Ceres2030
Sustainable Solutions to End Hunger

COMMENTARY

Ending Hunger Sustainably: Climate change adaptation and resilience

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Ceres2030 brings together the International Institute for Sustainable Development (IISD), Cornell University, and the International Food Policy Research Institute (IFPRI) to answer two linked questions: (i) What will it cost governments to end hunger as defined by Sustainable Development Goal (SDG) 2? And, (ii), What are the most effective public investments to end hunger sustainably based on the available evidence? Ceres2030 is a three-year project that will conclude early in 2021.

SDG 2 is the second of 17 Sustainable Development Goals that together comprise the UN's 2030 Agenda for Sustainable Development (UN General Assembly, 2015). SDG 2 is a commitment to end hunger sustainably, with sub-goals focused on ending hunger, improving nutrition, increasing small-scale producers' income, and reducing the environmental footprint of agriculture.

The project combines a state-of-the-art economic model to cost the interventions needed to end hunger with a machine-learning enhanced approach to systematic evidence reviews that assess the effectiveness of agricultural policy interventions. The evidence syntheses are designed to support decision-makers in making better use of the available evidence when they choose the interventions to invest in to advance sustainable food systems and end hunger. The project is focused on SDG 2.1, the commitment to end hunger, SDG 2.3 on doubling the productivity and income of small-scale food producers, and SDG 2.4 on ensuring agricultural sustainability and resilience.

This background paper discusses how the Ceres2030 project addresses the challenge of climate change adaptation and resilience. It is one of a series of papers written by the Ceres2030 project team on issues that are critical to the project's overall ambition but that are complex. It is not easy to do full justice to climate adaptation with the tools the project relies upon—namely, an economic cost model and syntheses of available published evidence on the effectiveness of agricultural interventions.

WHAT IS THE ISSUE?

Climate change is already having a significant impact on agriculture and food security, and that impact is expected to accelerate significantly in the decades ahead. The effects will be wide-ranging and potentially severe, with both direct and indirect effects on food security. For example, precipitation patterns are changing, with consequences for water availability and crop yields. Less direct effects include stresses on infrastructure, such as roads, flood barriers, and telecommunications. An increase in the incidence of extreme weather events will make supplies less predictable, in turn increasing both prices and transaction costs, which will constrain food access and availability. Together, these effects will increase vulnerability in rural areas, and food insecurity.

Climate adaptation describes diverse efforts to moderate, avoid or even to exploit the effects of climate change. Climate adaptation includes both responses to extreme events and to the gradual changes that have been predicted. This makes for a wide range of possible outcomes to take into consideration, and recent research has focused on building resilience more broadly rather than attempting to adapt to each impact singly. Resilience describes the "capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, … while also maintaining the capacity for adaptation, learning, and transformation" (Intergovernmental Panel on Climate Change [IPCC], 2014, p. 5). In relation to food security, the concept of climate resilience includes many elements. They include the resilience of household use and access to food; the availability of livelihood resources and supporting services (such as social safety nets); and the availability of and capacity to use effective institutions that protect food safety and ensure functioning markets and trade.

WHY DOES CLIMATE ADAPTATION MATTER TO CERES2030?

The achievement of the 2030 Agenda will require policy interventions that maximize the synergies available across the many goals and targets while limiting the inevitable trade-offs. Climate change will have consequences for each goal and sub-goal in the 2030 Agenda. Effective policy-making will consider climate adaptation interventions that, if successful, will strengthen the likelihood of achieving the 2030 Agenda more broadly. Box 1 shows the three targets of the Ceres2030 project (all from SDG 2) and describes interventions that will contribute to both the target and to climate adaptation. Of course, climate change will impose costs on achieving the SDG targets, due to the damage it is doing (a cost of not acting to mitigate climate change sooner), and to the necessity of introducing additional investments in targeted adaptation initiatives designed to prevent climate change effects from worsening (the cost of adaptation). The cost of climate adaptation has implications for the overall cost of meeting the SDG 2 targets and is therefore a cost of interest to Ceres2030.

