WORLD RESOURCES INSTITUTE

TECHNICAL NOTE

TRACKING PROGRESS TOWARD THE COOL FOOD PLEDGE: SETTING CLIMATE TARGETS, TRACKING METRICS, USING THE COOL FOOD CALCULATOR, AND RELATED GUIDANCE FOR PLEDGE SIGNATORIES

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EXECUTIVE SUMMARY

Highlights

The Cool Food Pledge is a global initiative that helps food providers sell delicious dishes with smaller climate footprints. This technical note, and the accompanying Cool Food Calculator, help pledge signatories and other food providers to do the following:

- Set a food-related greenhouse gas (GHG) emissions reduction target in line with the climate goals of the Paris Agreement (determined as a collective 25 percent emissions reduction by 2030 relative to 2015). Individual signatories should aim for at least a 25 percent absolute reduction in food-related GHG emissions or a 38 percent relative reduction in food-related GHG emissions per calorie.
- Use the Cool Food Calculator to estimate a set of five metrics to establish baselines and track progress toward the GHG emissions reduction target, including food purchases by food type, food-related GHG emissions from agricultural supply chains, food-related land use, food-related carbon opportunity costs, and normalized metrics (e.g., GHG emissions per calorie or per meal).
- Navigate synergies and trade-offs with other important environmental, social and ethical, and economic and financial sustainability goals.

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Technical notes document the research or analytical methodology underpinning a publication, interactive application, or tool.

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Context

The world faces a great balancing act. It needs to feed nearly 10 billion people by 2050, while also advancing human development and reducing agriculture's impact on the environment—on ecosystems, freshwater supplies, and the climate. Solutions that improve agriculture's productivity and environmental performance, along with solutions that make food consumption patterns more sustainable, will all be necessary if the world is to achieve this balance.

The Cool Food Pledge (www.coolfoodpledge.org) **is a global initiative that helps food providers advance one important consumption-focused solution: selling delicious dishes with smaller climate footprints.** The Cool Food Pledge helps signatories commit to a science-based pledge for food-related GHG emissions reduction, track the climate impact of the food they serve, develop plans to shift their offerings in a consumer-friendly way, and promote their achievements as leaders in a growing movement. Signatories come from various sectors, including companies, restaurants, city governments, universities, schools, and hospitals.

This technical note, and the accompanying Cool Food Calculator, help pledge signatories and other food providers set targets and track climate impacts over time. These resources are designed for sustainability and procurement managers working for pledge signatories—and are also applicable to a broad range of food providers more generally interested in GHG target-setting and measuring environmental impacts of the food they purchase. Specifically, this technical note and the accompanying calculator help Cool Food Pledge signatories do the following:

- **Set a food-related GHG emissions reduction target in line with the climate goals of the Paris Agreement.** This technical note draws from the *World Resources Report: Creating a Sustainable Food Future* (which has a Paris-compliant pathway for the food and agriculture sector for 2050) and the Science Based Targets initiative's target-setting methods to define a collective, sector-wide GHG emissions reduction target for Cool Food Pledge signatories for the year 2030: a 25 percent reduction relative to the year 2015. Individual signatories should aim for at least a 25 percent absolute reduction in food-related GHG emissions or a 38 percent relative reduction in food-related GHG emissions per calorie.
- **Calculate a set of metrics to establish baselines and track progress toward the GHG emissions reduction target.** This note draws from experience and user testing with more than 30 food providers to recommend metrics that are not only robust and relevant, but also feasible and cost-effective, to measure given commonly available data. The companion calculator includes default land-use and emission factors by region, drawing from two recent global studies, and helps pledge signatories enter and estimate five important metrics:

    1. Food purchases by food type (boneless equivalent, in kilograms or pounds)
    2. Food-related GHG emissions from agricultural supply chains, in tonnes of carbon dioxide equivalent (CO_2e)
    3. Food-related land use (in hectares)
    4. Food-related carbon opportunity costs (tonnes of CO_2e)
    5. Normalized metrics (several possible units of measure)

- **Navigate synergies and trade-offs with multiple sustainability goals.** Drawing from these user tests and the relevant literature, this note helps signatories think through ways to make progress toward the Cool Food Pledge GHG emissions reduction targets while also supporting other important environmental, social and ethical, and economic and financial sustainability goals.

Working with core Cool Food Pledge partners, World Resources Institute will periodically update this technical note and the Cool Food Calculator (available at www.coolfoodpledge.org) to include updated data sets and additional metrics and guidance.

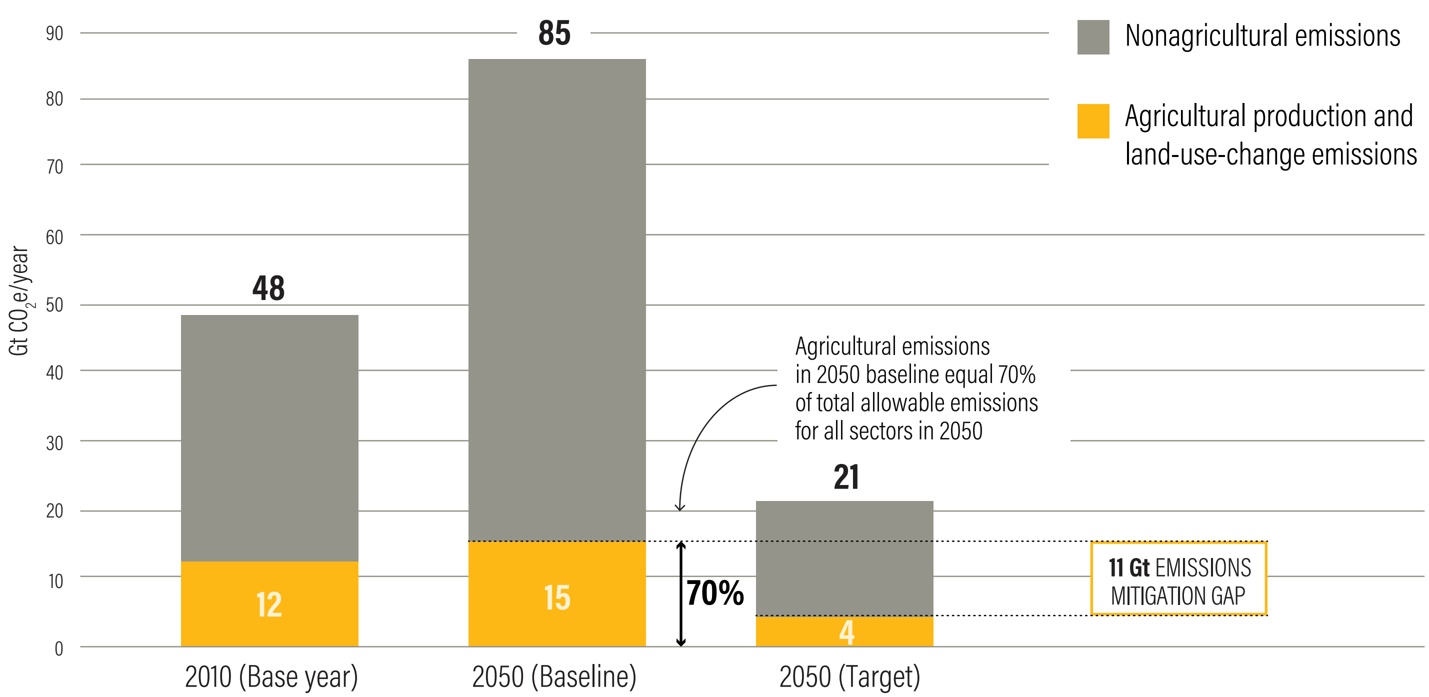
CONTEXT: SHIFTING DIETS, THE COOL FOOD PLEDGE, AND A SUSTAINABLE FOOD FUTURE

The global population is projected to grow from 7 billion in 2010 to nearly 10 billion by 2050 (UNDESA 2017). Overall food demand is on course to increase by 56 percent between 2010 and 2050, with demand for animal-based foods (meat, dairy, fish, and eggs) set to increase by nearly 70 percent (Searchinger et al. 2019).

This growth in food demand in the coming decades is likely to increase agriculture's pressure on the environment. Today, agriculture uses almost half of the world's vegetated land (FAO 2011), and agriculture and related land-use change generate nearly one-quarter of annual global net greenhouse gas (GHG) emissions (IPCC 2019).[1] According to Searchinger et al. (2019), under business-as-usual growth, agriculture is likely to expand by nearly 600 million hectares (ha)—nearly twice the size of India—by 2050, mostly at the expense of the world's remaining forests. Under this scenario, emissions from agricultural production and land-use change would collectively rise from 12 gigatons (Gt) in 2010 to 15 Gt in 2050. This level of agriculture-related emissions would account for the majority of allowable emissions from all sectors and sources to hold global warming below 2 degrees Celsius (°C) above pre-industrial temperatures, and exceed the entire annual emissions budget for holding warming below 1.5°C—the warming targets enshrined in the Paris Agreement on climate change. If agriculture were to reduce emissions in line with what is required of other sectors, maximum allowable emissions from the sector would be only 4 Gt per year by 2050, creating an 11 Gt "GHG mitigation gap" between business-as-usual emissions and the 4 Gt target (Searchinger et al. 2019) (Figure 1).

To hold warming below 1.5°C, these agricultural emissions reductions would also have to be accompanied by large-scale reforestation. Searchinger et al. (2019) estimated that at least 585 million ha of agricultural land would need to be reforested by 2050 in order to meet the more ambitious 1.5°C target.[2]

Figure 1 | **Projected agricultural emissions are approximately 70 percent of total allowable emissions for all sectors by 2050; emissions must instead decline by at least two-thirds between 2010 and 2050 to avoid dangerous climate change**



