Food and Agriculture Organization
of the United Nations

Optimizing allocation of public expenditure to accelerate agrifood system transformation with environmental sustainability in Rwanda – the ongoing work

Marco V. Sánchez

Deputy Director, Agrifood Economics & Policy Division, FAO
Head, Monitoring and Analysing Food and Agricultural Policies (MAFAP) programme, FAO

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1. Context

First policymaker dilemma: What objectives to prioritize and how to maximize synergies and minimize trade-offs?

	Objectives	Synergies	Trade-offs
BETTER PRODUCTION	***Produce more*** to provide enough food today	Efficient resource use; healthier ecosystem	Environmental degradation as agriculture intensifies
BETTER NUTRITION	***Deliver good food*** for all through healthy diets	Improved public health	Challenges for some sectors transitioning to healthier diets
BETTER ENVIRONMENT	***Protect the environment*** for society and resilience	Improved public health	Temporary disruption of supply chains or economic stability
BETTER LIFE	***Support farmers income*** to promote inclusive development	Poverty reduction Inequality reduction	Market distortions Land degradation

Second policymaker dilemma: Agricultural policy support is more than subsidies; but, in some cases, it is very low

POLICY SUPPORT TO FOOD AND AGRICULTURE DIFFERS ACROSS COUNTRY INCOME GROUP

Total, average 2013–2018

USD 630 billion

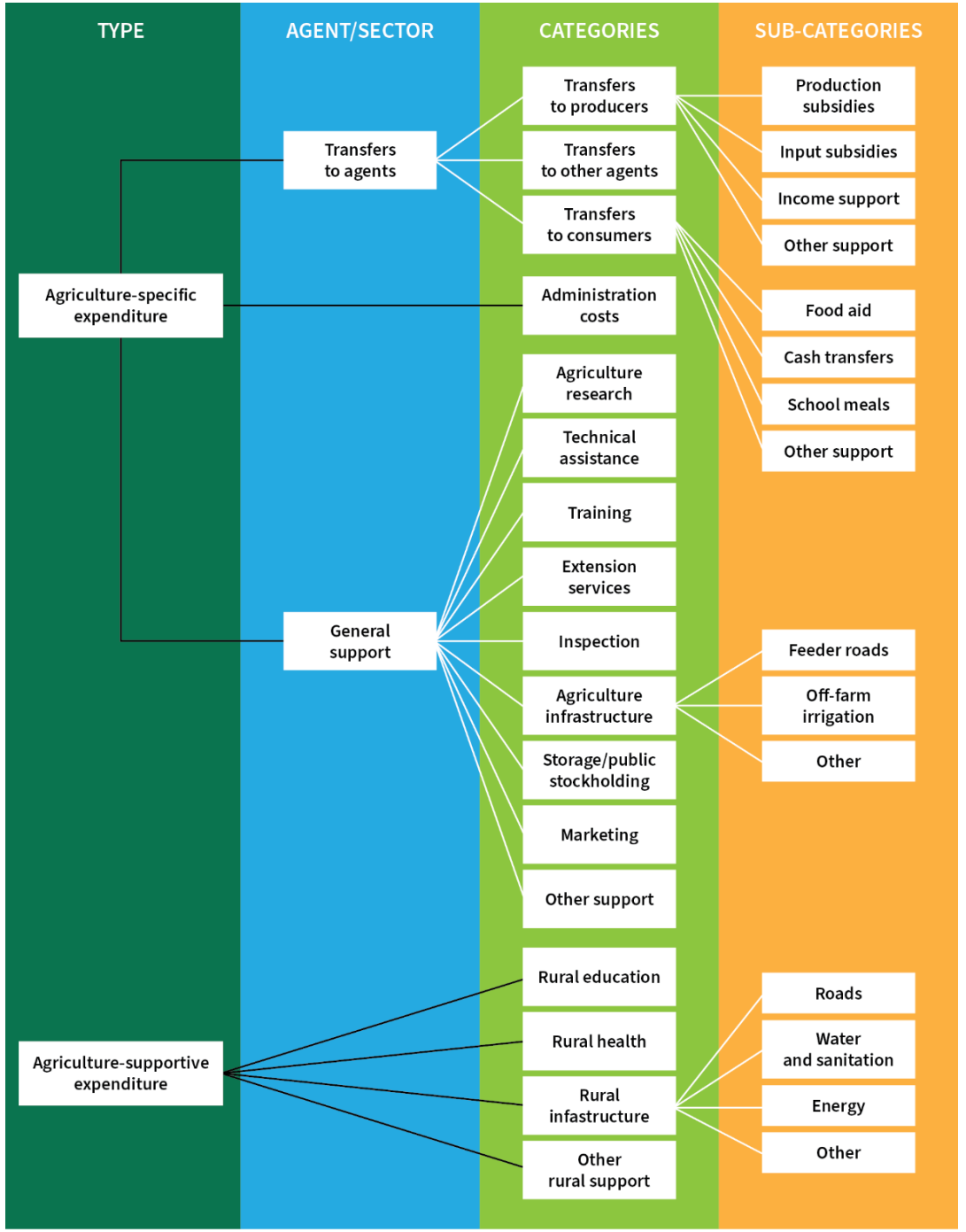
As a share of value of production, average 2013–2018

Country income group	Price incentives	Fiscal support (public expenditure)		
		Subsidies to producers	General services	Consumer subsidies
High-income countries	9.5%	12.6%	3.9%	4.6%
Upper-middle-income countries	10.8%	4.9%	3.0%	0.2%
Lower-middle-income countries	-7.6%	4.1%	2.5%	2.6%
Low-income countries	-9.5%	0.6%	2.3%	0.6%
Share of total, average 2013–2018	**32%**	**39%**	**18%**	**11%**

Source: FAO, IFAD, UNICEF, WFP and WHO. (2022) *The State of Food Security and Nutrition in the World 2022. Repurposing food and agricultural policies to make healthy diets more affordable.*

FAO's Monitoring and Analyzing Food and Agricultural Policy (MAFAP) programme

- A highly-recognized methodology to monitor public expenditure on food and agriculture.
- In-country capacity development training.
- In-depth classification analysis:
  - **Level of spending** and funding gaps
  - **Expenditure composition** (by type, sector, commodity, geographic area, etc.)
  - **Execution** vis-à-vis budget
  - **Coherence** vis-à-vis objectives and policies
- It allows us to map public expenditure data and its allocation across **policy-support measures (PSMs)**



Third policymaker dilemma: Too little money! Too many policies! What to prioritize/deprioritize?