BOX 1. CLIMATE CHANGE EFFECTS AND CLIMATE ADAPTATION NEEDS FOR SDGS 2.1, 2.3, AND 2.4

The cost model's three targets come from three SDG 2 sub-goals

SDG 2.1 End Hunger	**SDG 2.3** Smallholder productivity	**SDG 2.4** Sustainability
Target 1 **Reduce Hunger to 5%** Reduce the prevalence of undernourishment to 5% or less in every country	**Target 2** **Double Small-Scale Producers' Incomes** Double the average net income of small-scale agricultural producers	**Target 3** **Respect Environmental Boundaries** While the model considers the different dimensions of sustainability, it defines environmental targets such as greenhouse gas emissions in line with the Paris Agreement

EXAMPLES OF CLIMATE CHANGE EFFECTS

SDG 2.1 End Hunger	SDG 2.3 Smallholder productivity	SDG 2.4 Sustainability
• Food access, utilization, and price stability can be affected by climate change. • Climate-related risks affect calorie intake, particularly in areas where there is chronic food insecurity. • Sensitivity of current markets to climate extremes with impacts on food stability. • Impacts of climate change and extreme weather on infrastructure (roads, irrigation, storage) will affect food availability, including prices.	• For major crops (wheat, rice, and maize) in tropical and temperate regions, climate change without adaptation is projected to negatively affect production for local temperature increases of 2°C or more above late-20th-century levels, although individual locations may benefit. • Reduced stocking of dairy cows, a shift from cattle to sheep and goats, due to high temperatures. • Maize availability per head of cattle may decrease due to water scarcity.	• In many regions, significant decrease in water availability • Sea-level rise in coastal areas affecting biodiversity and human settlements. • Intense rainfall and flooding. increase soil erosion and runoff • Climate change will have effects on ecosystems, on their component species and genetic diversity within species, and on ecological interactions.

EXAMPLES OF ADAPTATION ACTIONS

SDG 2.1 End Hunger	SDG 2.3 Smallholder productivity	SDG 2.4 Sustainability
• Climate-resilient infrastructure, especially roads and food storage. • Reduction of food waste and food loss. • Availability of food aid and emergency services to address short-term food insecurity. • Access to food and cash vouchers to overcome food availability changes for farmers due to lost/reduced production and/or price changes.	• Targeted use of fertilizers and irrigation systems. • Alteration of cultivation and sowing times and selection of crop cultivars and species. • Timely access to seasonal and pest forecasts and market price information. • Access to credit and insurance to access inputs for effective land management. • Off-farm income generation. • Social security programs to support farmers.	• Improved erosion control through agricultural practices such as no-till field management as well as by maintaining natural vegetation and limiting land-use/cover change. • Reducing deforestation. • Promoting water management planning to ensure water availability for biodiversity, agriculture, and other uses.

Sources: Calzadilla et al., 2013; FAO et al., 2018; Global Commission on Adaptation, 2019; IPCC, 2014; Lobell et al., 2013; Mamun et al., 2018; Natkhin et al., 2013.

INTEGRATING CLIMATE ADAPTATION INTO THE CERES2030 MODEL AND EVIDENCE

The economic model used in Ceres2030 is a dynamic computable general equilibrium, multi-country, and multi-sector model that simulates national and international markets, considering production, demand, and prices. The model combines this economic simulation with an analysis of biophysical and socioeconomic trends (Laborde et al., 2013). The model integrates the central economic factors that affect agriculture, thereby providing a robust quantitative framework for estimating the costs of agricultural interventions. In relation to climate change effects, the model incorporates the gradual climate change impacts on yields caused by changes in average rainfall and temperatures. For these indicators, the projected change in crop yields by 2030 is relatively low. The model does not include the impacts of extreme weather or the effects of other extreme events such as pest and disease outbreaks.

The data is not yet available to allow a more precise costing of specific climate adaptation interventions in a model. A recent systematic review of models measuring the effect of climate change on water resources, land-use change, and agriculture showed that the integration of adaptation into models is also challenging for researchers because of a lack of systematic descriptions of adaptation processes and their effectiveness (Holman et al., 2018). The gaps in this type of systemic information include limited details about the specific triggers that prompt adaptation, limited understanding of the effectiveness of specific adaptation actions, and the time lag between adaptation actions and any resulting reduction in climate change risks.

