Ceres2030
Sustainable Solutions to End Hunger

POLICY BRIEF

A Policy-Centred Approach to Prioritize Effective Interventions to End Hunger

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ABSTRACT

Achieving the 2030 Agenda and the goals on addressing hunger, such as Sustainable Development Goal (SDG) 2, integrated and policy-relevant tools are needed to identify specific interventions and costs to assist with SDG 2 and another SDG implementation. Motivated by the need for tools to support evidence-based policy-making, three partner organizations—Cornell University, the International Food Policy Research Institute and the International Institute for Sustainable Development—formed a three-year partnership in 2018 called Ceres2030: Sustainable Solutions to End Hunger, with a focus on the targets of SDG 2. Drawing from the results from Ceres2030, this paper helps broadens the evidence base for effective interventions using a top-down macroeconomic model to evaluate and cost a portfolio of diverse actions, related trade-offs, and synergies to achieve the SDG targets. In addition, the research also assists by outlining ways of combining grey and peer-reviewed literature to improve evidence-based decision making by assisting policy-makers and donor agencies in allocating costs to policy options over the next decade necessary to achieve SDG 2 targets.

Keywords: SDG 2, agriculture, hunger, food security, CGE model

1. INTRODUCTION

Since the United Nations (UN) adopted the 2030 Agenda for Sustainable Development in September 2015, implementation efforts have focused on translating the Sustainable Development Goals (SDGs) into national strategies, implementation programs, and indicators to monitor progress.[1] Research in support of these efforts by national governments has remained largely technical, with a focus on monitoring the SDGs, understanding interaction between goals and targets (Reyers et al., 2017), and assessing the feasibility of achieving specific targets (Weitz et al., 2018). Recently, it has been suggested that there is a need to increase the relevance of research for decision making by providing implementation guidance, for example through accounting for trade-offs and synergies, assessing systemic interactions between policies, tools, and planned interventions aimed at achieving the SDGs (Aguiar et al., 2020; Coscieme et al., 2020; Machingura & Lally, 2017; Stafford-Smith et al., 2017).

In addition, the UN 2030 Agenda commits governments to evidence-based decision making (UN General Assembly, 2015). In the context of the SDGs, this means identifying the evidence for the effectiveness of potential measures to meet SDG targets, and then developing methods to analyze and synthesize this evidence to support decision making (Faludi, 2006; Hackl et al., 2019).

Given the research needs already identified, evidence-based policy-making would require "a new generation of science" that explicitly engages in an integrated, contextualized evaluation of policy options and their complex effects (Aricò, 2014). For research to feed into such evaluations, both the sources of information and methods of evaluation are critical. Research should build on existing knowledge as much as possible, so it should capture not only academic literature but also grey literature not published by established commercial or academic publishers (Jesson et al., 2011), as well as the experience of experts and stakeholders (Shepherd et al., 2015; Ghezzi-Kopel et al., 2022). At the same time, to evaluate the effectiveness of potential interventions that would contribute to reaching SDG targets, top-down "macro framework" models are likely to be more useful in undertaking economy-wide analysis driven by long-term national goals and policies, and for exploring trade-offs, constraints, and synergies among such potential interventions (Allen et al., 2018). In order to capture the key inclusive development objectives embedded in the 2030 Agenda, the analysis would also need to account for access (to basic resources) and allocation (of rights, responsibilities, and risks) for the most vulnerable (Pouw & Gupta, 2017). It is apparent that any suite of policy interventions that could achieve the SDG targets would require considerable financial resources from different sources, including domestic and international funders (Caiado et al., 2018). Research efforts need to identify gaps in financial allocations as well as to encourage decision-makers to apply limited resources effectively (Mayne et al., 2018). Fiscal resources everywhere will be constrained further by the recent COVID-19 pandemic, which has created unprecedented challenges in terms of societies' resources and

[1] The UN has a website for the national voluntary review database, available here https://sustainabledevelopment.un.org/vnrs/

capacity to allocate them toward SDG targets, further constraining our collective ability to meet the 2030 Agenda (UN, 2020a).

Drawing from a larger research project, this paper provides an overview of the challenges and opportunities for targeted research support to decision-makers in achieving the targets of SDG 2. In particular, this paper contributes by broadening the evidence base for effective interventions, using a top-down macroeconomic model to evaluate and cost a portfolio of diverse actions, related trade-offs, and synergies to achieve SDG targets. In our analysis, we also consider the effects of COVID-19 and the additional resource demands it involves.