Ethiopia

289 policy-support measures

	Commodity taxes (including tariffs) to promote production/consumption of a given commodity	Fertilizer subsidies	Seed subsidies	Extension services	R&D	Rural roads	Irrigation	Mechanization	Rural electricity	Cash transfers
Sugar cane	X	X	X	X	X	X	X	X	X	
Tobacco	X	X	X	X	X	X	X	X	X	
Cotton	X	X	X	X	X	X	X	X	X	
Flowers	X	X	X	X	X	X	X	X	X	
Cocoa	X	X	X	X	X	X	X	X	X	
Coffee	X	X	X	X	X	X	X	X	X	
Tea	X	X	X	X	X	X	X	X	X	
Vanilla	X	X	X	X	X	X	X	X	X	
Other cash crops	X	X	X	X	X	X	X	X	X	
Wheat	X	X	X	X	X	X	X	X	X	
Maize	X	X	X	X	X	X	X	X	X	
Rice	X	X	X	X	X	X	X	X	X	
Sorghum	X	X	X	X	X	X	X	X	X	
Millet	X	X	X	X	X	X	X	X	X	
Other cereal crops	X	X	X	X	X	X	X	X	X	
Vegetables	X	X	X	X	X	X	X	X	X	
Soybeans	X	X	X	X	X	X	X	X	X	
Groundnuts	X	X	X	X	X	X	X	X	X	
Sesame	X	X	X	X	X	X	X	X	X	
Sunflower	X	X	X	X	X	X	X	X	X	
Potatoes	X	X	X	X	X	X	X	X	X	
Cassava	X	X	X	X	X	X	X	X	X	
Other tubers	X	X	X	X	X	X	X	X	X	
Legumes	X	X	X	X	X	X	X	X	X	
Bananas	X	X	X	X	X	X	X	X	X	
Other fruits	X	X	X	X	X	X	X	X	X	
Cattle and buffaloes	X			X	X	X		X	X	
Goats	X			X	X	X		X	X	
Sheeps	X			X	X	X		X	X	
Swine/pigs	X			X	X	X		X	X	
Poultry	X			X	X	X		X	X	
Bee and natural honey	X			X	X	X		X	X	
Other animal products	X			X	X	X		X	X	
Forestry	X			X	X	X		X	X	
Fisheries	X			X	X	X		X	X	
Households										X

Third policymaker dilemma: Too little money! Too many policies! What to prioritize/deprioritize?

Ghana

175 policy-support measures

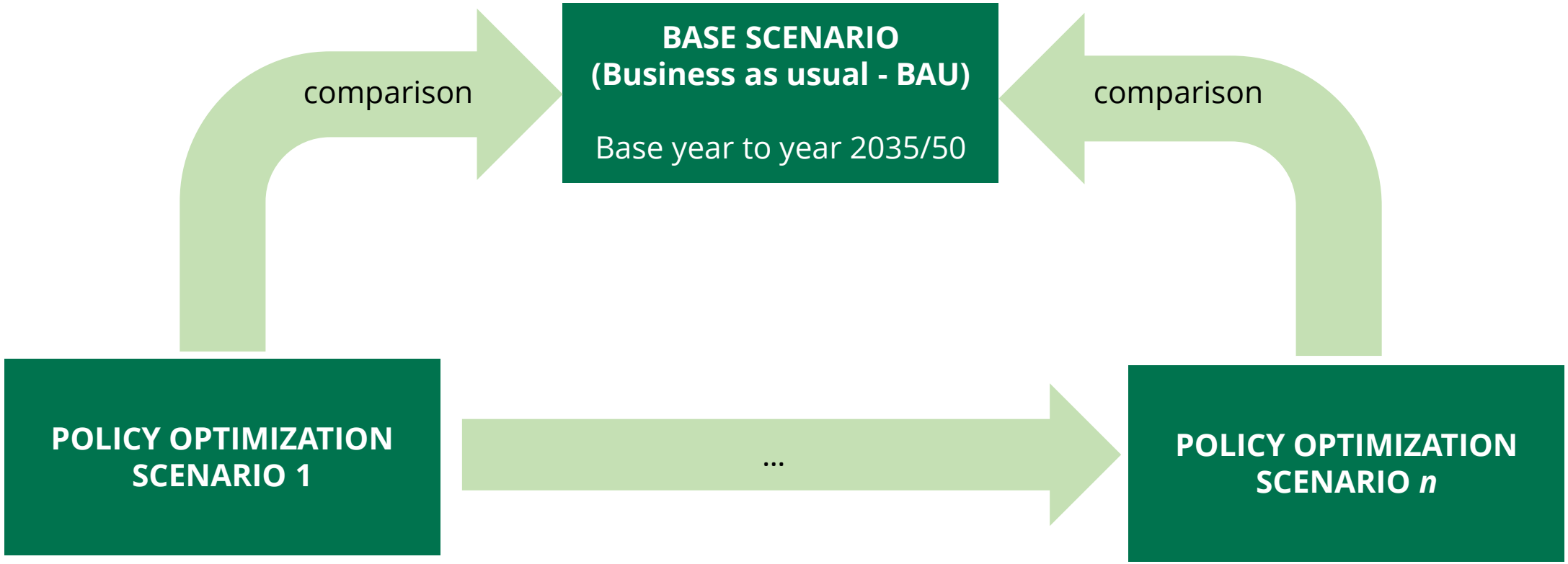
		Commodity subsidy		Government consumption		Government investment				Government transfers
	Commodity taxes (including tariffs) to promote production/consumption of a given commodity	Fertilizers	Seeds	Extension	R&D	Rural roads	Irrigation	Mechanization	Rural electricity	Cash transfers
Maize	X	X	X	X	X	X	X	X	X	
Sorghum and millet	X	X	X	X	X	X	X	X	X	
Rice	X	X	X	X	X	X	X	X	X	
Pulses	X	X	X	X	X	X	X	X	X	
Groundnuts	X	X	X	X	X	X	X	X	X	
Oilseeds	X	X	X	X	X	X	X	X	X	
Cassava	X	X	X	X	X	X	X	X	X	
Other roots	X	X	X	X	X	X	X	X	X	
Vegetables	X	X	X	X	X	X	X	X	X	
Sugar cane	X	X	X	X	X	X	X	X	X	
Tobacco	X	X	X	X	X	X	X	X	X	
Cotton	X	X	X	X	X	X	X	X	X	
Nuts	X	X	X	X	X	X	X	X	X	
Fruits	X	X	X	X	X	X	X	X	X	
Cocoa	X	X	X	X	X	X	X	X	X	
Other crops	X	X	X	X	X	X	X	X	X	
Cattle	X	X	X	X	X	X	X	X	X	
Poultry	X	X	X	X	X	X	X	X	X	
Other livestock	X	X	X	X	X	X	X	X	X	
Forestry	X	X	X	X	X	X	X	X	X	
Fishing	X	X	X	X	X	X	X	X	X	
Households										X

