therefore $NutritionPoorZ_r$. Secondly, the modelling framework provides the updated household surveys and income distributions, and assuming a constant value of μ, we compute the value $\underline{Diet}_r^0$ compatible with these values. Finally, the information on the budget shares associated with each food group in the composition of the healthy diet has been made available by the FAO team in charge of updating the healthy diet affordability data used in *The State of Food Security and Nutrition in the World 2022* (FAO *et al.*, 2022).

Tracking changes in healthy diet costs

It is possible to map each MIRAGRODEP sector *i* , with detailed commodities *c*. We define $\hat{p}_r^c$ as the price variation of a commodity *c* belonging to sector *i*. The main assumption here is that the relative price change for each commodity $\hat{p}_r^c$ is given by the $\hat{p}_r^i$ of the CGE for each good *c* $\in i.$ This means that, at the product level, we can use the prices for each sector/food group from the CGE model to calculate healthy diet costs.

Therefore, it is straightforward to compute the change in the cost of diets:

$$\underline{Diet}_r^1 = \sum_c p_r^c \cdot (1 + \boldsymbol{\hat{p}_r^c}) \cdot \underline{x}_r^c$$

$$= \underline{Diet}_r^{base} \left(1 + \sum_c sh_r^c \cdot \hat{p}_r^c\right)$$

$$= \underline{Diet}_r^{base} (1 + \sum_i SH_r^i \cdot \hat{p}_i^c)$$

with $SH_r^i = \sum_{c \in i} sh_r^c \cdot \hat{p}_r^c$

Obviously, this approach means that we do not consider changes in the composition of the reference healthy diet for each country. This assumption is reasonable in case of limited, absolute or relative, price changes. This is discussed more at length in the next section on limitations. This could also be interpreted as a nutrition-poverty line using a *Laspeyres* index definition (base weights).

We also do not need the detailed weight-shares, sh_r^c, originated from the cost minimization exercise but rather only the summary statistics regarding the aggregated weights by product category, SH_r^i.

Tracking changes in household income and food expenditures

Using the MIRAGRODEP approach of changes in income, capturing changes in terms of wages, remittances, output prices for smallholders etc., a new income distribution is generated, based on actual household surveys. We therefore compare either the income or (a more precise measure) the assumed food expenditure (63 percent of total expenditures) to the updated minimal-expenditures level obtained previously. The underlying assumption is that the theoretical share of income spent on food is fixed and does not change during the shock (no behavioural response). From this, we have also the change in the distribution of z, $\hat{z}_r^h$, for each household. Practically speaking, we have post-shock, or projected, distribution ${}^1f(y)$ and ${}^1g(z)$, and incidentally ${}^1f(\ \mu y)$. While we use this parametric representation for the sake of clarity, the computation is done in the modelling framework by applying these changes to each household in the household survey of each country, in order to track income changes at the household level.

Since we have now the revised distribution ${}^1g(z)$ and a new diet cost $\underline{Diet}_r^1$, we can now compute the new number of people in the population for which a healthy diet is unaffordable $NutritionPoorZ_r = \int_0^{\underline{Diet}_r^1,} {}^1g(z)\,dz$.

This computation is done for each year and for each simulation, making it possible to track the percent of population that could afford a healthy diet in all modelling outcomes.

Limitations

The main limitation of the current approach is the assumption that there is no change in the composition of the cost-minimized diets. Indeed, the results of the optimization program detailed in (1) could be modified only by significant changes in **relative** prices. In any case, the potential bias of our approach **is to overestimate the increase in the recommended basket prices.**

Of course, a more advanced procedure could involve estimating the full vector of $\hat{p}_r^c$ and re-running the optimization program in (1). This would be more time-consuming and would have limited potential gains. Indeed, two main elements should be kept in mind:

- The CGE level analysis will not provide different price changes for various products c belonging to the same CGE aggregate i. So, all fruits – if gathered in one sector – will face the same price changes. Except when very heterogenous shocks are considered – specific product subsidy/tax, or specific productivity shock – there is limited reason to assume intra-commodity group heterogeneity. Indeed, the production function (value-added structure, input use) information we have does not provide heterogenous cost structure. Similarly, income and price elasticities information remains limited, or highly noisy at the product level, and considering homogeneity by product group is a safer option. Therefore, using similar behavioural response and cost structure, the CGE model will generate the same price changes, except if heterogenous shocks are introduced.

- The previous remark has a direct impact about how the sh_r^c is expected to change. If all elements $c \in \boldsymbol{i}$ face the same price changes, and we do not have strong evidence of heterogenous income and direct price elasticities for the products belonging to the same i, we expect that:
  - no direct substitution will take place (relative prices are not changed), and
  - price and income responses will be the same.

Thus, the relative quantities and values will **not** change. The initial weights structure should be kept. This also implies that the initial ranking of products within a food group are not modified by the shock.

In this context, only two situations should require a specific action:

- Heterogenous shocks to specific products can reverse the relative ranking among products within a category, therefore leading to potential discontinuity in the targeted diet composition. (One product could fully disappear and be replaced by another one that will become less expensive in absolute terms). However, the practical consequences of such a case are very limited for our purpose. Indeed, the overall impact on the total diet will be quite limited and it can be proven that the potential error term is a third-degree or fourth-degree term when doing a tailored expansion of the overall cost formula around the solution of the initial optimization problem.
- Another concern is if there is a mismatch between the CGE product classification and the diet category. A simple example is the definition of the cereal group. Typically, the cost minimization exercise could consider that x grams of daily energy intake should come from one staple (either in terms of grains or flour), for instance wheat or maize. Depending on the country, and existing prices, one or the other cereal is included in the least-cost healthy diet and will be gathered into a staple category. However, for most common exercises, wheat and maize are kept separated in the CGE (different cost structure, yield dynamics, policies, links with the livestock or bioenergy sector, etc). Therefore, we have two products, two elements of c, that are considered as substitutes in the cost-of-diets exercise, and that are, in many cases, mutually exclusive, while the CGE will keep track of different price dynamics and therefore associate them with two distinct elements of i. Some solutions to this issue are currently implemented, mainly assuming that rice-based healthy diets (for instance, those in Asia), wheat-based healthy diets (such as those in Europe) and maize- and other grains-based healthy diets (such as those in Central America), will not be revolutionized by the shocks, and that the existing main cereal (or the existing mix) will continue to prevail. The methodology can be still fine-tuned.

In the policy simulations conducted in this report, we have processed *ex post* checks regarding relative price variations and concluded that none of these situations should occur on a significant scale.

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ISBN 978-92-5-137641-6 ISSN 2664-5785

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CC4348EN/1/02.23