METHODOLOGICAL APPROACH

Motivated by the need for tools to support evidence-based policy-making, three partner organizations—Cornell University, the International Food Policy Research Institute and the International Institute for Sustainable Development—formed a 3-year partnership in 2018 called Ceres2030: Sustainable Solutions to End Hunger, with a focus on the targets of SDG 2.

FOCUS ON SDG 2

Today 690 million people are hungry, an increase of 60 million people over the past 5 years (Food and Agriculture Organization of the United Nations [FAO] et al., 2020). As a result of COVID-19, a further 95 million people will be living in extreme poverty and hunger (Laborde & Smaller, 2020). Ironically, the very people whose livelihoods depend on food and agriculture are among the most likely to experience hunger (Bacon et al., 2014). To address these challenges, SDG 2 incorporates very different but closely interacting targets with the goal of ending hunger. For example, interventions to achieve SDG 2.3 (doubling productivity and incomes of small-scale food producers) will also have impacts on the sustainability of the production system and food consumption patterns—thus affecting the achievement of SDG 2.2 and 2.4 (Lipper et al., 2020). In addition, actions taken to achieve the SDG 2 targets also impact other SDGs: for example, land conversion to agriculture will impact SDG 15 on land and biodiversity, use fossil fuels in production will improve energy access to fulfill SDG 7 while negatively impacting goals on climate change (SDG 13) and acidification of oceans (SDG 14).

RESEARCH FOCUS AND QUESTIONS

Our project is focused on SDG 2.1 (ending hunger), SDG 2.3 (doubling the productivity and income of small-scale food producers), and SDG 2.4 (ensuring agricultural sustainability and resilience). We attempt to answer two questions:

- What does the published evidence tell us about agricultural interventions that work, in particular to double the incomes of small-scale producers and to improve environmental outcomes for agriculture?
- What will it cost governments to end hunger, double the incomes of small-scale producers, and protect the climate by 2030?

Nutrition (Target 2.2) was not the focus of this project because other global efforts, such as those by 1000 Days, R4D, and the World Bank, have already estimated the cost of ending malnutrition (see Shekar et al., 2015).

KEY ELEMENTS OF THE APPROACH

The project applied insights from systematic evidence reviews that examined documented effective interventions relevant to the selected SDG 2 targets. It used an economic model integrating the costs and income gains of these interventions into the national and global economies. In addition, members of the project team were in dialogue with decision-makers, development assistance donors, and experts working in academia and intergovernmental organizations to calibrate methods and conclusions with priority areas for application.

ABOUT THE EVIDENCE SYNTHESIS

The evidence synthesis identified interventions to achieve the selected SDG targets, such as focusing on small-scale food producers, improving the income and food security of these groups as well as reducing the environmental impacts of their agricultural production. The evidence synthesis combined standardized review methodologies to limit bias, maximize transparency, and ensure replicability in the retrieval and review of data (Gurevitch et al., 2018) with machine learning tools that allowed systematic review and synthesis of around 100,000 articles. The first step in our approach was to create and pilot the use of an a priori generic protocol (Porciello & Ghezzi-Kopel, 2020) to set out common definitions, study design, and the decision-making criteria for which publications to include. The protocol is a stand-alone document published on an open science framework (Open Science Framework, n.d.). Outputs of the evidence synthesis were grouped into eight papers and published as a series in Nature journals. This way, the journal's peer-review process created an important level of quality assurance for the methodology.

ABOUT THE MODEL

MIRAGRODEP is a global Computable General Equilibrium (CGE) model based on MIRAGE (Modelling International Relations under Applied General Equilibrium). The core MIRAGRODEP model is an open-source resource distributed by the African Growth and Development Policy (AGRODEP) network (AGRODEP, n.d.). The multi-country CGE model captures international economic linkages through the

international trade of goods, as well as through the movement of people and capital. The most recent version of the GTAP database (Aguiar et al., 2016) is MIRAGRODEP's main source of data; the model can cover 141 regions/countries in the world and up to 65 sectors. In addition, the database is improved by adding datasets on land use, agricultural production, food balance sheets, agricultural domestic support, and trade policies (Laborde et al., 2017). The model allows users to measure the results of policy measures on both macroeconomic impacts and inequality indicators, such as changes in production, wages, value added by sector, real income, land use changes, and caloric consumption per capita. By using the outcomes of the evidence synthesis to provide inputs for policy interventions, we were able to assess the effects of proposed interventions and their costs on achieving SDG 2 targets.