2. PolOpT in a nutshell

PolOpT in a nutshell

- **Multi-criteria decision making technique + computable general equilibrium (CGE) model.**
- **This economy-wide modelling framework combines:**
  - Policy objectives that can be prioritized using weights.
  - Policy instruments to achieve objectives.
  - Bounds on policy instruments.
  - Government financing mechanisms.
  - Restrictions from CGE model → institutions' budget constraints & market equilibrium conditions
- **What does it do?**
  - Allows "policymaker" to improve on priority policy objectives, considering weights.
  - Identifies an ideal/utopian solution or point of reference for policymaker (e.g. quasi zero poverty).
  - Finds solution as close as possible to the ideal solution under the existent constraints.
  - Best possible compromise for policy objectives considering all constraints.

Evidence from comparing policy optimization scenarios and a business-as-usual scenario



Combinations of potential changes: selection of policy objectives and their relative weights; policy instruments to optimize, budget neutrality or alternative financing options; bounds to policies instruments/financing, etc.

Optimize policy-support measures for crops and livestock to ⇨		Socioeconomic objectives					Environmental objectives	
		maximize agrifood GDP	maximize agricultural exports	maximize rural off-farm employment	minimize rural poverty	minimize the cost of a healthy diet	minimize GHG emissions from agriculture	minimize deforestation
Single-objective scenarios	Weights	1	0	0	0	0	0	0
	Weights	0	1	0	0	0	0	0
	Weights	0	0	1	0	0	0	0
	Weights	0	0	0	1	0	0	0
	Weights	0	0	0	0	1	0	0
	Weights	0	0	0	0	0	1	0
	Weights	0	0	0	0	0	0	1
Multiple-objective scenarios	Weights	0.20	0.20	0.20	0.20	0.20	0	0
	Weights	0.14	0.14	0.14	0.14	0.14	0.14	0.14

Main transmission mechanisms

Policy-support measures (PMS)

- Seeds subsidies
- Fertilizer subsidies
- Extension services
- Research and development
- Breeding programmes
- Feeding programmes
- Investment in irrigation
- Investment in mechanization
- Investment in rural electrification
- Investment in rural roads

If not budget neutral, then financing:

- indirect and/or direct taxation
- domestic borrowing
- foreign borrowing
- foreign grants
- mix of the above

Total factor productivity by sector

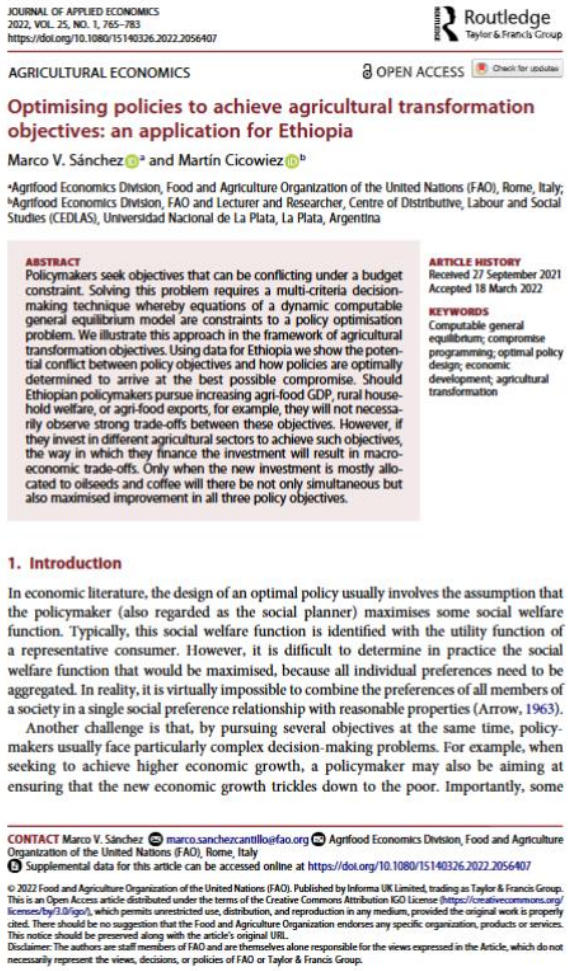
- Elasticities
- Coverage ratios
- Unit costs

→ effectiveness by which PSMs can increase productivity
→ exposure to PSMs
→ cost of scaling up the intervention

- Prices

Economy-wide effects depending on objectives pursued

An internationally peer-reviewed and published tool



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AGRICULTURAL ECONOMICS

OPEN ACCESS

Optimising policies to achieve agricultural transformation objectives: an application for Ethiopia

Marco V. Sánchez [a] and Martín Cicowiez [b]

[a]Agrifood Economics Division, Food and Agriculture Organization of the United Nations (FAO), Rome, Italy; [b]Agrifood Economics Division, FAO and Lecturer and Researcher, Centre of Distributive, Labour and Social Studies (CEDLAS), Universidad Nacional de La Plata, La Plata, Argentina

ABSTRACT

Policymakers seek objectives that can be conflicting under a budget constraint. Solving this problem requires a multi-criteria decision-making technique whereby equations of a dynamic computable general equilibrium model are constraints to a policy optimisation problem. We illustrate this approach in the framework of agricultural transformation objectives. Using data for Ethiopia we show the potential conflict between policy objectives and how policies are optimally determined to arrive at the best possible compromise. Should Ethiopian policymakers pursue increasing agri-food GDP, rural household welfare, or agri-food exports, for example, they will not necessarily observe strong trade-offs between these objectives. However, if they invest in different agricultural sectors to achieve such objectives, the way in which they finance the investment will result in macroeconomic trade-offs. Only when the new investment is mostly allocated to oilseeds and coffee will there be not only simultaneous but also maximised improvement in all three policy objectives.