The Ceres2030 model implicitly integrates adaptation. This integration begins with data inputs into the model, for example, to obtain yield data projections up to 2030. Our data incorporates assumptions about the negative effect on yields that climate change will have, and is used in both the baseline scenario—where additional public investment to achieve SDG 2 is not included, and the world follows a "business-as-usual" path—and in the scenarios that cost the additional public investment required in the interventions that will achieve SDG 2.

The model is designed to generate global cost estimates; it models interventions on a national scale but not subnational. The Ceres2030 model does not model within-year or within-nation occurrences, such as a week-long heatwave, a month-long drought, or differences in temperature increases over several years at a subnational level. This is because, although the science agrees that climate change will have negative impacts on agriculture, the specific impacts over time, crops, and regions are not easy to project. The model relies on disparate data sources limited to the annual or national level.

In terms of responses to climate change, the team's primary focus is on mitigation efforts while creating synergies with adaptation efforts and related benefits. Overall, to protect the sub-goals of SDG 2, it is important to ensure (as far as possible) that food security challenges are met while minimizing the related increase in greenhouse gas (GHG) emissions. Several countries in our model,[1] such as Ethiopia and Nigeria, are already in the top 20 countries globally in terms of their GHG emissions related to agriculture (FAOSTAT, n.d.). Using agricultural interventions that contribute to mitigation efforts, such as targeting the use of fertilizers, improving soil management practices, and optimizing irrigation can help countries achieve their emissions reduction and food security targets simultaneously. These efforts will help to limit land-use change, which will provide additional climate mitigation and adaptation benefits. The model includes interventions that optimize water management, improve livestock practices, and target fertilizer use.

[1] The list of countries in the model can be viewed here: https://ceres2030.org/wp-content/uploads/2019/11/ceres2030tech-sample-countries-online.pdf

If the model's primary focus is on mitigation efforts, it is important to underline that mitigation interventions can provide adaptation benefits, too. Targeting the use of fertilizers, improving irrigation, and reducing land-use change all offer potential adaptation benefits. Moreover, to limit the negative impacts of climate change on food systems—and thus the negative impacts on SDG Targets 2.1 and 2.3—agricultural interventions need to improve yields and reduce post-harvest losses. These measures, too, will not only improve agricultural productivity but also provide adaptation benefits. For example, reducing post-harvest losses is positive for farm income and improves consumer access to food. At the same time, reduced losses will lessen the impact of potential yield drops caused by climate change. The cost model also includes interventions to support market access and raise productivity through investment in infrastructure development, national and international research and development (R&D), and extension services. All of these can be expected to improve farm-level resilience to climate change. Finally, the model includes social safety net interventions, including food subsidies. Safety nets provide support to the most vulnerable to cope with climate shocks.

The Ceres2030 team also worked with researchers to assess the available body of published literature on the effectiveness of agricultural interventions for small-scale producer income and improved environmental performance for agriculture. The resulting eight evidence syntheses, forthcoming in Nature Research (October 2020), represent another component of the project's work on climate adaptation.

A number of interventions are relevant in considering an issue as broad as climate adaptation. They include farm-level adaptation strategies (which depend on the farm household's capacity), the use of safety nets and other off-farm income sources, and the presence of knowledge networks and institutions. They also involve national and subnational investment in rural infrastructure, along with policies and programs to address adaptation in the trade sector. Decisions at the farm level about which crop varieties to plant and when, as well as when to harvest, are decisions that are highly specific to different farm types and locations. The effects of such adaptations cannot yet be generalized sufficiently to include in the model. The factors affecting the adoption of climate-resilient seeds were the subject of one of the evidence syntheses (Acevedo et al., 2020). In the model, we include climate-resilient infrastructure investments such as those for irrigation and roads that support farmers' market access. Improving networks and collaborations between farmers, policy-makers, other stakeholders to develop capacities and share knowledge are not included because there is insufficient information in the literature on the effectiveness of these activities at the level needed to generate costing parameters. The role of farmers' organizations is another intervention explored in an evidence synthesis (Bizikova et al., 2020). Other papers in the evidence series also included consideration of policies to encourage more sustainable agricultural practices. National strategies to promote adaptation in terms of changing trade and market relations as well as commodity prices are still limited and were not included in the model.

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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.

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