DIALOGUE WITH DECISION-MAKERS AND EXPERTS' INVOLVEMENT

The project was guided by a Global Advisory Board with 19 international experts from academia, donor agencies, and non-governmental organizations to guide the selection of key questions and the focus of evidence synthesis. The evidence synthesis teams included 78 globally distributed researchers and experts grouped around delivery of eight evidence synthesis papers. The project team also coordinated with networks such as the SDG2 Advocacy Hub ((Alliance to End Hunger, 2021) to coordinate the project outputs with global efforts on mobilizing resources, and provided targeted briefings to over 30 development organizations including national agencies from the United Kingdom, Canada, Norway, international agencies, and networks such as the Global Donor Platform for Rural Development, The Development Fund, and CGIAR partnership.

KEY CONTRIBUTIONS OF THIS RESEARCH TO ADVANCE THE 2030 AGENDA

COMBINING DIVERSE SOURCES OF INFORMATION TO IMPROVE EVIDENCE-BASED DECISION MAKING

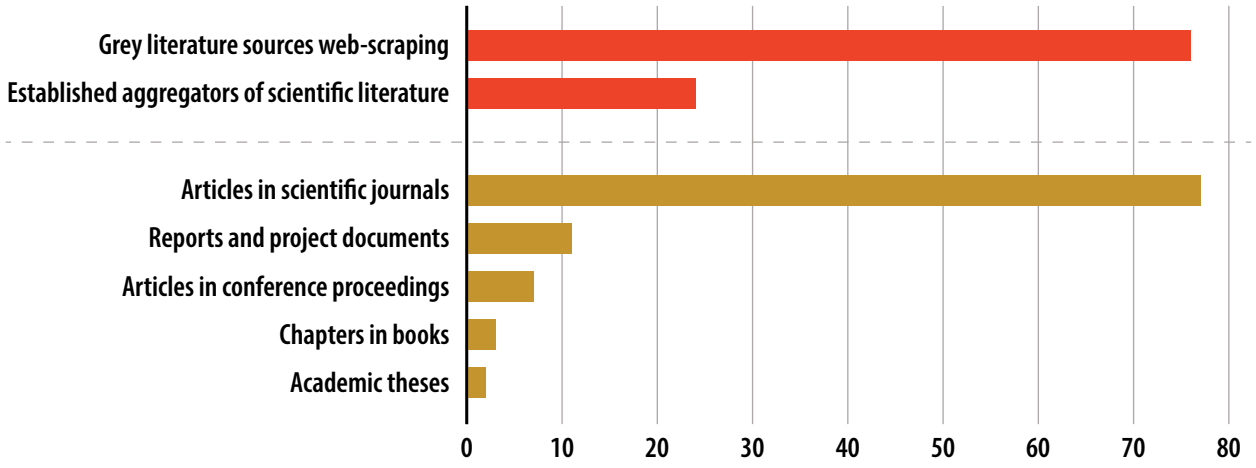
Given the limited time frame for the implementation of the SDGs, it is crucial to identify and adopt interventions already known to be effective. By integrating peer-reviewed and diverse types of grey literature, including agency and organization reports, briefing notes, and conference proceedings, this study was able to consider a broad range of evidence for the effectiveness of interventions.

There are few aggregators of grey literature, and they do not cover much of the literature because this literature does not have the metadata indexing systems that the aggregators depend on. The Ceres2030 team addressed this challenge by using machine learning to increase the comprehensiveness of what the research teams could examine individually. Data scientists performed web scraping from nearly 50 agency websites such as international and UN agencies, specific governmental and non-governmental organizations, and universities using a machine learning model to perform repetitive tasks, such as the classification of thousands of text-based materials quickly and accurately (similarly to Gil et al., 2014). This process saved the project valuable time: while the average

evidence synthesis takes between 18 and 36 months to complete (Haddaway & Westgate, 2019), our distributed global teams completed their reviews in less than a year.

In total, 123,937 records were identified covering both well-established scientific literature aggregators (94,420 records) and grey literature (29,894 records). From the identified records, 1.7% (1,409 records) were included in the eight papers as they addressed the research question of at least one of the eight papers. When looking at the structure of the records included, 76% (1,071 records) are based on articles from scientific literature aggregators, and thus the total dataset was expanded by a third from grey literature materials, mostly reports and project documents as well as articles in conference proceedings.

FIGURE 1. OVERVIEW OF THE LITERATURE SOURCES AND TYPES OF GREY LITERATURE DOCUMENTS INCLUDED IN THE PAPERS



In our studies, the inclusion of the grey literature added value to the scoping reviews by adding evidence such as production subsidies on non-staple crops such as pulses, fruits, and vegetables and applications of new varieties (Acevedo et al., 2020; Liverpool-Tasie et al., 2020), measures by donor agencies and development agencies to promote fodder production (Baltenweck et al., 2020), and expanding the list of assessed countries (Bizikova et al., 2020). Four scoping review papers assessed the quality of the methodological approach included in the reviews: 68% of the articles from well-established aggregators were deemed to use high-quality methods, while this rate was 55% for the grey literature.