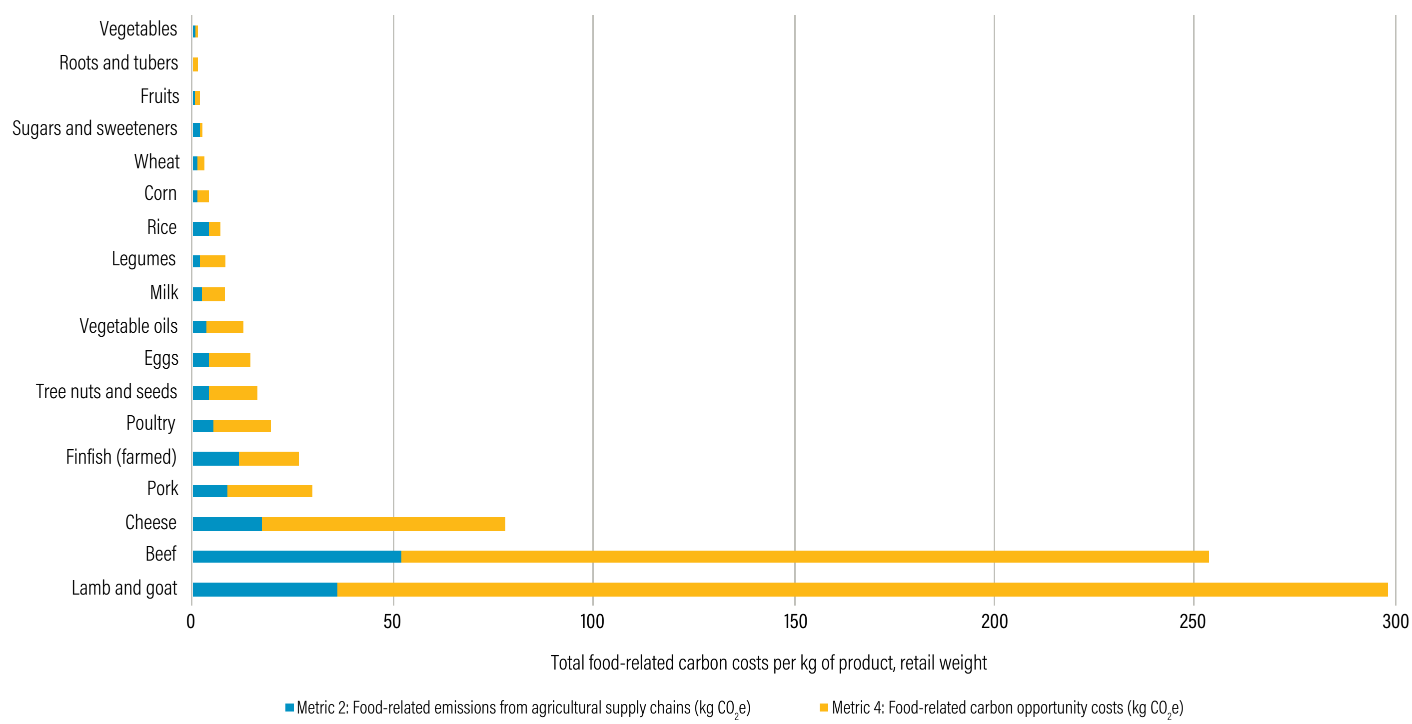
Note: "2050 Baseline" refers to a scenario with business-as-usual growth in agricultural production and land-use-change emissions. "2050 Target" refers to a scenario holding global warming below 2°C. To hold warming below 1.5°C, and keep agricultural production and land-use-change emissions to net zero by 2050, reforestation of at least 585 million hectares of agricultural lands would also be necessary.

Sources: GlobAgri-WRR model (agricultural production and land-use-change emissions); WRI analysis in Searchinger et al. 2019, based on raw data from UNEP 2012, FAO 2012, EIA 2012, and Houghton (2008), modified by WRI.

To achieve a sustainable food future, therefore, the global food and agriculture system must increase the food supply by more than 50 percent while halting deforestation and reducing emissions by at least two-thirds—no small task. And although the challenge is vast, a number of potential solutions exist, including improving the productivity and environmental performance of agriculture (including crops, livestock, fisheries, and aquaculture), reducing food loss and waste across supply chains, and shifting high-meat diets toward plant-based foods.

This latter strategy, of shifting diets high in meat toward plant-based foods, is gaining interest as a largely untapped climate solution. Animal-based foods are generally more resource intensive than plant-based foods, with ruminant meat (e.g., beef and lamb) requiring resources far exceeding those needed for plant-based foods (Figure 2). Meanwhile, demand for ruminant meat is projected to rise by 88 percent between 2010 and 2050, as incomes rise and nations urbanize. Reducing the global growth in demand for animal-based foods (particularly ruminant meats) by moderating consumption among wealthier populations could nearly eliminate the need for additional agricultural expansion (and related deforestation) while closing nearly half of the GHG mitigation gap shown in Figure 1 (Searchinger et al. 2019). Beyond benefits to forests and the climate, such a shift could also potentially help the world make progress toward several other United Nations Sustainable Development Goals, including those on hunger, healthy lives, water management, and sustainable production and consumption (Willett et al. 2019).

Figure 2 | **Animal-based foods are more resource intensive than plant-based foods**



Sources: Poore and Nemecek 2018; Searchinger et al. 2018.

The Cool Food Pledge (www.coolfoodpledge.org) is a global initiative that helps signatories commit to a science-based pledge for food-related GHG emissions reduction, track the climate impact of the food they serve, develop plans to sell delicious dishes with smaller climate footprints, and promote their achievements as leaders in a growing movement. The Cool Food Pledge is led by a partnership of environmental and health organizations (World Resources Institute [WRI], United Nations Environment, EAT, Carbon Neutral Cities Alliance, Health Care Without Harm, Practice Greenhealth, the Sustainable Restaurant Association, and Climate Focus), with WRI serving as secretariat. This technical note and accompanying Cool Food Calculator help signatories (and other interested food providers) set targets and track climate impacts over time.

Box 1 | **Defining and Describing Science-Based Targets**

The term "science-based targets" arose when environmental groups were encouraging companies to make their GHG emissions reduction targets more ambitious by anchoring them in science. This was seen as particularly important to ensure that corporate target-setting mirrored the scale of the challenge and complemented commitments from national governments. Science provides the objectivity in science-based targets, which are also informed by subjective influences—for example, moral and ethical considerations and civil society perspectives.

Although the term science-based targets is not strictly accurate, because these targets include both science and subjective influences, science is the anchoring component. The term is becoming widely used and understood to mean GHG emissions reduction targets that are informed by the latest climate science and sufficient to meet the goals of the Paris Agreement. Another term with the same meaning that is also widely used is "context-based targets."

Source: Putt del Pino et al. 2016.

1. SETTING A FOOD-RELATED GHG EMISSIONS REDUCTION TARGET

As shown in Figure 1, agricultural emissions will have to decrease by 67 percent by 2050 if the world is to meet the Paris Agreement climate goals, even as world population and total food demand grow.[3] What would be an appropriate medium-term target in line with common planning horizons?

Sector-Wide, Absolute Reduction Target

The Science Based Targets initiative (Box 1), which champions GHG emissions reduction target-setting as a powerful way of boosting companies' competitive advantage in the transition to a low-carbon economy, sets targets between 5 and 15 years into the future—in line with longer-term targets (e.g., through 2050). To set company-specific or sectoral targets, reductions can follow linear or compounded reduction pathways (SBTi 2019).

In a linear pathway, a 67 percent GHG emissions reduction over 40 years, based on the reduction target shown in Figure 1 (about 1.7 percent reduction per year, relative to a base year), would require approximately a 25 percent reduction over a 15-year period.[4] If the global food and agriculture sector collectively reduced emissions by 25 percent by 2030 (relative to 2015), it would be on the necessary pathway to 2050 (Figure 3).

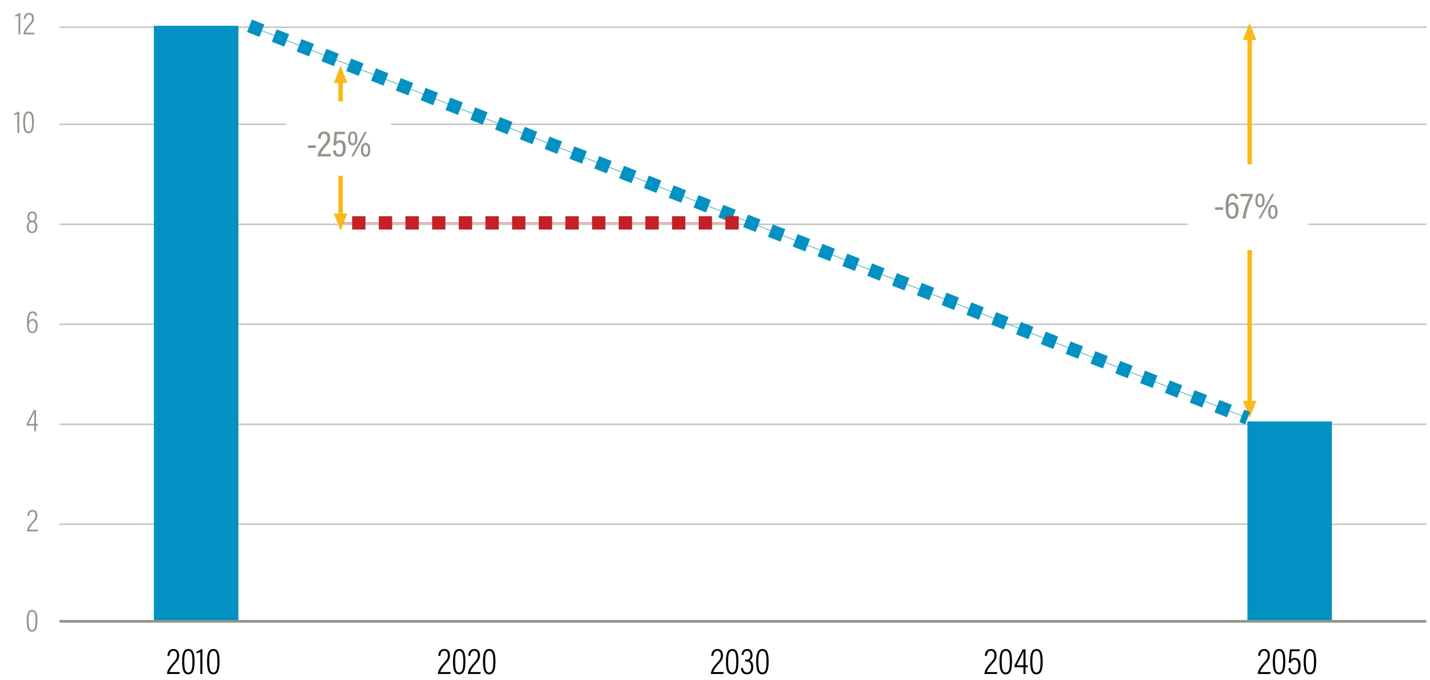
Cool Food Pledge signatories should aim to reduce their absolute food-related emissions by at least 25 percent by 2030 to put the group on the path toward collective success.[5] Because signatories are mainly entities that sell food to consumers, rather than entities that grow or manufacture food, the pledge tracks signatories' upstream[6] Scope 3 emissions associated with food purchases. More specifically, it tracks the total carbon costs (GHG emissions from agricultural supply chains, plus carbon opportunity costs, each described in greater detail below) associated with signatories' food purchases each year, and aims for a collective 25 percent reduction by 2030.

Signatories that project significant business growth may find it more meaningful to aim individually for an ambitious intensity target, as described below.

Sector-Wide, Emissions Intensity Reduction Target

Although the food sector will have to reduce GHG emissions, that sector, as well as some Cool Food Pledge signatories, will also grow to feed more people between 2015 and 2030. Therefore, it is also instructive to define an intensity target for the sector—that is, a reduction in emissions relative to a specific business metric; in this case, emissions per kilocalorie (kcal or calorie) of food.[7]

Figure 3 | **The sectoral target of reducing food-related GHG emissions by 25 percent by 2030 relative to 2015 is downscaled from a longer-term 2050 target**



Sources: Searchinger et al. 2019; SBTi 2019.