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KEYWORDS
Computable general equilibrium; compromise programming; optimal policy design; economic development; agricultural transformation

1. Introduction

In economic literature, the design of an optimal policy usually involves the assumption that the policymaker (also regarded as the social planner) maximises some social welfare function. Typically, this social welfare function is identified with the utility function of a representative consumer. However, it is difficult to determine in practice the social welfare function that would be maximised, because all individual preferences need to be aggregated. In reality, it is virtually impossible to combine the preferences of all members of a society in a single social preference relationship with reasonable properties (Arrow, 1963).

Another challenge is that, by pursuing several objectives at the same time, policymakers usually face particularly complex decision-making problems. For example, when seeking to achieve higher economic growth, a policymaker may also be aiming at ensuring that the new economic growth trickles down to the poor. Importantly, some

CONTACT Marco V. Sánchez marco.sanchezcantillo@fao.org Agrifood Economics Division, Food and Agriculture Organization of the United Nations (FAO), Rome, Italy

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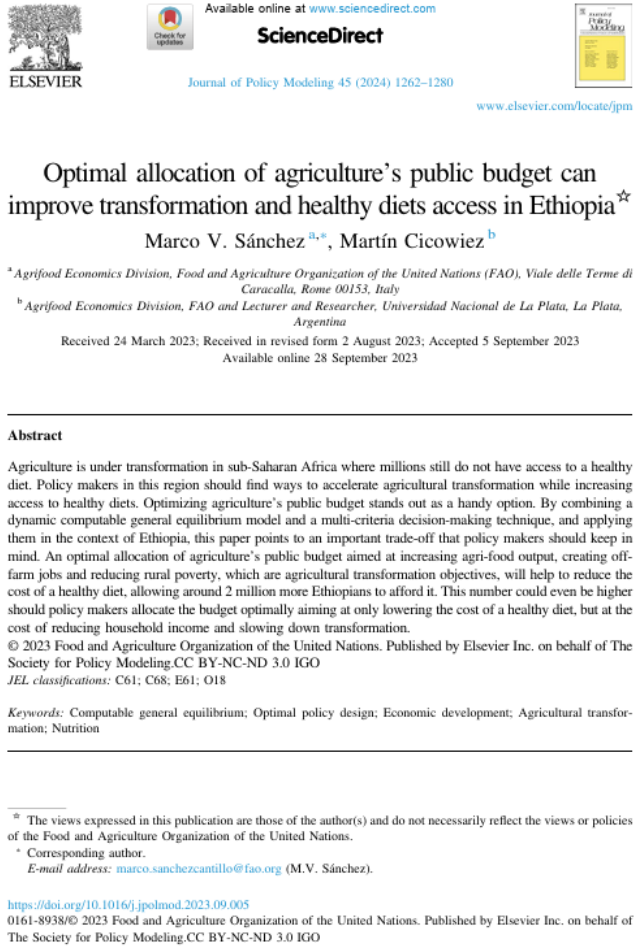

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Optimal allocation of agriculture's public budget can improve transformation and healthy diets access in Ethiopia☆

Marco V. Sánchez [a,*], Martín Cicowiez [b]

[a] *Agrifood Economics Division, Food and Agriculture Organization of the United Nations (FAO), Viale delle Terme di Caracalla, Rome 00153, Italy*
[b] *Agrifood Economics Division, FAO and Lecturer and Researcher, Universidad Nacional de La Plata, La Plata, Argentina*

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Abstract

Agriculture is under transformation in sub-Saharan Africa where millions still do not have access to a healthy diet. Policy makers in this region should find ways to accelerate agricultural transformation while increasing access to healthy diets. Optimizing agriculture's public budget stands out as a handy option. By combining a dynamic computable general equilibrium model and a multi-criteria decision-making technique, and applying them in the context of Ethiopia, this paper points to an important trade-off that policy makers should keep in mind. An optimal allocation of agriculture's public budget aimed at increasing agri-food output, creating off-farm jobs and reducing rural poverty, which are agricultural transformation objectives, will help to reduce the cost of a healthy diet, allowing around 2 million more Ethiopians to afford it. This number could even be higher should policy makers allocate the budget optimally aiming at only lowering the cost of a healthy diet, but at the cost of reducing household income and slowing down transformation.

JEL classifications: C61; C68; E61; O18

Keywords: Computable general equilibrium; Optimal policy design; Economic development; Agricultural transformation; Nutrition

☆ The views expressed in this publication are those of the author(s) and do not necessarily reflect the views or policies of the Food and Agriculture Organization of the United Nations.

* Corresponding author.
E-mail address: marco.sanchezcantillo@fao.org (M.V. Sánchez).

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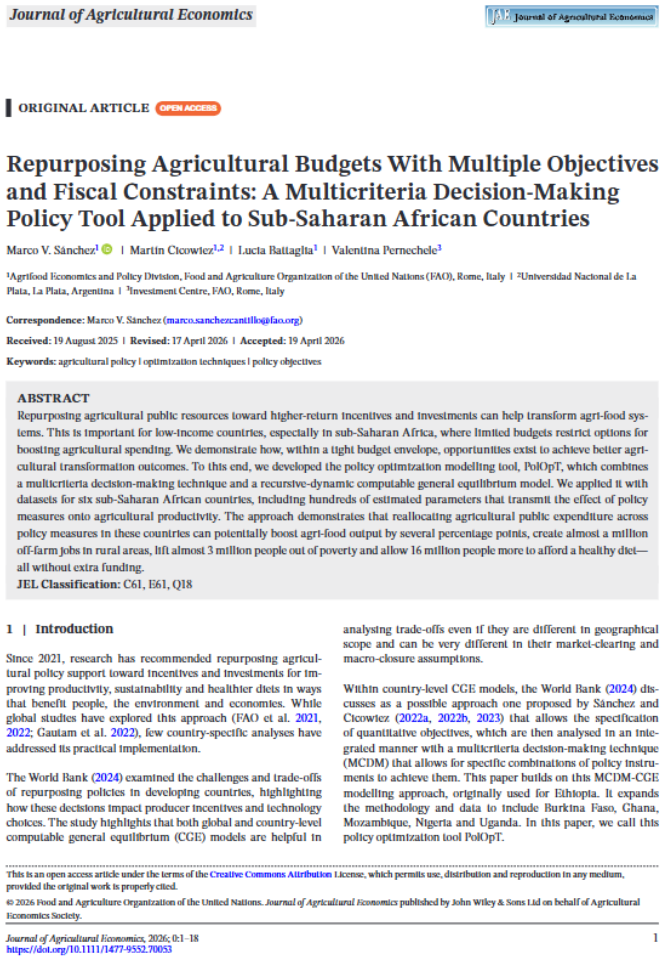