Of the papers included in the reviews, only 10 studies were found to have high-quality data on both the effectiveness of interventions as well as their costs, so modelling inputs were limited to this set. Out of these 10 papers, 60% were scientific literature and 40% grey literature. These contributing papers resulted in three new interventions being incorporated into the model and improvements to two of the other 11 existing interventions. These three new interventions were significant in achieving

the SDG 2 targets, and would require 13.6% of the estimated yearly increase in public investment needed to end hunger sustainably by 2030 as derived in the model.

CREATING A TOP-DOWN ECONOMIC MODEL TO EXPLORE TRADE-OFFS AND SYNERGIES TO ACHIEVE THE SDG 2 TARGETS

One important contribution of our research was to help policy-makers identify a mix of interventions that can deliver SDG Targets 2.1, 2.3, and 2.4. In addition, we were able to estimate the macroeconomic impacts of the COVID-19 pandemic and how those would absorb resources, complicating the implementation of the proposed interventions to achieve SDG targets. Corresponding to Target 2.1, the model simulates at a household level the elimination of hunger, as measured by the FAO's Prevalence of Undernutrition (PoU) (FAO et al., 2015). For Target 2.3, the productivity and incomes of small-scale producers (interpreted in the model as net incomes) double on average between 2015 and 2030. This demonstrates synergies in support of SDG 1 on poverty reduction.

For SDG Target 2.4, the inclusion of the environmental dimension in the modelling framework is critical, as environmental sustainability may be negatively impacted by the expansion of food production and consumption required to achieve SDG 2.1 and 2.3. Environmental sustainability in the model is measured by three indicators: land expansion and conversion, greenhouse gas emissions and water quality and use relating to SDG 13 and 14 (where lower values are preferred in all cases). To include environmental impacts in the model, we could not yet rely on guidance from the UN for indicators to track progress on SDG 2.4 because they are still in development and under negotiation (FAO, n.d.). Where available, we use the 2015 Paris Agreement National Determined Contributions (NDCs) to define the target for greenhouse gas reductions that are also a priority for policy-makers. This target meant that the intervention mix is optimized to meet the country's NDC target at the lowest costs. Since no such target exists for water and land use, we monitor and compute water use indicators. To connect the three environmental indicators with the considered interventions needed to achieve the selected SDG targets, for each intervention, their impacts for the selected environmental indicators are included in the model. In addition, selection of interventions is optimized to meet the country's NDC target at the lowest costs.

In this study, we define interventions and combinations of interventions as policy choices. Each intervention aims to address challenges faced by a given sector, region, and/or population (Table 1). Even if not exhaustive, there are a number of interactions between interventions, so the overall efficacy of interventions will benefit from combining them to manage synergies and balance trade-offs. For example, a fertilizer subsidy could help farmers increase yields, but its effectiveness would be constrained if a poor road network makes it too costly for produce to reach markets. A production subsidy may boost food production and producer incomes but could result in land conversion and unsustainable agricultural practices. The mix of policy instruments used in the model considers how they interact and complement each other, allowing assessment of the components of an appropriate investment strategy to accomplish multiple objectives. This allows policy-makers to focus not only on

priority interventions but also on relevant support systems, including infrastructure, access to banking services, and social capital. While the lack of detailed information on social capital and institutions is problematic (Bizikova et al., 2020; Liverpool-Tasie, 2020; Stathers et al., 2020), the modelling approach captures some of the interlinkages between different forms of support systems at the household level and their impact on the broader economy.

Interventions were allocated across the small-holder population in a bottom-up fashion by maximizing the efficiency and relevance of policy application based on household surveys (International Food Policy Research Institute, 2011) to define small-holder conditions. For instance, we define a household safety net intervention based on income level from household surveys (observable) instead of nutritional status (caloric intake). The latter, while being directly linked to our target, is not a readily observable criterion for policy implementation. While the targeting issue is key to achieving proper outcomes at a reasonable cost, we should not overestimate the capacity of institutions and policy-makers to implement precisely targeted programs. To address this limitation, the targeting of the intervention/policy can include conditionality criteria.