Searchinger et al. (2019) project that overall food demand (measured in crop calories) is likely to grow by 56 percent between 2010 and 2050, implying a growth in demand of roughly 21 percent between 2015 and 2030.[8] Taking that 21 percent growth in food demand, and the need to reduce food-related emissions by 25 percent globally during that period, the necessary reduction in emissions per calorie of food would be 38 percent between 2015 and 2030.[9] This equates to a linear emissions reduction of about 2.5 percent per calorie of food per year, relative to the base year.

Cool Food Pledge signatories that project significant business growth between 2015 and 2030—meaning they may capture a greater share of the market during that period—should aim for at least a 38 percent relative reduction in emissions per calorie, even if their growth means that a 25 percent absolute reduction will not be possible.

The Cool Food Pledge secretariat will monitor both the absolute and relative performance of the group, and report collective, aggregate performance against both targets (25 percent absolute reduction, 38 percent relative reduction) on an annual basis. The secretariat will also confidentially share signatories' individual progress annually.

Other Targets

Signatories may internally aim for their own more stringent targets, such as setting a maximum amount of GHG emissions per meal or setting specific targets on purchases of certain food types per meal (e.g., in line with the "healthy reference diet" in Willett et al. 2019). Such targets, however, are not required for participation in the Cool Food Pledge.

2. METRICS AND DATA NEEDS

If the entire food and agriculture sector is to reduce emissions by 25 percent by 2030 (which is equivalent to a 38 percent reduction in emissions per calorie of food), how can individual Cool Food Pledge signatories set baselines and track progress against these collective targets over time?

GHG Accounting and Reporting Principles

The GHG Protocol's *Corporate Value Chain (Scope 3) Accounting and Reporting Standard* provides guidance for companies and other institutions to quantify the indirect GHG emissions resulting from activities in their supply chains (WRI and WBCSD 2011).[10] Accounting and reporting are based on the principles of relevance, completeness, consistency, transparency, and accuracy (Table 1) (WRI and WBCSD 2011).

Table 1 | **How GHG Protocol Accounting Principles Are Applied in the Context of the Cool Food Pledge**

PRINCIPLE	DEFINITION	HOW APPLIED IN CONTEXT OF COOL FOOD PLEDGE
Relevance	The relevance principle ensures the GHG inventory appropriately reflects the GHG emissions of the organization and serves the decision-making needs of users—both internal and external to the organization.	The measurement process uses input data (annual food purchases) commonly available to companies and other institutions, and provides output data (calculations of associated land use and GHG emissions) that can help Cool Food Pledge signatories think through strategies to serve more climate-friendly meals as a way to reduce emissions. The process also helps signatories track (individually and as a group) progress against the collective GHG reduction targets.
Completeness	Completeness requires accounting for and reporting on all GHG emission sources and activities within the inventory boundary. Disclose and justify any specific exclusions.	The activities tracked account for "upstream" Scope 3 emissions related to purchased agricultural products, from cradle to point of purchase by the signatory, plus carbon opportunity costs. They do not account for retail-level emissions (which would fall under Scope 1 and Scope 2) nor do they account for post-retail stages (e.g., consumer waste) that were not considered by Poore and Nemecek (2018) because of low data availability. The "mandatory" food types tracked (animal and plant proteins) collectively tend to account for 80 percent or more of institutions' total food-related supply chain emissions and carbon opportunity costs (Figure 4) and thus tend to offer the most significant opportunities for emissions reduction.[11] Tracking the other plant-based foods (e.g., fruits, vegetables, roots and tubers, vegetable oils, sugars, spices), which tend to account for less than 20 percent of institutions' food-related supply chain emissions and carbon opportunity costs, is optional but recommended.[12] Signatories may wish to track and report them for a fuller picture over time and to enable additional analysis (e.g., nutrition, water use).
Consistency	Use consistent methods to allow for meaningful performance tracking of emissions over time. Transparently document any changes to the data, inventory boundary, methods, or any other relevant factors in the time series.	The database used by Poore and Nemecek (2018) includes standardized data on five environmental indicators (GHG emissions, land use, freshwater withdrawals, acidification, and eutrophication). Searchinger et al. (2018) define a carbon benefits index that measures how changes in land use contribute to the global capacity to store carbon (e.g., in forests) and/or to reduce GHG emissions. Signatories report in a consistent way each year (Box 3).
Transparency	Address all relevant issues in a factual and coherent manner, based on a clear audit trail. Disclose any relevant assumptions and make appropriate references to the accounting and calculation methods and data sources used.	Signatories use a common reporting template (Box 3) and track any caveats, assumptions, and exclusions in the food purchase data they submit. Default emission factors come from freely downloadable, peer-reviewed databases. The Cool Food Pledge signatories' aggregated group emissions are reported externally on an annual basis.
Accuracy	Accuracy ensures that the quantification of GHG emissions is systematically neither over nor under actual emissions, as far as can be judged, and that uncertainties are reduced as far as practicable. It is also meant to achieve sufficient accuracy to enable users to make decisions with reasonable confidence as to the integrity of the reported information.	Regional emission factors are used to increase accuracy of GHG emissions estimates where possible. More granular (e.g., national, subnational, or organization-level) factors may be used if available and of similar quality.

Source: WRI and WBCSD 2011; Authors.

Box 2 | **The Better Buying Lab and User Testing**

Launched in 2016, WRI's Better Buying Lab (www.betterbuyinglab.org) cooks up cutting-edge strategies to enable consumers to buy and consume more sustainable foods. The Better Buying Lab brings together the brightest and best minds from consumer research, behavioral economics, marketing strategy, and food companies to research, test, and scale up adoption of new strategies and plans that help consumers select sustainable foods.

During 2017 and 2018, through Better Buying Lab's partner networks, 32 food providers generously provided data and staff time to help us test this data collection process and an early version of the calculator. Insights gleaned from this user testing process also informed the development of this document.

GHG accounting classifies a company's GHG emissions into three "scopes." Scope 1 emissions are direct emissions from owned or controlled sources. Scope 2 emissions are indirect emissions from the generation of purchased energy. Scope 3 emissions are all other indirect emissions (not included in Scope 2) that occur in the value chain of the reporting company, both upstream and downstream.

As with financial accounting and reporting, generally accepted GHG accounting principles are intended to underpin and guide GHG accounting and reporting to ensure that the reported inventory represents a faithful, true, and fair account of an organization's GHG emissions. The five principles described in Table 1 are adapted from the GHG Protocol Corporate Standard and are intended to guide the accounting and reporting of an organization's Scope 3 inventory (WRI and WBCSD 2011).

In keeping with GHG Protocol guidance, this document uses the words "shall," "should," and "may" to indicate which provisions are requirements, which are recommendations, and which are permissible or allowable options that Cool Food Pledge signatories may choose to follow. The term "shall" is used throughout to indicate requirements for signatories in reporting their food purchases. The term "should" is used to indicate a recommendation, but not a requirement. The term "may" is used to indicate an option that is permissible or allowable.

The method in this technical note and the Cool Food Calculator, building from the Scope 3 standard, calculates annual upstream emissions related to purchased goods and services (agricultural products), from cradle to point of purchase, prioritizing data collection efforts on animal-based foods and plant proteins to capture the majority of emissions. Signatories estimate food-related emissions and land use by multiplying kilograms (kg) or pounds (lb) of food purchased by emission factors (emissions or land use per kg or lb of food purchased).[13]

Food purchase data are primary data collected by signatories. The data collection process described in this document was tested with more than 30 food providers during 2017–2018 through the Better Buying Lab (Box 2).

Data on emission factors continue to improve; just in the past two years, several global meta-analyses of food life cycle assessments have been published (Poore and Nemecek 2018; Heller et al. 2018; Clune et al. 2017). The default emission factors in the Cool Food Calculator come from secondary data contained in a global life cycle meta-analysis by Poore and Nemecek (2018) and a global assessment of carbon opportunity costs of agriculture by Searchinger et al. (2018). This technical note and the calculator will be updated periodically as environmental data improve, but for consistency's sake baselines may also have to be recalculated if a default data set changes.

All GHG emissions data in the calculator use global warming potential (GWP) values in units of carbon dioxide equivalent (CO_2e) based on a 100-year time horizon, provided in the *Fifth Assessment Report* of the Intergovernmental Panel on Climate Change (IPCC) (Stocker et al. 2013). Recent research (Allen et al. 2018) has highlighted that using conventional CO_2 equivalent metrics (GWP over 100 years, or GWP100) can misrepresent the impact of short-lived climate pollutants—which, importantly for agriculture, include methane—on future long-term impacts on global temperature. This is because, although methane has a strong warming influence when first emitted, it decays rapidly in the atmosphere, so its warming effects over 100 years are overstated under GWP100. That said, by an alternative metric, GWP over 20 years or GWP20, methane's effect on the climate looks worse than by the conventional GWP100 metric because of its short-term warming effects, which are relevant given the 2030 time horizon for the Cool Food Pledge. Further, Shindell et al. (2017) note the need to rapidly reduce emissions from short-lived climate pollutants (such as methane) to provide near-term climate benefits as the world also works to reduce long-lived GHGs (such as CO_2) to stabilize the climate in the longer term. Given these considerations, and the fact that global data sets for food-related GHG emissions currently all use GWP100, using GWP100 is recommended at this time.

Metrics Tracked by the Cool Food Pledge

The Cool Food Calculator helps pledge signatories enter and estimate five important metrics. These metrics are described below along with their data needs:

1. Food purchases by food type (boneless equivalent, in kg or lb) (includes input data provided by signatory)
2. Food-related GHG emissions from agricultural supply chains (tonnes CO_2e)
3. Food-related land use (ha)
4. Food-related carbon opportunity costs (tonnes CO_2e)
5. Normalized metrics (several possible units of measure)

An illustrative example of the five metrics, for a Cool Food Pledge signatory serving approximately 3.5 million meals per year, is shown in Figure 4.

Metric 1: Food purchases (boneless equivalent, in kg or lb) (includes input data provided by signatory)

As shown in Figure 2, production of different foods leads to different land-use requirements and different levels of GHG emissions. The amount of each food type purchased is a straightforward indicator of potential resource use and emissions.

Data needs

Data on food purchases are primary and come from Cool Food Pledge signatories. Signatories shall track these data on an annual basis and report in weight (kg or lb) unless the units are otherwise specified (e.g., liters (L), gallons) (Box 3).

The base year for the Cool Food Pledge is 2015, so when signatories first join, they shall set their baseline by using food purchase data from the most recent year as well as food purchase data from 2015. If data from 2015 are unavailable, then a more recent base year may be used.[14] For communication purposes, the Cool Food Pledge secretariat will assume that food purchases were constant from the true base year back to 2015.

Default factors that convert bone-in meat and fish weights to boneless (retail) weights come from a secondary source—a recent global life cycle meta-analysis (Poore and Nemecek 2018). The Cool Food Calculator automatically converts the reported weights to boneless equivalent weights.

Considerations

This indicator is conceptually simple, and can be used to track shifts in proportions of foods served over time. However, collecting and organizing food purchase data in this way may be new for many signatories. It may require contacting multiple suppliers and establishing a practicable way for tracking the data over time. It may also require figuring out ways to convert different units of measure (e.g., cases, gallons, amount spent) into kilograms and pounds. See Appendix A for additional guidance.