Journal of Agricultural Economics

ORIGINAL ARTICLE OPEN ACCESS

Repurposing Agricultural Budgets With Multiple Objectives and Fiscal Constraints: A Multicriteria Decision-Making Policy Tool Applied to Sub-Saharan African Countries

Marco V. Sánchez[1] | Martín Cicowiez[1,2] | Lucia Battaglia[1] | Valentina Pernechele[3]

[1]Agrifood Economics and Policy Division, Food and Agriculture Organization of the United Nations (FAO), Rome, Italy | [2]Universidad Nacional de La Plata, La Plata, Argentina | [3]Investment Centre, FAO, Rome, Italy

Correspondence: Marco V. Sánchez (marco.sanchezcantillo@fao.org)

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Keywords: agricultural policy | optimization techniques | policy objectives

ABSTRACT

Repurposing agricultural public resources toward higher-return incentives and investments can help transform agri-food systems. This is important for low-income countries, especially in sub-Saharan Africa, where limited budgets restrict options for boosting agricultural spending. We demonstrate how, within a tight budget envelope, opportunities exist to achieve better agricultural transformation outcomes. To this end, we developed the policy optimization modelling tool, PolOpT, which combines a multicriteria decision-making technique and a recursive-dynamic computable general equilibrium model. We applied it with datasets for six sub-Saharan African countries, including hundreds of estimated parameters that transmit the effect of policy measures onto agricultural productivity. The approach demonstrates that reallocating agricultural public expenditure across policy measures in these countries can potentially boost agri-food output by several percentage points, create almost a million off-farm jobs in rural areas, lift almost 3 million people out of poverty and allow 16 million people more to afford a healthy diet—all without extra funding.

JEL Classification: C61, E61, Q18

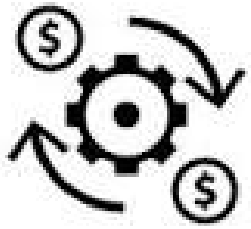
1 | Introduction

Since 2021, research has recommended repurposing agricultural policy support toward incentives and investments for improving productivity, sustainability and healthier diets in ways that benefit people, the environment and economies. While global studies have explored this approach (FAO et al. 2021, 2022; Gautam et al. 2022), few country-specific analyses have addressed its practical implementation.

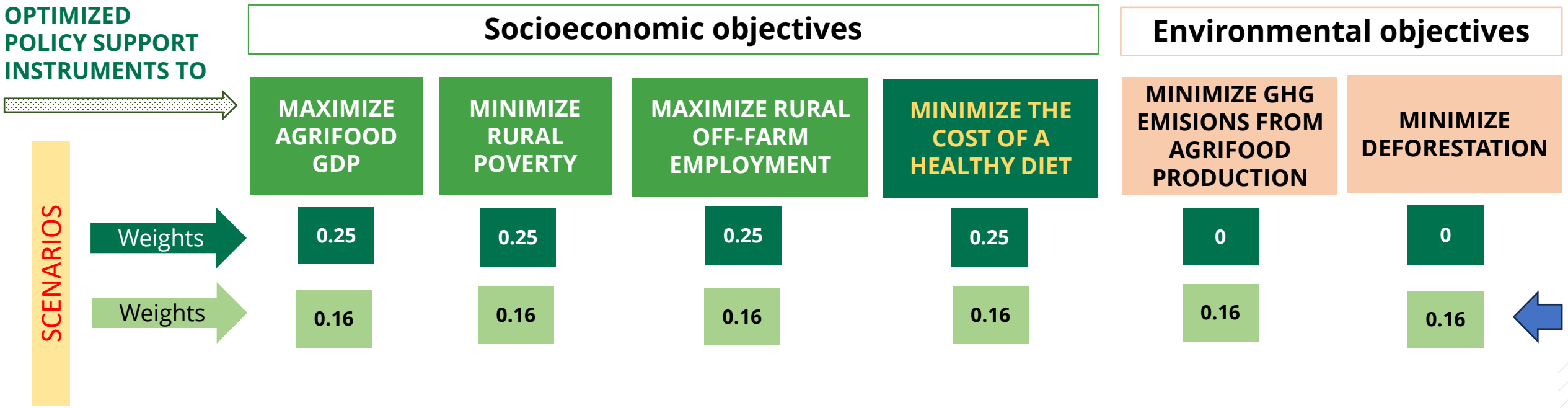
The World Bank (2024) examined the challenges and trade-offs of repurposing policies in developing countries, highlighting how these decisions impact producer incentives and technology choices. The study highlights that both global and country-level computable general equilibrium (CGE) models are helpful in analysing trade-offs even if they are different in geographical scope and can be very different in their market-clearing and macro-closure assumptions.

Within country-level CGE models, the World Bank (2024) discusses as a possible approach one proposed by Sánchez and Cicowiez (2022a, 2022b, 2023) that allows the specification of quantitative objectives, which are then analysed in an integrated manner with a multicriteria decision-making technique (MCDM) that allows for specific combinations of policy instruments to achieve them. This paper builds on this MCDM-CGE modelling approach, originally used for Ethiopia. It expands the methodology and data to include Burkina Faso, Ghana, Mozambique, Nigeria and Uganda. In this paper, we call this policy optimization tool PolOpT.