COVID-19 has significantly impacted the resources available at the national and household levels to implement these policy interventions. To integrate the effects of COVID-19, the economic model used 2020 data on food security to show how the pandemic has eroded household welfare as well as adjusted macroeconomic projections for the period 2020–2023 (van Braun et al., 2020). We found that an additional USD 10 billion of social protection spending would be needed to prevent a hunger crisis and ensure that households are able to maintain their pre-COVID-19 consumption levels and patterns. USD 5 billion of this must come from donor governments as aid, with the rest provided by developing countries.

TABLE 1. LIST OF SELECTED PUBLIC POLICY INTERVENTIONS FOR CERES2030

	INTERVENTION	TARGETING/COVERAGE	STRUCTURAL EFFECTS
Enabling Inclusion			
1	Food subsidy	Food items for households with income below the poverty line (USD 1.95 purchasing power parity)	Food cost reduction per capita through an endogenous homogenous subsidy rate at the household level.
2	Vocational training		Allows people to move between rural and urban employment more easily.
On the Farm			
3	Investment subsidy	All agricultural sectors, all producers	Ad volume subsidy to domestic investments.

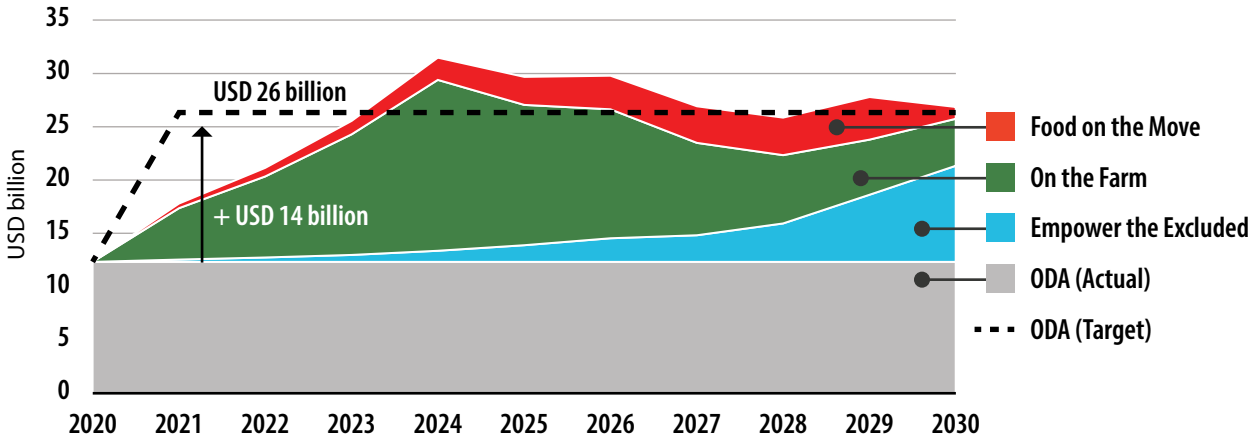
	INTERVENTION	TARGETING/COVERAGE	STRUCTURAL EFFECTS
4	Fertilizer subsidy	Crop sectors, all producers	Ad valorem subsidy on chemical inputs consumed by agricultural sectors with yield effects captured by changes in the production function.
5	Capital endowment	All agricultural sectors, only small-holders	Allocation of physical capital (e.g., machinery, livestock) given to targeted households.
6	Production subsidy	All staple crops sectors, all producers	Ad valorem production subsidy applied to the farm gate price.
7	Research and development (R&D) National Agricultural Systems (NARS)	All agricultural sectors, all producers	Agricultural total factor productivity (TFP) is increased based on the stock evolution of NARS R&D.
8	R&D CGIAR	All agricultural sectors, all producers Affects all of Africa at once	Agricultural TFP is increased based on the stock evolution of CGIAR R&D.
9	Extension Services	Agricultural sectors, small-holders	Efficiency of production factors, that is, the difference between physical and efficient units, for small-holders.
10	Rural infrastructure (irrigation)	Crops sector, all producers	Agricultural TFP is increased based on the growth of irrigated area.
11	Livestock subsidy – agroforestry	Dairy sector, small-scale producers	Ad volumen subsidy to year 1 fixed costs (extension and shrubs). Ad volumen reduction in greenhouse gas emissions.
12	Livestock subsidy – improved forage	Ruminant sector, small-scale producers	Ad volumen subsidy to year 1 fixed costs (extension, seed, and inputs).
Food on the Move			
13	Storage-Post Harvest losses	Crop sectors, small-holders	Efficiency of production factors for small-holders and reduction of an initial shadow tax on factors of production.
14	Rural Infrastructure (roads)	Agricultural sectors, all producers	Agricultural TFP is increased based on the growth of road infrastructure.