Metric 2: Food-related GHG emissions from agricultural supply chains (tonnes CO_2e)

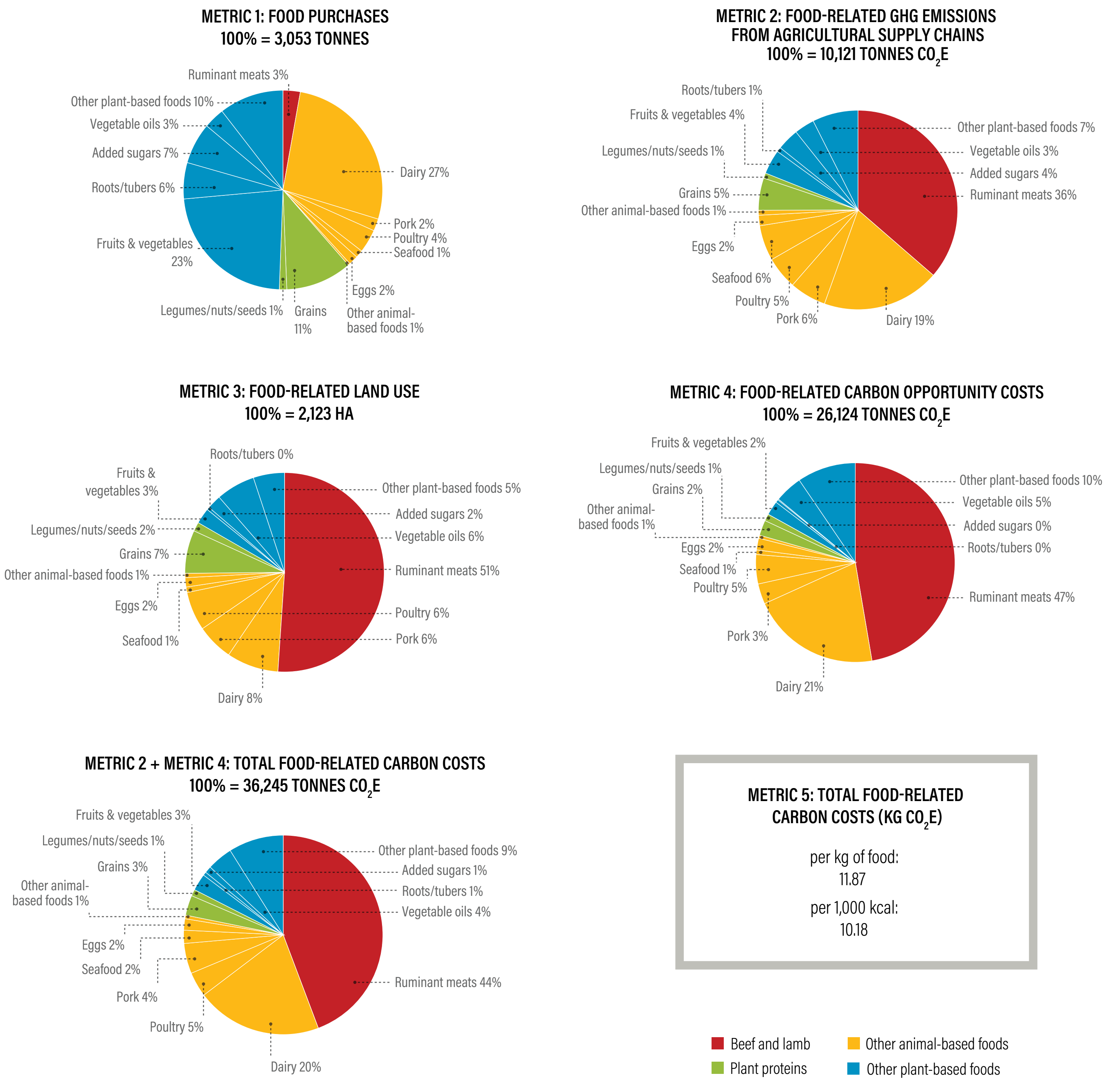
This metric includes all upstream GHG emissions from agricultural supply chains, except land-use change, which is covered in Metric 4.

Most agricultural supply chain emissions come from the production process. These agricultural production emissions come from six major sources (IPCC 2019) (Figure 5):

- "enteric" methane emitted from the stomachs of ruminant animals (cattle, buffalo, goats, and sheep);
- methane and nitrous oxide from manure management in confined animal facilities;
- nitrous oxide from animal wastes left on pasture;
- nitrous oxide from crop and pasture fertilization;
- methane from rice production; and
- carbon dioxide from energy use in on-farm activities and in the production and transport of agricultural inputs such as fertilizer.

Besides production of food and animal feed, upstream

Figure 4 | **The mandatory food types tracked by the Cool Food Pledge tend to account for more than 80 percent of food-related GHG emissions, land use, and carbon opportunity costs (illustrative annual data)**



Note: Numbers may not sum to 100% due to rounding. Data are illustrative for one Cool Food Pledge signatory serving approximately 3.5 million meals per year with food purchases proportional to the average U.S. diet in 2013. "Total food-related carbon costs" refers to agricultural supply chain emissions (Metric 2) plus carbon opportunity costs (Metric 4).
Sources: Agricultural supply chain emission factors are from Poore and Nemecek 2018, carbon opportunity cost emission factors are from Searchinger et al. 2018, U.S. food supply data are from FAO 2019.

Box 3 | Reporting Food Purchases by Food Type

Signatories shall report the previous year's food purchase data on an annual basis. They may report at the aggregate level (shown in bold—e.g., fish and seafood; liquid dairy) or at a more detailed level (e.g., finfish, crustaceans; milk, yogurt). More detailed reporting will allow for increased accuracy. As shown in Figure 4, the mandatory items collectively tend to account for more than 80 percent of signatories' total food-related agricultural supply chain emissions, land use, and carbon opportunity costs.

MANDATORY ITEMS

Animal proteins

- **Beef**
- **Lamb/sheep/goat**
- **Pork**
- **Poultry**
- **Fish and seafood**
  - Fish (finfish)
  - Crustaceans (e.g., shrimp, prawns)
  - Mollusks (e.g., clams, oysters)
- **Liquid dairy**
  - Milk
  - Yogurt
- **Solid dairy**
  - Cheese
  - Butter
  - Ice Cream
- **Eggs**

Plant proteins

- **Legumes and pulses**
  - Beans, peas, lentils, chickpeas
  - Peanuts and peanut butter
  - Soybeans and tofu
- **Nuts and seeds, nut/seed butters**
- **Grains**
  - Rice
  - Wheat (flour)
  - Corn (maize) (flour)
  - Bread and baked goods
  - Pasta and noodles
  - Other grains and flours (as relevant or feasible)
- **Plant-based milk substitutes**
  - Almond milk
  - Oat milk
  - Rice milk
  - Soy milk

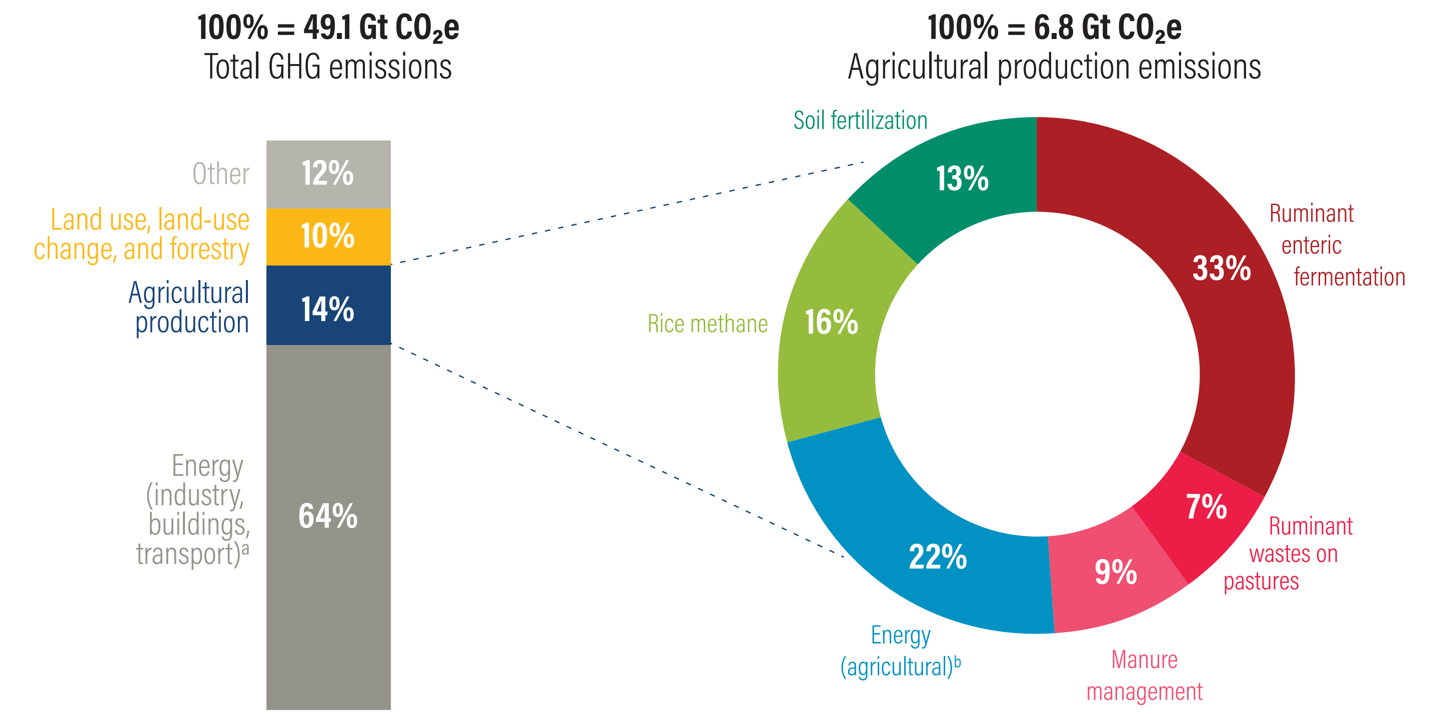
OPTIONAL ITEMS

- Fruits
- Vegetables (excluding roots and tubers)
- Roots and tubers
- Vegetable oils
- Sugars and sweeteners
- Tea, coffee, spices
- Alcoholic beverages
- Other foods (please list)

The Cool Food Pledge secretariat is working with signatories and partners to assess the feasibility of moving several of the optional items to the mandatory category in future years—particularly vegetables, fruits, and roots and tubers, which are all foods that (along with plant proteins) are common replacements for animal-based foods in dishes. Tracking these additional items would also have the side benefit of providing greater clarity on other indicators, such as nutrition.

Guidance on reporting on other plant-based meat, dairy, fish, and egg substitutes and pre-mixed items is provided in Appendix A. For guidance on accounting for different production systems, see Section 3.

Figure 5 | **Agricultural production emissions arise from six major sources (emissions are for 2010)**



Note: Numbers may not sum to 100% due to rounding.

[a] Excludes emissions from agricultural energy sources described above.