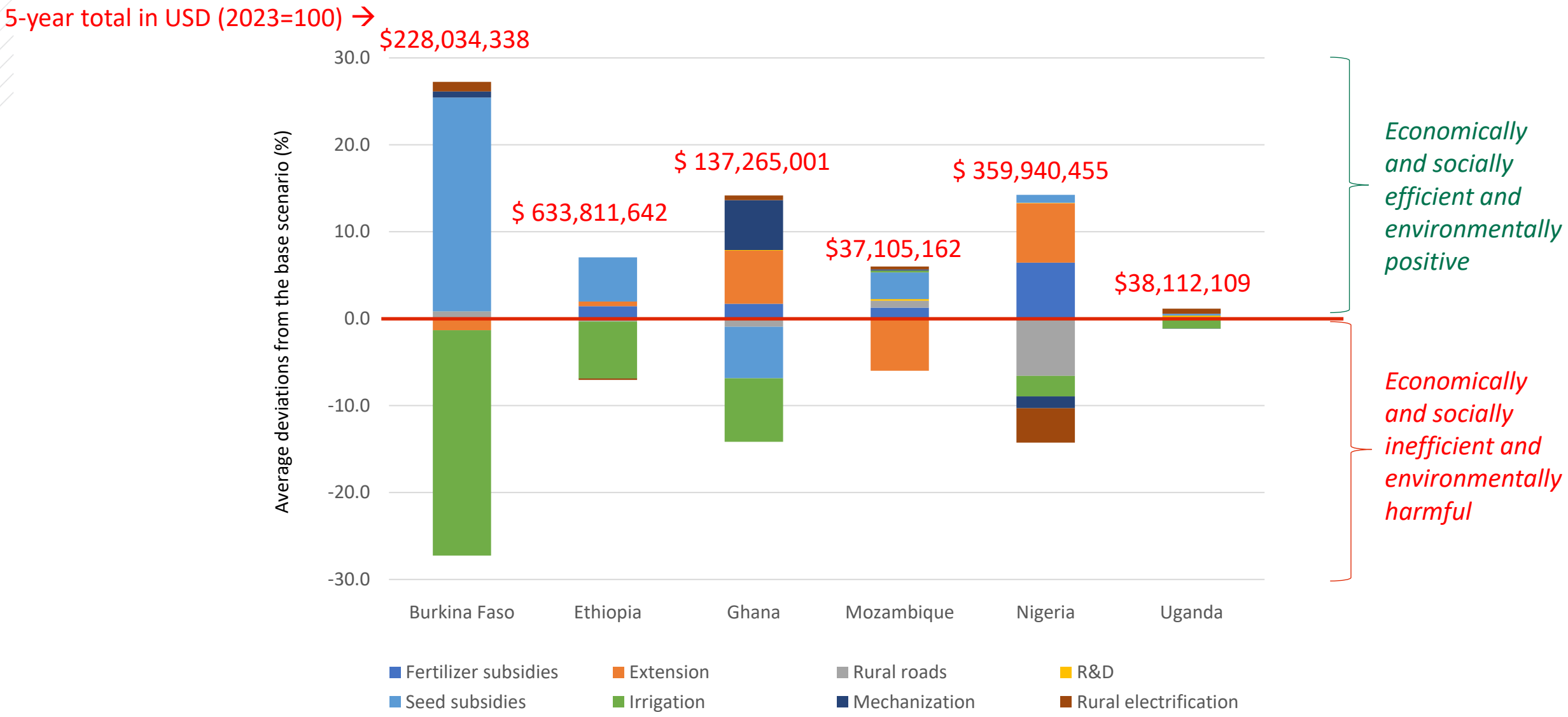
3. Multi-objective policy optimization scenarios: A sample of results



Example 1: Multi-objective policy optimization scenario with equal weights, including six objectives in six sub-Saharan African countries