Source: Laborde et al., 2020.

ASSISTING POLICY-MAKERS AND DONOR AGENCIES IN ALLOCATING COSTS TO POLICY OPTIONS OVER THE NEXT DECADE

The main purpose of our research was to accelerate the implementation of the 2030 Agenda by enabling decision-makers. Making decisions about where to direct public spending now more than ever requires information on costs, target populations, and the mix of diverse interventions with differing effectiveness and their interactions. A plan to achieve the SDG 2 targets requires not only the identification of potential policies and their impacts to create a mix of preferred interventions but also the ways this mix may change over time. One critical consideration is the time needed for an intervention to deliver impacts—and thus its ability to contribute to the 2030 SDG targets. For example, interventions focused on supporting farm-level production through R&D can deliver outcomes with a time lag (Pardey et al., 2016), so their earlier application can have impacts before 2030. Research support policies would need to be complemented by interventions in value chains that fall under the broad category of "Food on the Move." By contrast, interventions to support poverty reduction and food security through food stamps depend on the poverty levels of the country as well as timing: in a short time horizon, no other type of intervention can increase farmers' income. The pathways and sequencing of policy implementation also depend on characteristics of the target population in the specific countries, such as poverty levels, access to land and other assets, and availability and quality of infrastructure.

FIGURE 2. OVERVIEW OF THE ALLOCATION AND RELATED COST OF THE POLICY OVER TIME



Source: Laborde et al., 2020.

Each of the 14 policy instruments has a cost, paid either by the public or private sector, and a direct impact that contributes to SDG 2 targets as well as other SDGs. The model outcomes indicate both the total resources needed as well potential domestic and foreign sources and allocation of these resources in terms of the mix of interventions. Donors currently spend USD 12 billion per year on food security and nutrition. Our research suggests that these policy interventions can meet the goals but

will require more than a doubling of ODA, that is, 14 billion USD per year in contributions (Laborde et al., 2020). And ODA alone will not be enough. Additional public spending of USD 19 billion per year on average until 2030 will have to be provided by low- and middle-income countries through increased taxation. Together, the additional public investment from donors and low- and middle-income countries will prevent 420 million people from experiencing hunger, double the incomes of 545 million producers and their families on average, and limit greenhouse gas emissions for agriculture to the commitments made in the Paris Agreement.[2]

Finally, to increase the relevance of this work for decision-makers, the research team provided targeted briefings for donor agency groups, international agencies, and diverse expert groups. The focus of these sessions was to stress the need to increase ODA, provide details on the effective interventions, and discuss how these interventions address the SDG priorities.

DISCUSSION

This paper describes an approach to assist governments and other stakeholders in identifying and implementing effective interventions that can achieve the 2030 Agenda. We combine knowledge of proven interventions from the literature with cost data and macro modelling of economic outcomes to show how to achieve three intertwined targets: SDG 2.1, 2.2, and 2.3. We estimate the costs of achieving these targets to require more than a doubling of ODA currently directed to food security and nutrition and an additional USD 19 billion annually in fiscal outlays by governments in low- and middle-income countries. The study identified the value of expanding the sources of information and knowledge beyond scientific literature when selecting tools and actions, elaborated methods for effective connection between quantitative and qualitative domains, and integrated factors that cannot be readily modelled as well as tools for decision-makers and for development agencies and other stakeholders. These methods have implications for future studies of this kind.

RELATIVELY MODEST RESOURCES NEEDED TO ACHIEVE THE SELECTED SDG 2 TARGETS

Costing information is a critical tool for policy-makers to adjust their policies and interventions. Currently, there is a wide range of estimates for the cost of achieving zero hunger—from an additional 11 billion USD per year to end hunger by 2030 (Laborde et al., 2016) to over 50.2 billion USD by 2025 aiming to achieve both SDG 1 and SDG 2 (FAO et al., 2015). In a 2019 study, Investments in Africa estimated it would cost about 15 billion USD per year between 2015 and 2030 to achieve these results as part of a larger package of investments costing around 52 billion USD in developing countries

[2] The results from the modelling should be interpreted as an estimate of the scale of resources needed at the big-picture level. This is useful to inform resource allocation decisions from the global level down to the national level but is insufficient to inform strategy, planning, and programming at the subnational level.

(Mason-D'Croz et al., 2019). The same study also accounted for the climate change impacts, assuming the additional investments in Africa to achieve these results under climate change at USD 15 billion per year between 2015 and 2030 compared to the baseline scenario (Mason-D'Croz et al., 2019).