[b] Includes emissions from on-farm energy consumption as well as from manufacturing of farm tractors, irrigation pumps, other machinery, and key inputs such as fertilizer. It excludes emissions from the transport of food.

Sources: GlobAgri-WRR model (agricultural production emissions); WRI analysis in Searchinger et al. 2019, based on raw data from UNEP 2012, FAO 2012, EIA 2012, and Houghton 2008, modified by WRI.

supply chain emissions arise from the following sources (Poore and Nemecek 2018):

- transport of food and animal feed;
- food processing;
- food packaging; and
- losses during harvest, transport, processing, and packaging.

Because the scope is from cradle to point of purchase (by the signatory), emissions at the retail (e.g., refrigeration) and consumption (e.g., cooking) stages are not counted, nor are losses and waste from retail and consumption.[15] Default emission estimates are made on the basis of generic modeling of food transport, processing, packaging, and upstream losses, and may not accurately reflect the specifics of a signatory's supply chains.

Signatories shall estimate food-related agricultural supply chain emissions by multiplying the food purchase data (Metric 1) by emission factors from cradle to point of purchase, using regional default values found in Poore and Nemecek (2018), as provided in the calculator. The calculator automatically estimates values for each food type and totals them.

Data needs

Default regional emission factors by food type (per kg of food, retail weight) come from a secondary source—a recent global life cycle meta-analysis (Poore and Nemecek 2018). The emission factors in this data set compare well with other recently published meta-analyses (Table 2).[16]

This data set is of high quality in terms of the data quality indicators in the GHG Protocol, which include representativeness (technological, temporal, geographical), completeness, and reliability (WRI and WBCSD 2011). The data set is supplemented with several entries from Feitz et al. (2007) (for dairy) and Tyedmers et al. (2019) (for seafood).

The calculator automatically loads in the factors for the region where the signatory is located. Signatories may also substitute a different region's emission factor for a given food type if the majority of that food type is imported from that other region.

Considerations

Signatories may wish to use (i.e., substitute) country-level emission factors. They can be found in the full data set of Poore and Nemecek (2018) (http://science.sciencemag.org/content/360/6392/987). However, countries may have very few or no individual observations, meaning that in many cases the region-level emission factors are the most appropriate.

If primary (e.g., farm-level) data are available for certain emission factors, signatories may use such emission factors, provided that the data are of higher quality than the secondary data in Poore and Nemecek (2018) according to the data quality indicators in Table 3. Requests to use primary emission factor data shall be submitted to the Cool Food Pledge secretariat for consideration.

Table 2 | **Comparison of Three Recent Life Cycle Meta-analyses, Including the Data Set in the Cool Food Calculator**

META-ANALYSIS	CLUNE ET AL. (2017)	HELLER ET AL. (2018)	POORE AND NEMECEK (2018)	POORE AND NEMECEK (2018)
Life cycle assessment boundary	Cradle to regional distribution center	Cradle to farm gate	Cradle to farm gate[a]	Cradle to farm gate[a]
Averaging method (across primary studies)	Median (Global)	Mean (Global)	Weighted mean (Global)	Weighted mean (North America)
AVERAGE GHG EMISSION FACTORS (KG CO_2E PER KG OF BONE-FREE PRODUCT [RETAIL WEIGHT])				
Beef	26.61	32.85	44.25	33.53
Lamb	25.58	34.75	30.31	34.79
Poultry	5.41[b]	3.38[b]	3.38	2.38
Pork	5.77	5.56	6.78	7.6
Milk	1.29	1.32	1.75	1.45
Cheese	8.55	9.97	15.45	12.47
Eggs	3.46	3.75	3.52	3.32
Finfish	3.49	3.11	9.89	3.62
Corn (maize)	0.47	0.55	0.72	0.62
Wheat	0.52	0.36	0.82	0.95
Rice	2.55	1.54	3.55	1.82
Legumes and pulses	0.51	0.31[c]	0.65	0.98

Notes:
a. Cradle to farm gate emission factors in Poore and Nemecek (2018) are shown here to provide a better comparison with Clune et al. (2017) and Heller et al. (2018), but the Cool Food Calculator also includes Poore and Nemecek's estimates of GHG emissions from the transport, processing, packaging, and upstream losses stages of the supply chain. Emission factors shown in this table do not include land-use change.
b. Averages of emission factors of chicken and turkey.
c. Specific emission factor for beans.

Table 3 | **Data Quality Indicators**

INDICATOR	DESCRIPTION	COMMENT ON SPECIFIC DATA SET IN COOL FOOD CALCULATOR		
		Poore and Nemecek (2018)	**Searchinger et al. (2018)**	**Signatories' food purchase data**
Technological representativeness	This is the degree to which the data set reflects the actual technology or technologies used.	Regional emissions data come from more than 38,000 farms in 119 countries, and 40 food types representing approximately 90 percent of global calorie and protein consumption.	Data come from a new global model based on data sets on vegetation, soils, crops, and livestock products, covering more than 50 food types.	Data are drawn from current year (or recent year if conducting historical baseline), organized into food types that match the two emission factor data sets.
Temporal representativeness	This is the degree to which the data set reflects the actual time (e.g., year) or age of the activity.	Median reference year is 2010.	Reference year is 2005.	Data are drawn from current year (or recent year if conducting historical baseline).
Geographical representativeness	This is the degree to which the data set reflects the actual geographic location of the activity (e.g., country or site).	Emission factors that are available at global, regional, or country level; each observation (primary study) is weighted by share of national agricultural production it represents, and each country by share of global production.	Emission factors are global, reflecting the global nature of total food demand.	Signatories record majority region of origin of each food type.
Completeness	This is the degree to which the data are statistically representative of the relevant activity. Includes the percentage of locations for which data are available and used out of the total number that relate to a specific activity, and seasonal and other normal fluctuations in data.	See "Technological representativeness," above.	See "Technological representativeness," above.	See "Technological representativeness," above.
Reliability	This is the degree to which the sources, data collection methods, and verification procedures used to obtain the data are dependable.	Data come from a peer-reviewed academic source.	Data come from a peer-reviewed academic source.	Signatories make a good-faith effort to accurately provide all mandatory food purchase data.

Source: Based on WRI and WBCSD 2011; Weidema and Wesnæs 1996, modified by WRI.

Metric 3: Food-related land use (ha)

An important target for achieving a sustainable food future is to avoid further expansion of global agricultural land area, including cropland and pastureland. In 2010, ongoing land-use change (vegetation clearing and soil plowing) accounted for roughly 10 percent of all human-caused GHG emissions (Figure 5), mostly as agriculture expanded into forests and other natural ecosystems. However, the large majority of modeled pathways for stabilizing the climate below 2°C of warming require halting deforestation (and net emissions from changes in land use) by 2050. Indeed, most require significant amounts of reforestation (and negative emissions from changes in land use) (IPCC 2019).

If the world must avoid further agricultural land expansion—and liberate some of today's agricultural land for future reforestation—it follows that signatories should seek to limit or reduce their food-related land use. Fortunately, as Figure 4 shows, the shifts they could make to reduce food-related GHG emissions from agricultural supply chains (Metric 2) are similar to those that would reduce land use (Metric 3).

Signatories shall estimate food-related land use by multiplying the food purchase data (Metric 1) by land-use factors.

Data needs

Default regional land-use factors by food type (per kg of food, retail weight) come from Poore and Nemecek (2018), as provided in the calculator. The data set is supplemented with several entries from Feitz et al. (2007) (for dairy) and Tyedmers et al. (2019) (for seafood).

The calculator automatically loads in the factors from the region where the signatory is located. Signatories may also substitute a different region's emission factor for a given food type if the majority of that food type is imported from that other region.

Considerations

As with Metric 2, signatories may wish to use (i.e., substitute) country-level land-use factors. They can be found in the full data set of Poore and Nemecek (2018) (http://science.sciencemag.org/content/360/6392/987). However, countries may have very few or no individual observations, meaning that in many cases the region-level land-use factors are the most appropriate.

If primary (e.g., farm-level) data are available for certain land-use factors, signatories may use such factors, provided that they are of higher quality than the secondary data in Poore and Nemecek (2018) in terms of representativeness (technological, temporal, geographical), completeness, and reliability (WRI and WBCSD 2011) (Table 3). Requests to use primary land-use factors shall be submitted to the Cool Food Pledge secretariat for consideration.

Metric 4: Food-related carbon opportunity costs (tonnes of CO_2e)

Nearly all of the world's croplands originally stored more carbon in their vegetation and soils than they do today, whether their original ecosystems were forest, woody savannas, grasslands, or wetlands. In addition, more than 30 percent of the world's pasturelands were originally forested (Searchinger et al. 2018).[17] Deforestation and other land-use changes have contributed between one-quarter and one-third of the carbon that humans have released to the atmosphere since 1750, and the conversion of natural ecosystems to agricultural use continues to contribute to climate change (IPCC 2019; Le Quéré et al. 2016). However, common evaluation methods of food-related GHG emissions do not fully reflect the carbon opportunity cost of using land for agriculture.

The carbon opportunity cost of a food is the amount of carbon likely to be lost from plants and soils because of additional production of that food (and resulting agricultural expansion). Conversely, it can be defined as the amount of carbon that could be stored if production of that food declined and land in agriculture returned to its native vegetation. Life cycle assessments, including Poore and Nemecek (2018), often estimate GHG emissions from agricultural production and subsequent stages in the food supply chain (Metric 2) and sometimes also estimate food-related land use (Metric 3).[18] However, most do not fully translate agricultural land use into carbon opportunity costs.[19]

In our world, where agriculture continues to expand into natural ecosystems, production of every food type in every country in every year—even if the food was not produced on land recently converted to agriculture—has some carbon opportunity cost. The carbon opportunity cost of a food is calculated by estimating total global carbon losses caused by producing that food to date, divided by global annual production of that food, and the result is expressed in kilograms of CO_2e per kilogram of food (Searchinger et al. 2018). Because carbon losses from clearing native vegetation to expand food production occur quickly, but food production on a cleared plot of land can continue well into the future, this metric annualizes the carbon opportunity cost over a period of 33 years.[20] In effect, this analysis assumes that each additional kilogram of production of a food will require an amount of carbon to be released at the global average of past carbon losses. The carbon opportunity costs per kilogram of each food therefore depend on the yield (kg per ha) of that food and on the amount of carbon that could be otherwise stored on the lands currently used to produce that food. Because animal-based foods (especially ruminant meats) require a relatively large amount of land to produce a kilogram of food, these foods have higher carbon opportunity costs per kilogram.

If a Cool Food Pledge signatory's carbon opportunity cost grows from year to year (because of purchasing a more land-intensive mix of foods), this would imply that the change in purchasing increased pressure on the world's forests, savannas, and other ecosystems typically converted to produce those foods—and this metric estimates the resulting (detrimental) effect on the climate. Conversely, if a signatory's carbon opportunity cost falls from year to year (because of purchasing a less land-intensive mix of foods), this would imply that the change in purchasing reduced pressure on the world's remaining natural ecosystems—with this metric estimating the resulting (beneficial) effect on the climate.