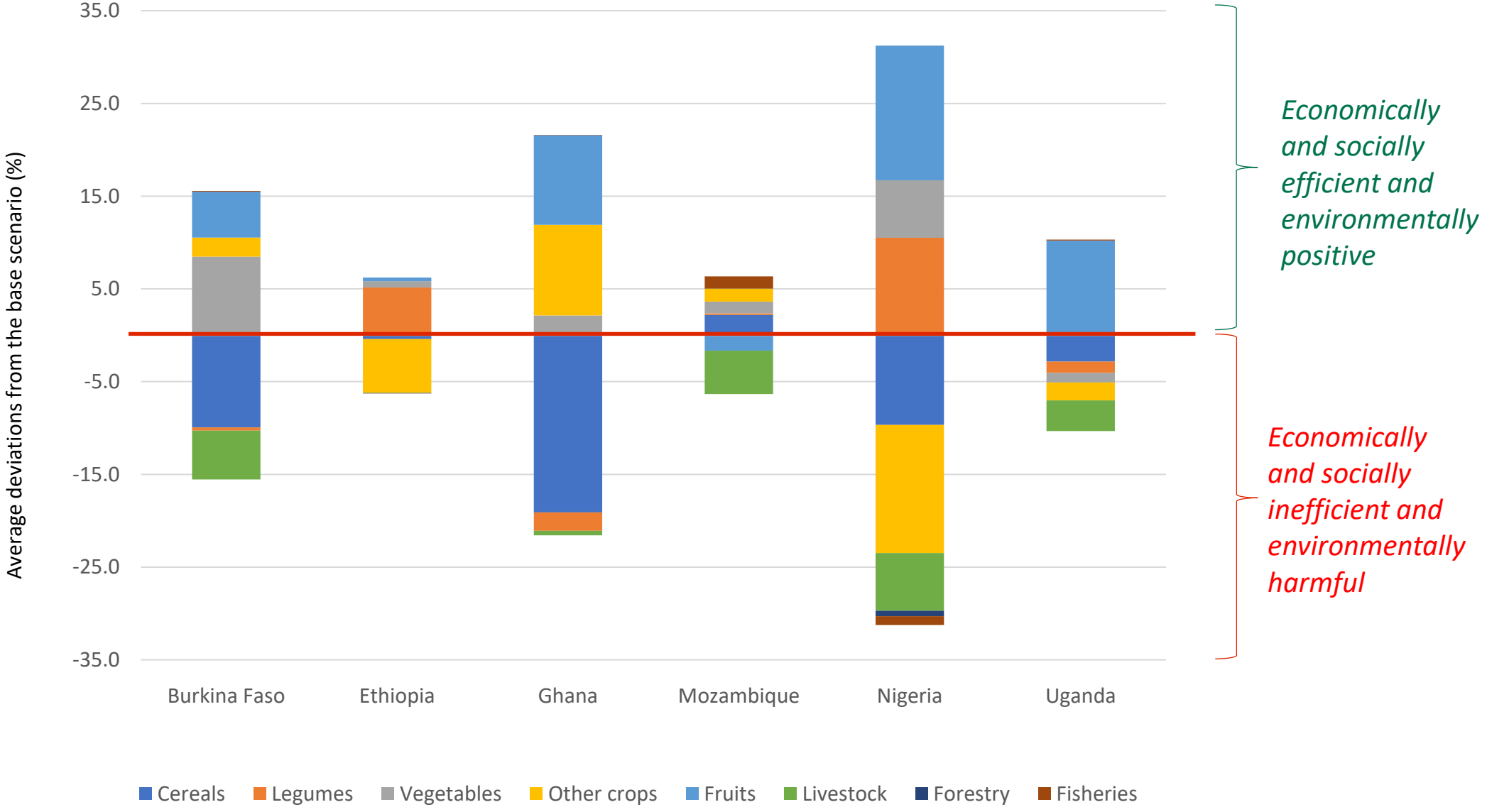


Budget support reallocation by policy-support measure in the crop farming and livestock sector in the optimization scenario with six policy objectives, 2026–30



Source: Marco V. Sánchez and Martín Cicowiez, PolOpT developers at FAO. https://openknowledge.fao.org/items/15f50469-de88-4ce2-a4ad-c5aa27ee132a

Budget support reallocation by subsector in the crop farming and livestock sector in optimization scenario with six policy objectives, 2026–30



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Socioeconomic benefits from optimizing policy support to pursue six policy objectives (compared with business-as-usual scenario)

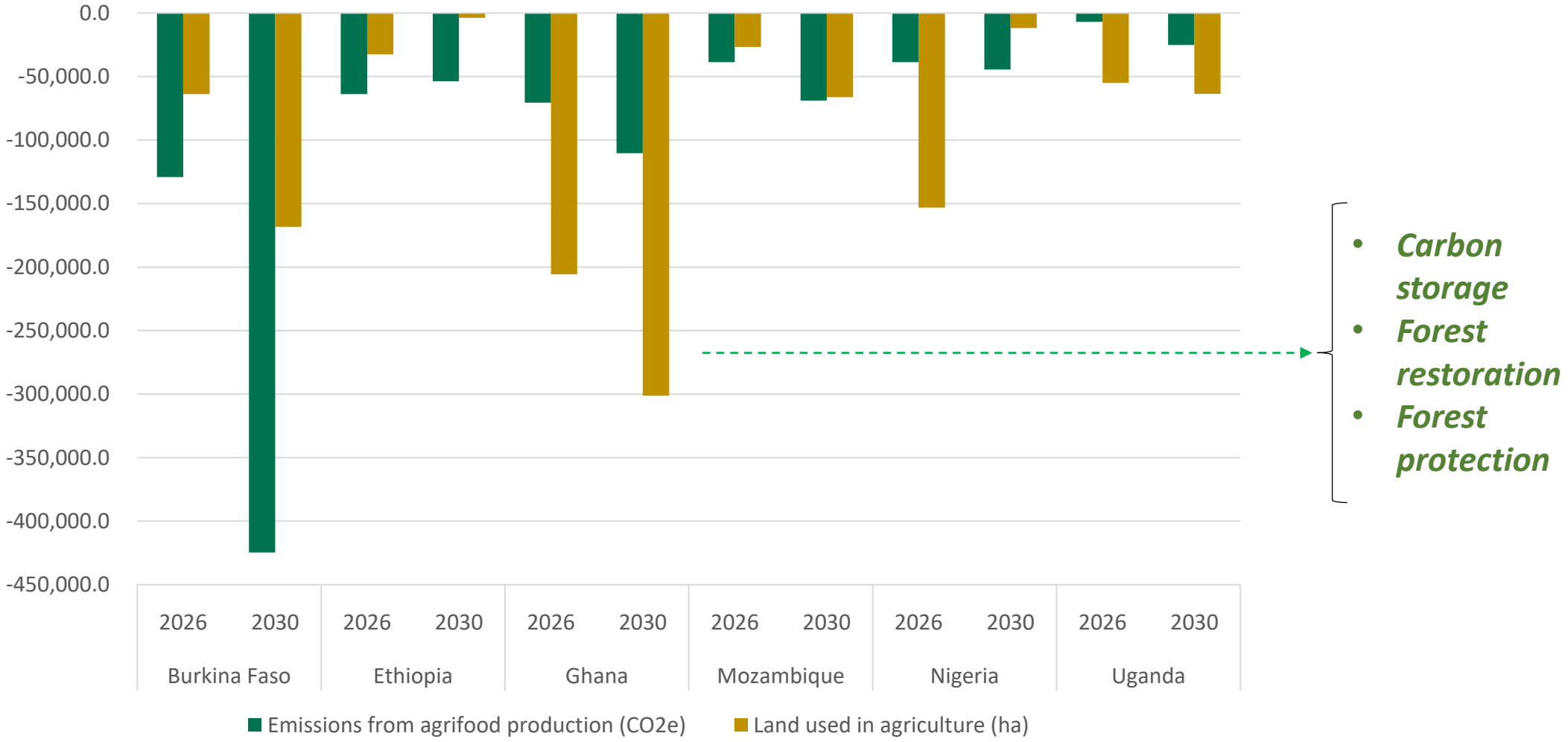





	Burkina Faso		Ethiopia		Ghana		Mozambique		Nigeria		Uganda	
	2026	2030	2026	2030	2026	2030	2026	2030	2026	2030	2026	2030
Agrifood GDP (%)	2.0	7.3	2.0	3.3	3.6	5.2	4.7	7.1	0.4	0.3	1.7	3.1
Off-farm jobs in rural areas (#)	33,977.5	87,844.3	40,211.4	56,573.2	84,350.5	114,994.7	55,456.6	100,689.6	108,228.7	67,952.5	65,879.8	93,032.8
People living in poverty (#)	-166,538.8	-511,102.3	-537,361.9	-709,382.7	-148,622.6	-186,357.8	-248,463.3	-432,312.7	-260,560.7	-168,364.9	-149,840.1	-163,395.7
People who cannot afford a healthy diet (#)	-387,170.6	-1,220,827.7	-2,846,134.2	-5,077,533.8	-2,065,331.3	-2,238,443.9	-592,067.3	-964,223.0	-1,314,857.7	-749,768.6	-926,846.8	-1,142,540.6