Our findings indicate that to achieve the global commitment to end hunger sustainably between now and 2030, donors need to double their current level of spending. That means an additional USD 14 billion per year is needed on top of current spending, which stands at USD 12 billion per year. Like other estimates, our outcomes also show that most of the additional resources need to be targeted to countries in Africa where there will be the highest concentration of hunger and the highest dependency on external resources in the next decade. Our cost estimate is close to the lower estimates in the literature, which take a narrower focus (only the targets of SDG 2). These lower estimates from our findings are due to improved targeting and effective allocation and types of the considered interventions.

The current studies integrate a number of interventions focused on agriculture and/or small-holders, including investments in rural infrastructure and market access, farm-level support, research, development and extension, policy and institutional development, safety nets, and cash transfer programs (Bodnar & de Steenhuijsen Piters, 2011; Gilligan et al., 2013; Laborde et al., 2016; Mogues et al., 2012; Schmidhuber & Bruinsma, 2011). Among the suggested interventions, those focused on rural infrastructure and value chains, farm-level support, and extension services are suggested to have the most significant positive effects on hunger (Bodnar & de Steenhuijsen Piters, 2011; Mogues et al., 2012; Ton et al., 2013). In our approach, we included these measures along with targeted measures to specifically empower the poorest by providing access to education and access to income, so they also benefit from measures focused on agricultural development and market access.

Finally, our estimates, as well as those available in the literature, provide policy-makers with information regarding potential costs and on types of interventions to allocate the resources. Most of these models are not yet available as decision-making support tools that can be adjusted by policy-makers to answer their specific costing needs. Such needs would, for example, allow the generation of specific national and subnational costs as well as select different combinations of interventions preferred by countries (e.g., because the interventions have already been used in current programs).

INTEGRATE FINDINGS FROM THE GREY LITERATURE TO INCREASE POLICY RELEVANCE

There is increasing evidence that grey literature can make an important contribution to comprehensive evidence bases, including systematic reviews for not only health sciences but also for environmental management and the SDGs (Adams et al., 2016; Haddaway & Bailyss, 2015; Sweiling, 2020). This is often attributed to a practitioner-generated approach, which broadens the range of evidence but also tends to be problem-oriented, filling gaps while contextualizing and complementing the findings in academic literature (Adams et al., 2016). There are already, for example, useful reviews of national efforts to implement policies to achieve the SDGs (Sweileh, 2020). Our

approach specifically demonstrated that grey literature can meet peer-reviewed methodological standards and provide useful insight on practical interventions to achieve the SDGs, their effectiveness and costs, as well as essential contextual factors related to social capital, quality of institutions, and governance.

Despite complementary findings elsewhere on the relevance of grey literature to policy-making, it is seldom included in evidence reviews because of the difficulty of representative literature searches, appraisals, and data synthesis. In terms of grey literature searches, Godin et al. (2015) suggest using targeted web-based and google searches as well as expert consultations to identify additional literature. A simplified approach is suggested by Aftab et al. (2020) using publications developed by major agencies instead of broad web search, which we supplemented in this study with an artificial intelligence-based web scraping tool. These methods allowed the team to process a large number of grey literature sources and indicated a potentially useful methodology for future grey literature efforts. For data appraisal, the literature suggests accounting for less-standardized ways of presenting research results, such as interview outcomes, observations, impact evaluations, budget reviews, and others (Adams et al., 2016). In this study we pilot tested approaches to integrate this diversity in both grey and academic literature. For each category in the data entry form, an open field was provided to allow for additional descriptors for that item. Standardized approaches to online search, appraisal, data description, and data synthesis were summarized in protocols that proved to be highly effective in increasing the transparency of the review and bringing together diverse sources of information across a large team.

Based on our experience with integrating grey literature as well as the issues raised by others cited above, producers and funders of such literature could extend their audience and impact by updating publication platforms with simple features to make this literature more accessible. Donors in R&D should fund models and tools that facilitate the collection and inclusion of grey literature together with more traditional academic research that can be integrated using existing commercial platforms so as to provide user groups with timely, accessible, and valuable analysis.

CHALLENGES IN ASSESSING COST EFFECTIVENESS OF INTERVENTIONS TO INFORM ACTIONS FOR SDGS

This study combined an empirical review with a modelling exercise using a dynamic CGE model to assess interventions most effective in achieving the targets of SDG 2. The selection of interventions to include was constrained by the availability of detailed costing information needed for a CGE model.