As shown in Figure 2, in the case of almost all foods, the annualized carbon opportunity costs (Metric 4) are higher than annual GHG emissions from agricultural supply chains (Metric 2).[21] This means that Metric 4 tends to be higher than Metric 2 when assessed at the level of a signatory's total annual food purchases (Figure 4). Figures 2 and 4 show that including carbon opportunity costs provides a fuller picture of the climate impacts of food production and consumption, and also that the climate benefits of shifting high-meat diets toward plant-based foods are larger than commonly calculated.[22]

Signatories shall estimate food-related carbon opportunity costs by multiplying the food purchase data (Metric 1) by emission factors.

Data needs

Default global emission factors by food type (per kg of food, retail weight) come from Searchinger et al. (2018), and are provided in the Cool Food Calculator.[23] Emission factors are global, reflecting the global nature of total food demand. The data set is supplemented with several entries from Feitz et al. (2007) (for dairy) and Tyedmers et al. (2019) (for seafood). At the time of writing, region- and country-level carbon opportunity cost emission factors were not yet publicly available.

It is possible to imagine future work that would estimate carbon opportunity costs spatially, allowing for very site-specific estimates. However, it is difficult to estimate the precise locations where land conversion to produce additional food will occur. As elaborated in Searchinger et al. (2018, 255): "To estimate where conversion will occur and the resulting carbon losses, such approaches require overlapping multiple spatial datasets, each of which has its own random errors." The method used here, which estimates global average carbon losses per kilogram of a given food across all lands devoted to producing that food worldwide, provides many opportunities to average out random errors.

Considerations

This metric provides a fuller picture of the GHG emissions consequences of food purchases from year to year (Figures 2 and 4). Adding Metric 2 (food-related GHG emissions from agricultural supply chains) and Metric 4 together—and tracking changes from year to year—can show how changes in food purchases can not only reduce food-related emissions on farms, but also reduce pressure on forests and other natural ecosystems by avoiding additional emissions from conversion to agriculture.[24]

Because Metric 4 has elements of avoided emissions, it is not included in standard Scope 3 GHG inventories (WRI and WBCSD 2011) and must be reported separately. Therefore, although the Cool Food Pledge's annual report shows signatories' total (aggregated) food-related carbon costs (Metric 2 plus Metric 4), these two metrics are also reported separately for clarity and transparency.

As of the time of writing, this approach of estimating food-related carbon opportunity costs is still somewhat novel. That said, failing to account for carbon opportunity costs can significantly underestimate or obscure the significance of dietary shifts on the climate.

Metric 5: Normalization (several possible units of measure)

As noted, during the Cool Food measurement period of 2015 to 2030, the global population and global food demand are projected to grow—and signatories' businesses may also be projected to grow during this period. Normalizing Metrics 2, 3, and 4 by a common business metric (e.g., per calorie of food, per meal, per amount spent) can help a signatory know if its progress is in line with the necessary level of ambition, even given growth. Normalization can also help put food-related GHG emissions into context.

The Cool Food Calculator provides two default normalization metrics (Metrics 2, 3, and 4 per kg of food, and per 1,000 calories). To normalize per 1,000 calories, the calculator converts food purchase data in weight (Metric 1) into calories using regional conversion factors by food type from FAO (2019), and divides Metrics 2, 3, and 4 by the caloric estimate.

As illustrated in Table 4, there is no perfect normalization factor, because:

- If food purchase weight (e.g., kilograms) is used as a denominator, fluid milk is relatively GHG-efficient, but this is because fluid milk is mostly water, which provides no macro- or micronutrients. Shifting to fluid milk as a way to improve performance on this metric could be problematic as dairy products tend to account for a sizable amount of food-related land use and GHG emissions (Figure 4). Using weight as a denominator also makes other foods with high water content (e.g., fruits and vegetables) look much more efficient than dried foods such as grain flours or beans.
- If calories are used as a denominator, sugars and sweeteners are very GHG-efficient. Shifting to added sugars as a way to improve performance on this metric would be problematic as nutritional recommendations call for limiting consumption of added sugars (WHO 2015).[25]
- If other optional denominators (e.g., meals, transactions, covers, card swipes, amount spent) that are relevant to a signatory are used, it may not be possible to compare performance on this metric with other signatories' performance, given varying use and definitions of the denominators between signatories.

Data needs

Default regional weight-to-calorie conversion factors by food type come from FAO's Food Balance Sheets (FAO 2019) and are included in the Cool Food Calculator.[26] The calculator automatically loads in the factors from the region where the signatory is located, but the user may select a different region by food type if the majority of that food type is imported from another region.

Considerations

Besides normalizing Metrics 2, 3, and 4 per kg or per 1,000 calories, signatories may provide additional, optional normalization factors (e.g., meals, transactions,

Table 4 | **Examples of Trade-offs between Normalization Factors**

	KCAL/KG (RETAIL WEIGHT)	METRIC 2 (FOOD-RELATED GHG EMISSIONS FROM AGRICULTURAL SUPPLY CHAINS) (KG CO_2E)		METRIC 3 (FOOD-RELATED LAND USE) (M^2)		METRIC 4 (FOOD-RELATED CARBON OPPORTUNITY COSTS) (KG CO_2E)	
		Per kg	Per 1,000 kcal	Per kg	Per 1,000 kcal	Per kg	Per 1,000 kcal
Beef	2,158	52.05	24.12	202.31	93.76	201.65	93.45
Poultry	1,945	5.06	2.60	12.22	6.28	14.70	7.56
Milk	559	2.18	3.90	8.95	16.01	6.20	11.08
Wheat	2,684	1.38	0.51	3.85	1.43	1.83	0.68
Legumes/pulses	3,654	1.78	0.49	5.04	1.38	6.30	1.73
Fruits	413	0.59	1.43	1.16	2.82	1.03	2.50
Vegetables	251	0.58	2.30	0.44	1.75	0.71	2.82
Sugars and sweeteners	3,563	1.58	0.44	1.92	0.54	0.20	0.05

Note: Emission factors shown are global weighted averages; m^2 means square meters.
Sources: Based on raw data from FAO 2019, Poore and Nemecek 2018, and Searchinger et al. 2018, modified by WRI.

covers, card swipes, amount spent) that may be especially relevant to their businesses and useful in communicating changes in normalized metrics over time. There is a line in the calculator on which to enter optional normalization factors.

Signatories should also note that any food types left out of the analysis (e.g., optional foods such as sugars and sweeteners) may skew the normalized results, and so these results should be interpreted with caution, especially if they are compared with another entity's performance that included the optional foods. For example, sugars and sweeteners are high in calories but low in GHG emissions per kilogram, so excluding them from the analysis will not affect the estimates of total emissions (Metric 2 and Metric 4) much, but it will make "emissions per 1,000 calories" artificially high.

3. NAVIGATING SYNERGIES AND TRADE-OFFS ACROSS SUSTAINABILITY GOALS

Although the Cool Food Pledge's target and metrics (Sections 1 and 2) are aimed at helping signatories measure and reduce their food-related GHG emissions, sustainability and procurement managers deal with many other important goals related to their food purchases, including environmental, social and ethical, and economic and financial goals. In addition, they may be aiming to source foods from specific production systems. When seeking for reduced GHG emissions, signatories should be mindful of minimizing trade-offs with these other goals and maximizing progress across all of them.

This section highlights common potential trade-offs that test users highlighted between food-related GHG emissions reduction and other sustainability goals (Table 5). Although not meant to be exhaustive, it includes some advice for navigating these trade-offs and advancing progress against multiple goals.

Environmental Goals

As shown in Figure 2, animal-based foods have higher impacts than plant-based foods across GHG emissions and land use. Poore and Nemecek (2018) also show this pattern repeating for terrestrial acidification and eutrophication—two indicators associated with pollution and ecosystem degradation (Figure 6). In general, given that agricultural expansion continues to be the leading driver of biodiversity loss (IPBES 2019), reducing agricultural land use and preserving carbon-rich habitats (e.g., forests, wetlands) tends to benefit biodiversity, although such a benefit is not automatic (Searchinger et al. 2019).

Water use

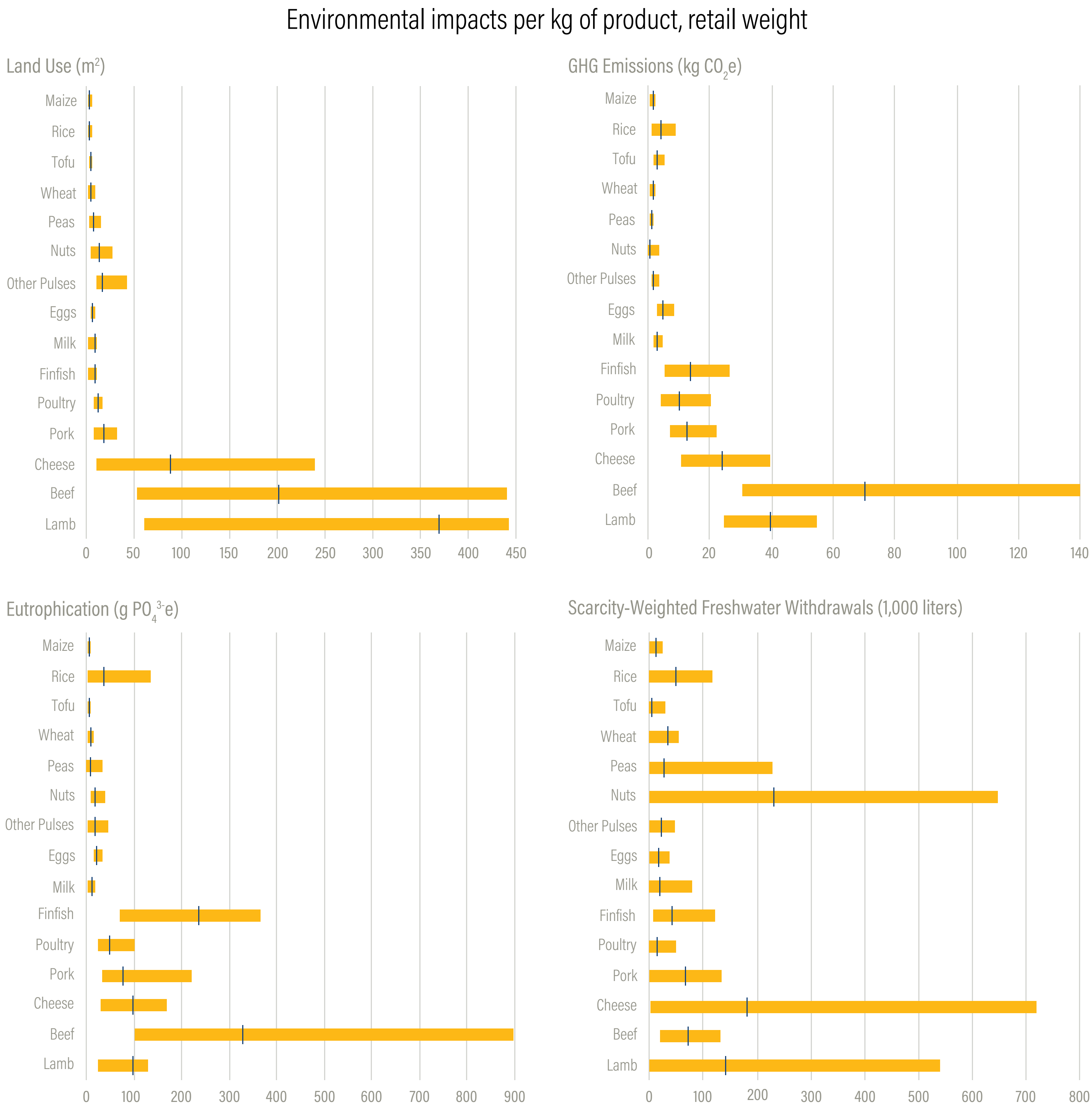
Although irrigation water use is generally higher for animal-based foods than for plant-based foods, it can be high for certain crops (e.g., tree nuts and some fruits and vegetables) (Willett et al. 2019; Poore and Nemecek 2018) (Figure 6). True sustainability of water use depends on the local context.