Source: Marco V. Sánchez and Martín Cicowiez, PolOpT developers at FAO. https://openknowledge.fao.org/items/15f50469-de88-4ce2-a4ad-c5aa27ee132a

Environmental benefits from optimizing policy support to pursue the six policy objectives (compared with the optimization scenario with only four socioeconomic objectives)



Source: Marco V. Sánchez and Martín Cicowiez, PolOpT developers at FAO. https://openknowledge.fao.org/items/15f50469-de88-4ce2-a4ad-c5aa27ee132a

Evidence from policy optimization scenarios is informing policy and planning through FAO's MAFAP programme

Country	Counterpart	Policy/planning	Purpose	Status
Burkina Faso 	Ministry of Agriculture	• Étude prospective 2050	Inform medium-term policy/investment planning with environmental sustainability	Forthcoming
Mozambique 	Ministry of Agriculture, Environment and Fisheries	• Plano Estratégico de Desenvolvimento do Sector Agrário 2026-2035 (PEDSA III) • National Agricultural Investment Plan (PNISA III) 2026–2030	Inform sectoral prioritization of agricultural investments with environmental sustainability	**Ongoing**
Nigeria 	Federal Ministry of Agriculture and Food Security (FMAFS)	• National Agrifood Systems Investment Plan (NASIP) 2026-2027	Inform sectoral prioritization of agricultural investments with environmental sustainability	**Concluded**
Bangladesh 	Ministry of Agriculture	• Agriculture sector Transformation Programme (AsTP)	Inform sectoral prioritization of crop sector investments with environmental sustainability	**Ongoing**

Example 2: Multi-objective policy optimization scenarios with equal weights (i.e. five- and seven-objective scenarios) in Rwanda (work in progress!)

Optimize policy-support measures for crops and livestock to ⇨	Socioeconomic objectives					Environmental objectives	
	maximize agrifood GDP	maximize agricultural exports	maximize rural off-farm employment	minimize rural poverty	minimize the cost of a healthy diet	minimize GHG emissions from agriculture	minimize deforestation
Multiple-objective scenarios							
Weights ⇨	0.20	0.20	0.20	0.20	0.20	0	0
Weights ⇨	0.14	0.14	0.14	0.14	0.14	0.14	0.14

4. Final considerations

Key takeaways

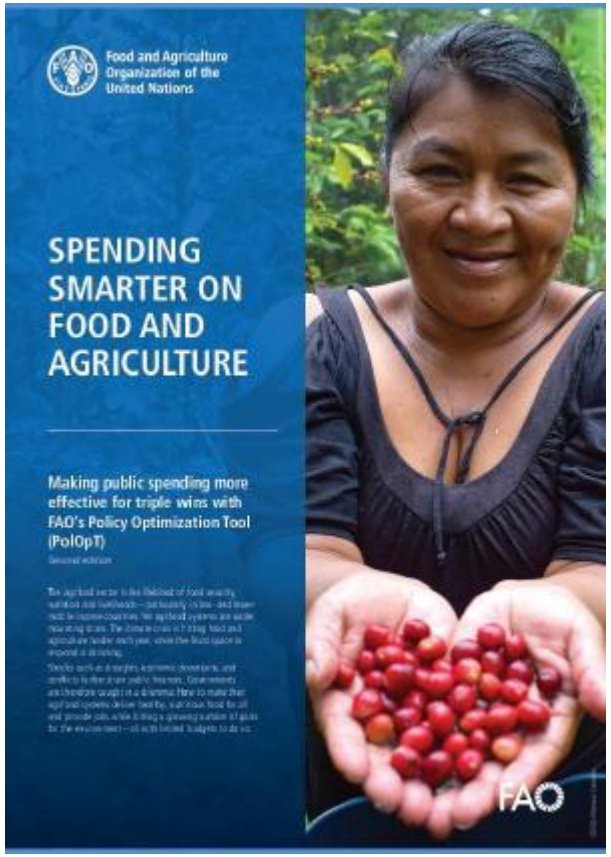
- Optimization of budget allocations across policy-support measures (PSMs) for crops and livestock subsectors allows us to identify:
  - cost-effectiveness (or lack thereof) of PSMs
  - potential reallocations across PSMs (and subsectors) with payoffs
- In the case of Rwanda, these reallocations can potentially bring about significant economic and social payoffs:
  - boosting agrifood output and exports several percentage points
  - creating thousands of jobs
  - lifting hundreds of thousands out of poverty
  - making healthy diets affordable for almost a million
- Compromising for the environment implies adjustments in reallocations
  - millions of GHG emissions less
  - thousands of hectares of land not used in agriculture (not deforested)
  - at the cost of a trade-off for economic and social outcomes but with still significant socioeconomic payoffs

Cautionary notes

- Model-based exercise with prospective scenario results largely determined by key assumptions of the tool
  - projections of what should be expected to occur under very specific conditions (e.g., no world price shocks!), rather than forecasts of what will happen.
  - focus on direction rather than exact magnitude.
  - the suggestion is not to fix existing allocative inefficiencies or immediately reallocate to where the allocative efficiencies are; the purpose is to show this evidence!
- Only a % of total expenditure in agriculture (specific and supportive) is being considered and optimized
  - focus on expenditures that affect on-farm productivity
  - parameters cannot be computed for all PSMs due to micro-data limitations
- Reallocations are budget neutral; though the impact of increased budgets can be assessed.

What PolOpT does not capture

- Political economy of policy reform — public expenditure cuts in some areas may face strong resistance from farmer lobbies and traders.
- Implementation capacity constraints — reallocating public resources to inputs may require functioning distribution systems that do not yet fully exist.
- Private sector response — private sector may not invest in fertilizer or seeds at the required scale unless there is awareness and stakeholder engagement.
- Climate shocks are not predicted — drought or flooding years would alter outcomes significantly.
- Nutrition behaviour change — lower diet cost increases the consumption of nutritious foods but in practice this may not be easy if cultural food preferences are strong. Nutritional outcomes *per se* are not captured.



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Thank you!

E-MAIL: marco.sanchezcantillo@fao.org

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