However, the information available in the academic literature on the effectiveness and costs of agricultural interventions is limited. Other recent research reaches similar conclusions. Scoping reviews on agricultural interventions in Ghana and on global organic agriculture found fewer than 5% of studies provided details on costs (Behera & Bhoi, 2021; Lencucha et al., 2020). A huge number of documents on agricultural interventions were needed by Adu et al. (2018) to enable a quantitative analysis synthesizing the effect of these interventions because of limited information on costs. Other

authors reviewing sustainable food production and climate-smart agriculture interventions have concluded that cost-effectiveness analyses are methodologically constrained due to a lack of evidence for effectiveness and poor reporting of cost parameters (Haby et al., 2016; Westerman et al., 2018).

Further studies applying quantitative modelling to interventions will benefit from research that includes partial budget analyses and cost-benefit analyses for relevant interventions in order to capture key parameters such as labour costs and opportunity costs. To find the small number of costing and impact studies available, researchers and CGE modellers may apply machine learning (including natural language processing) to partially automate and speed up the search process. As the availability of information increases, augmenting search strategies with machine learning will become increasingly important.

CONTEXTUAL FACTORS AND EFFECTIVENESS OF INTERVENTIONS

In practice, agricultural and nutrition policy interventions can be delivered in a variety of ways that rely on different delivery mechanisms and supporting systems. This study included information from scoping reviews on income, gender, and family status, and modelled factors such as access to land, assets, and caloric intake. But other factors are also considered important in shaping effective interventions in context, such as the use of formal and informal institutions, access to knowledge and physical infrastructure, as well as considering social, historical, and cultural conditions when promoting the interventions (Bizikova et al., 2020; Totin et al., 2018).

In our study, for instance, we consider the impact of food subsidies (e.g., food stamps) that can be delivered through universal unconditional cash transfer depending on the country context. In our model we do not yet integrate an appraisal of institutions and delivery mechanisms that would likely speed implementation or increase effectiveness. Such delivery mechanisms are critical and often include the agencies of central or regional governments (or other public or non-governmental entities) to ensure that, for example, a fertilizer subsidy reaches its intended beneficiaries (e.g., Somanathan et al., 2014).

Effective implementation strategies always operate at the intersection of governance, accountability, and stakeholder engagement across relevant sectors and scales. In our model, we make assumptions about strategies that are tailored to local conditions and how they are implemented. The institutional dimension in particular is highly context specific and is therefore not yet represented in our global model. To guide specific implementation features, we rely on findings from the evidence review conducted as part of Ceres2030 and published in the dedicated edition of Nature Research (2020).

TOOLS FOR DECISION-MAKERS TO ADVANCE SDG IMPLEMENTATION

To accelerate the implementation of the 2030 Agenda, it is imperative to enable decision-makers, donors, and development agencies to target their policies, programs, and efforts effectively and

clearly. It is difficult, however, to pinpoint the types of tools and tailored information required to support better decision making without formal decision analysis (Masaki et al., 2017). Decision-makers and development agencies must define and evaluate the actions, programs or projects that are expected to achieve SDGs (Shepherd et al., 2015). Comparative cost-effectiveness estimates provide crucial information for policy-makers in order to allocate resources. The approach presented in this study should be augmented to provide decision support tools that can be tailored by policy-makers to specific regional or national needs, for example, to reflect national or subnational relative costs, or to give priority to interventions that are already being implemented in existing programs. In addition to such supplementary tools, the influence of evidence on policy can be enhanced by relationship building, alliances with different actors, and targeted, tailored briefings of the type delivered by the study team in this project (Mayne et al., 2018).

Finally, information for decision-makers needs to be up to date and, in the current context, to also account for the social and economic implications of the ongoing COVID-19 pandemic and recovery. The pandemic has strained governments' fiscal positions and exacerbated existing inequalities among and within societies while highlighting the growing importance of reaching the SDGs (UN, 2020a, 2020b). Research efforts to support policy decision making to achieve SDG targets must, therefore, also integrate impacts of COVID-19 to remain relevant for decision-makers.

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Ceres2030
Sustainable Solutions to End Hunger

ABOUT CERES2030

Ceres2030 brings together three institutions who share a common vision: a world without hunger, where small-scale producers enjoy greater agricultural incomes and productivity, in a way that supports sustainable food systems. Our mission is to provide the donor community with a menu of policy options for directing their investments, backed by the best available evidence and economic models.

The partnership brings together Cornell University, the International Food Policy Research Institute (IFPRI) and the International Institute for Sustainable Development (IISD). Funding support comes from Germany's Federal Ministry of Economic Cooperation and Development (BMZ) and the Bill & Melinda Gates Foundation (BMGF).

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