Table 5 | **Examples of Potential Trade-offs between Food-Related GHG Emissions Reduction and Other Sustainability Goals**

SUSTAINABILITY PILLAR	ISSUE	POTENTIAL TRADE-OFF WHEN REDUCING FOOD-RELATED GHG EMISSIONS
Environmental	Water use	Shift to crops that consume large amounts of irrigation water (e.g., tree nuts, or certain fruits and vegetables), potentially from water-stressed areas
Social and ethical	Nutrition	Shift from meat to energy-dense, nutrition-poor foods high in sugars, oils, or refined grains
	Animal welfare	Shift from beef and lamb to poultry, pork, or fish (more animals killed, less humane conditions)
Economic and financial	Sales and profitability	Shift to plant-rich meals or ingredients with higher costs, lower profit margins, and/or lower sales

Note: Examples are not exhaustive.
Source: WRI.

Figure 6 | **Animal-based foods have higher impacts than plant-based foods across most environmental impact categories, but effects between production systems can vary**



Notes: Global weighted averages shown. Bars show 10th-percentile, mean, and 90th-percentile impacts across all producers. $PO_4^{3-}e$ means phosphate equivalents; m^2 means square meters. Beef entries are weighted averages of beef and dairy herds. Finfish are farmed. GHG emissions from agricultural supply chains shown here do not perfectly correspond to Metric 2 because they also include estimates of retail-level emissions and land-use-change emissions not included in the Cool Food Calculator.
Source: Based on raw data from Poore and Nemecek 2018, modified by WRI.

Although not included in the current version of the Cool Food Calculator, calculation of sustainable water use generally follows two steps (Pacific Institute 2017):

- **Identify overall dependence on water resources.** Signatories may use irrigation water use factors to determine the cubic meters of irrigation water consumed per year to grow food and animal feed—and to identify "hot spots" of high water use.
- **Identify where dependence on water resources poses supply chain risk.** Signatories may use databases (e.g., WRI Aqueduct) to determine the levels of water stress and water risk in relevant agricultural production regions.

Future versions may incorporate guidance from initiatives defining "context-based water targets" (Pacific Institute 2017). In the interim, as a general rule, if the Cool Food Pledge stimulates a signatory to buy a new ingredient (e.g., imported soy or avocado), the signatory should conduct due diligence just as it would when establishing or scaling up any other supply chain to determine whether there are local environmental or social issues associated with the product.

Deforestation-free products

The majority of tropical deforestation in recent decades has been driven by the expansion of production of beef, palm oil, soy, and other agricultural commodities, as well as demand for timber products. Beef has the largest deforestation "footprint" of these commodities, both in terms of area of forest cleared (Henders et al. 2015) and in deforestation-related emissions. According to Pendrill et al. (2019), tropical deforestation in 2010–2014 caused 2.6 $GtCO_2e$ of net annual GHG emissions, with beef expansion responsible for 0.9 $GtCO_2e$ and expansion of oil crops (oil palm and soy) together responsible for 0.6 $GtCO_2e$. Henders et al. (2015) had a similar estimate for beef-related deforestation emissions during 2000–2011, followed by oil palm (0.3 $GtCO_2e$) and soy (0.1 $GtCO_2e$) during that period.

In response, hundreds of companies that source these commodities have committed to reducing or eliminating deforestation from their supply chains and have put a variety of measures and standards in place to track progress. If enough companies and financial institutions make deforestation-free supply chain commitments that together account for a large share of market demand or financing of these commodities, this has the potential to persuade farmers, agricultural companies, and jurisdictions (e.g., districts, states) to meet growing demand by boosting yields and efficiency instead of by expanding agricultural area.

However, the impact of these company commitments on curbing deforestation and associated GHG emissions currently remains unclear and challenging to assess (Taylor and Streck 2018). More fundamentally, if demand for these commodities continues to rise, and growth in their yields per ha does not keep pace, agricultural expansion will continue to occur despite efforts to source deforestation-free products from specific suppliers and geographies.

The Cool Food Calculator does not attempt to measure deforestation-related emissions directly (related to a specific commodity in a specific geography and year). Instead, the carbon opportunity cost (Metric 4) provides an estimate of a signatory's overall pressure on forests and other natural ecosystems (and related effects on the climate) as the volume and mix of foods purchased by the signatory changes over time.

Counterintuitively, the oilseed crops directly responsible for deforestation in recent years fare quite well on Metric 4, with annual carbon opportunity costs (per kg of product) of 10 kg CO_2e for soybean oil and 8 kg CO_2e for palm oil, compared with 202 kg CO_2e for beef. This is because the oilseed crops have much higher yields than beef in terms of kg of food produced per ha: the next unit of soybean oil or palm oil demanded by the world has a much lower land use requirement and carbon opportunity cost than the next unit of beef. And because soy is an important ingredient in animal feeds, the carbon opportunity cost of using soy as animal feed is accounted for in the carbon opportunity costs of producing those meats (e.g., 21 kg CO_2e for pork, 15 kg CO_2e for poultry) (Searchinger et al. 2018).

That said, even if a signatory's overall performance on Metric 4 (carbon opportunity cost) improves over time, it does not guarantee that any particular forest has been protected or restored. Other actors will need to complement pledge signatories' efforts to reduce agricultural land demand and pressure on forests by working to preserve forests at risk of deforestation in specific places. This is where deforestation-free commitments can play an important role, especially if complemented by measures that improve governance, promote rural development and sustainable intensification of agriculture on existing agricultural lands, and create incentives to conserve and restore forests (Taylor and Streck 2018).

Social and Ethical Goals

Many previous studies have shown that it is possible to shift to diets that are both healthier and better for the climate and the broader environment (Willett et al. 2019; see also Box 8 in Ranganathan et al. 2016). However, such multiple benefits are not automatic and not necessarily proportional (Garnett 2016). In addition, shifts to more climate-friendly diets have the potential to affect labor conditions and animal welfare in divergent ways.

Nutrition

The EAT–*Lancet* Commission report defines a healthy reference diet as one that "largely consists of vegetables, fruits, whole grains, legumes, nuts, and unsaturated oils, includes a low to moderate amount of seafood and poultry, and includes no or a low quantity of red meat, processed meat, added sugar, refined grains, and starchy vegetables" (Willett et al. 2019, 1). Figure 2 shows that in many cases, shifts toward lower-GHG foods can coincide with shifts toward a healthier mix of foods. However, there are also many low-GHG foods that are unhealthy in large quantities, including added sugars, vegetable oils, and refined grains. In addition, the nutritional benefits of novel plant-based meat, dairy, egg, and fish alternatives (relative to the products they may replace in human diets) is a subject of current debate (Hu et al. 2019).

Tracking food purchase data allows not only for environmental analysis as described in this technical note, but also for assessing changes in the mix of foods purchased from a nutritional standpoint, although how to conduct this nutritional analysis is outside the scope of this document. To do this, signatories will likely need to track the full range of foods purchased, so they can see changes in purchases of low-GHG but healthy foods (e.g., fruits, vegetables) or low-GHG but unhealthy foods (e.g., sugars or sugar-sweetened beverages), and also track food purchases at a higher level of granularity (e.g., separating whole from refined grains). Signatories should monitor shifts in the mix of foods purchased over time to ensure that, at a minimum, efforts to reduce food-related GHG emissions maintain overall nutritional quality of the signatory's food offering—ideally, such efforts would increase nutritional quality.

Animal welfare

Animal welfare organizations often seek to minimize the suffering of animals in agricultural production systems. This can include advocating for less consumption of animal-based foods overall, for changes in production systems to make them more humane, or both (Almiron 2019; Freeman 2010). Although a shift from beef or lamb toward poultry, pork, or fish would result in a GHG emissions reduction, this shift would also generally result in more (smaller) animals being killed overall—and the animals might be raised in more crowded conditions (Saja 2013). A shift instead toward plant-based foods can avoid this trade-off.[27]

Other social and ethical considerations

Signatories must also be aware of other social and ethical considerations when making procurement choices, such as labor conditions in agricultural supply chains, human rights, and trade issues. However, there is no clear correlation between these considerations and the GHG intensity of food production.

If a signatory reduces purchases of a certain food from a certain geographic area, effects on food producers could be negative. That said, because of population growth, rising incomes, and urbanization, global demand for animal-based foods continues to rise, with demand for meat and dairy projected to rise by 70 percent between 2010 and 2050, and for ruminant meat in particular by 88 percent during that period (Searchinger et al. 2019). Even large-scale reductions in meat consumption across populations where consumption levels are high could still lead to (albeit slower) overall growth in meat production at the global level, preserving an abundant role for the world's livestock farmers. Indeed, in the United States, despite per capita beef consumption falling by one-third since the 1970s, overall beef production has held steady (USDA 2019).

Economic and Financial Goals

Signatories often operate with low margins and are conscious of maximizing profits and sales while minimizing costs. Although shifts from animal-based toward plant-based ingredients can reduce ingredient costs (Ranganathan et al. 2016), allow for purchases of higher-quality ingredients, or both (Hamerschlag and Kraus-Polk 2017), such shifts can also increase other costs (e.g., labor costs for preparation, chef training). Furthermore, the lower-GHG dishes themselves must be appealing to consumers in order to maintain or grow overall sales and maintain customer satisfaction. WRI's "Playbook of Behavior Change Interventions" (Attwood et al., forthcoming) can guide signatories on how to introduce more plant-based or plant-rich offerings while maintaining or growing sales and profits.

Accounting for Food Waste Reduction in Signatory Operations

Cool Food Pledge signatories working on food waste reduction may be interested in accounting for changes in food waste over time as well. However, because this method counts upstream Scope 3 GHG emissions—emissions from activities that occurred in agricultural supply chains prior to the point of purchase by the signatory—such reductions will only show up in Metrics 2–5 if they affect the amounts of food purchased. For example, a signatory who reduces "overproduction" for buffets may be able to buy less of the foods that otherwise would have gone to waste, while maintaining sales.[28]

Signatories may wish to use the Food Loss and Waste Protocol (www.flwprotocol.org) to quantify food loss and waste occurring across their supply chains, in order to design targeted strategies to reduce waste.

Accounting for Different Production Systems

The Cool Food Calculator includes default weighted regional average factors for GHG emissions from agricultural supply chains (Metric 2) and for land use (Metric 3) per kilogram of each food type. In this way, it captures important differences in agricultural production systems between regions (e.g., more efficient production systems in developed countries). In the default case, where a Cool Food Pledge signatory is sourcing the majority of each food type through national distribution channels, such default factors are the most appropriate. The calculator also includes global average factors for carbon opportunity costs (Metric 4) per kilogram of each food type, using the assumption that a change in food demand (whether an increase or decrease) will affect agricultural land demand at the global (aggregate) level.

However, factors for a given food type can vary widely by production system within regions, especially for ruminant meats, such as beef (Figure 6). A number of different strategies—including boosting yields; directly reducing agricultural production emissions through improved inputs, technologies, and management; and sequestering carbon in soils—can reduce the climate impacts of food production (Searchinger et al. 2019). How can signatories account for such variations in production systems, especially if they have already made efforts to source specific foods from more responsibly produced, premium-labeled, or certified foods (e.g., local, organic, grass-finished)?

In some cases, signatories may have primary (e.g., farm-level) emission factor data available from their suppliers. Requests to use primary emission factor data (to help calculate Metrics 2–4) shall be submitted to the Cool Food Pledge secretariat for consideration. If approved—and if deemed to be of equal to, or higher quality than, the secondary data in Poore and Nemecek (2018) in terms of representativeness (technological, temporal, and geographical), completeness, and reliability (Table 3)—signatories may substitute such emission factors for the defaults. In that case, the substitute emission factors can be entered directly in the calculator overriding the default factors, with the overriding clearly marked (e.g., through a comment in the calculator sheet) and justified (with documentation showing why the substitute factors are appropriate).

In other cases, however, signatories may have data on a specific attribute or certification (e.g., local, organic, regenerative, grass-finished) but without a clear link to how this would affect Metrics 2–4. Although such attributes are often thought of as more sustainable forms of food production[29]—and can be beneficial for other aspects of environmental, social, and/or economic sustainability—links to the land use and climate metrics measured by the Cool Food Calculator can be unclear or complex, or both. Below are a few examples:

- **Local:** Although reducing "food miles" is commonly thought of as a climate solution, Poore and Nemecek (2018) found that more than 80 percent of global food-related GHG emissions in 2010 were associated with agricultural production and land-use change, with only 6 percent from transport.[30] Reducing purchases of air-freighted food (usually seafood or out-of-season produce) can substantially reduce food transport emissions (Weber and Matthews 2008), but beyond that the GHG impacts of sourcing more locally are likely to be small.

- **Organic:** From a global standpoint, organic yields are 19 to 25 percent lower than conventional, implying that land use (Metric 3) per kilogram of organic food produced (and potentially carbon opportunity costs, as calculated in Metric 4) would be 23 to 33 percent higher.[31] That said, organic production has other beneficial effects for other sustainability aspects (e.g., less pesticide exposure for farmworkers, higher farm profitability) and unclear or mixed effects on water use, water quality, and soil quality (Seufert and Ramankutty 2017).
- **Grass-finished beef and regenerative systems:** Because finishing cattle on grass (versus grain) leads to slower animal growth and lower slaughter weight (Broocks et al. 2016), land use and production-related emissions per kilogram of grass-finished beef actually tends to be higher than that of grain-finished beef (Hayek and Garrett 2018; Nijdam et al. 2012). This suggests that carbon opportunity costs per kilogram of grass-finished beef could also be higher. Although the potential for grazing systems to sequester carbon in pasture soils (also called regenerative grazing) is sometimes cited as an argument to source grass-finished beef, a recent review concluded that the global sequestration potential from grazing management could only offset 20–60 percent of annual GHG emissions from grazing systems (Garnett et al. 2017). The review further noted that any potential sequestration was time-limited, as soils reach carbon equilibrium after a few decades, and that effects on output of meat per ha could be positive or negative depending on the location and production practices. If negative, the shift to carbon-sequestering but lower-yielding grazing practices could trigger additional land conversion to agriculture elsewhere to replace the forgone meat production, leading to additional CO_2 emissions.[32] Similar considerations also apply to regenerative cropping systems designed to build soil carbon.

Because of the caveats above, simply having data on attributes, practices, or certifications (versus actual site-specific emission factor data) should not lead signatories to use emission factors other than the defaults at this time. Future versions of this technical note and the Cool Food Calculator may seek to further differentiate emission factors among production systems as publicly available data improves.

4. CONCLUSIONS

As companies and other food providers look for new frontiers in climate action—beyond work on reducing fossil fuel use, responsible sourcing, and reducing food loss and waste—shifting high-meat diets toward plant-based foods represents a potentially powerful but largely untapped climate solution. Enabling such dietary shifts, if done carefully, can also advance food providers' progress toward other sustainability goals.

The Cool Food Pledge works with food providers to help them set a food-related GHG emissions reduction target in line with the climate goals of the Paris Agreement. This technical note recommends that pledge signatories aim for at least a 25 percent absolute reduction in food-related GHG emissions by 2030 relative to 2015 (in line with signatories' collective reduction target) or a 38 percent relative reduction in food-related GHG emissions per calorie during that time period. This document and the Cool Food Calculator draw on publicly available environmental data to help signatories calculate a set of five metrics to establish GHG emissions baselines and track progress toward reduction targets.

Companion resources available at www.coolfoodpledge.org will also help pledge signatories plan interventions to sell delicious dishes with smaller climate footprints, based on the latest behavioral science. The Cool Food Pledge will also help signatories to promote their achievements as leaders in a growing movement of food providers that are not only doing better, but also doing enough, to help reduce GHG emissions from the food and agriculture sector and achieve a sustainable food future.

APPENDIX A: COLLECTING AND ORGANIZING FOOD PURCHASE DATA FOR COOL FOOD PLEDGE REPORTING

Collecting and organizing food purchase data for Metric 1—the data necessary to calculate Metrics 2–5—may be new to many Cool Food Pledge signatories. This appendix gives additional guidance for data collection, drawing from WRI and WBCSD (2011) guidance and test users' experience.

Overall Rule of Thumb: Prioritize High-Emitting Foods

As noted, animal-based foods tend to account for 80 percent or more of food-related GHG emissions in high-income countries (Figure 4) and are more resource intensive than plant-based foods (Figure 2). Ruminant meats such as beef and lamb are particularly GHG intensive. Mixed food items, a large number of suppliers, and limited capacity and resources to collect data (on the part of signatories or supply chain partners) all pose challenges to data collection. Therefore, as signatories figure out the best routes to collecting their food purchase data, they should focus their efforts on high-emitting foods to capture the majority of their food-related emissions while keeping the data collection workload manageable.

Obtaining Data from Food Service Providers and Other Supply Chain Partners

Some signatories may already have the food purchase data at hand. Others may need to obtain the data from their food service providers—who, in turn, may need to obtain data from their vendors and suppliers for certain items. See Table A-1 for guidance for obtaining food purchase data from supply chain partners. During the first year of participation in the Cool Food Pledge, signatories may wish to work with their supply chain partners to establish a practicable way for tracking the data over time.

Table A-1 | **Challenges and Guidance for Collecting Food Purchase Data from Supply Chain Partners**

CHALLENGE	GUIDANCE
Large number of suppliers	▪ Target most relevant suppliers based on amount spent and/or anticipated emissions impact (i.e., focus on animal proteins). ▪ Target suppliers where the signatory has a higher degree of influence (e.g., contract manufacturers or suppliers where the signatory accounts for a significant share of the supplier's total sales).
Lack of capacity and resources for tracking data	▪ Make the data request as simple as possible. ▪ Use a simple, user-friendly, standardized data template or questionnaire (e.g., share or adapt the template provided by the Cool Food Pledge). ▪ Provide a clear list of data required and where to find data. ▪ Use an automated online data collection system to streamline data entry, or find a supply chain partner who can automate data collection at a reasonable cost. ▪ Coordinate data request with other requests.
Confidentiality concerns of suppliers	▪ Protect suppliers' confidential and proprietary information (e.g., through nondisclosure agreements).

Source: Adapted from WRI and WBCSD (2011).

Converting Food Purchase Data into Weight

When signatories first obtain their food purchase data, it may not already be in weight (i.e., kilograms [kg] or pounds [lb]), although the weights are required for reporting and entry into the Cool Food Calculator. The data may initially be in different units of measure with differing weights (e.g., cases, bunches, gallons), differing in quantity of money spent, or both. Below is some guidance for converting data into weight:

- **If from other units of measure:** for each food type (or product), signatories shall convert to weight using online conversion data, such as the data in the U.S. Department of Agriculture's *Weights, Measures, and Conversion Factors for Agricultural Commodities and Their Products* handbook for the United States (USDA 1992; www.ers.usda.gov/publications/pub-details/?pubid=41881), or using internal rules of thumb (e.g., each case of yogurt from Supplier X weighs 10 kg).
- **If from quantity of money spent:** For each food type (or product) for which signatories have spending data, signatories shall use the average price per kg (or lb) they paid for that food type (or product) during the reporting year to estimate weights, which they then report.[33]

Additional guidance for other common data collection situations is as follows:

- **Bones (from meats and fish):** for each food type, signatories shall report bone-in and boneless purchases separately. If necessary, signatories may use a rule of thumb for each food type according to their best estimate (e.g., "poultry was 100% boneless in 2018," "beef was 50% boneless in 2018"). This allows the Cool Food Calculator to estimate the equivalent amount of boneless meat or fish, which matches the emission factors and allows for increased accuracy.
- **By-products (e.g., soup bones, offal):** these by-products products shall not be tracked, as GHG emissions are assigned to the primary products (e.g., meats).
- **Plant-based meat, dairy, egg, and fish substitutes:** emission factors for common plant-based milks (almond, oat, rice, soy) are included in the Cool Food Calculator, but as of the time of writing, emission factors for other novel plant-based meat, dairy, egg, and fish substitutes were not yet widely available. There are two options for including plant-based substitutes:
  - Option 1: Simply classify the plant-based substitute in the calculator according to its primary ingredient (e.g., soy, pea, wheat). Based on manufacturer-commissioned life cycle assessment studies of the Impossible Burger (Khan et al. 2019) and the Beyond Burger (Heller and Keoleian 2018), it appears that the land use (Metric 3) related to these plant-based burgers is comparable with that of their raw ingredients (which makes sense, as processing would not increase the amount of land needed to grow ingredients). This also suggests that these burgers' carbon opportunity costs (Metric 4) would also be comparable with the raw ingredients. However, this approach would underestimate agricultural supply chain emissions (Metric 2) because of high processing emissions.
  - Option 2: Search for a relevant life cycle assessment to substitute in the emission factor for Metric 2. The two studies cited above estimated these plant-based burgers' agricultural supply chain emissions at around 3.5 kg CO_2e/kg product—quite a bit higher than Metric 2 for the raw ingredients (soy at 1.8 kg CO_2e/kg and peas at 0.7). Creating a duplicate entry for soy or peas in the calculator, and substituting in this higher emission factor for Metric 2, would be the most accurate approach. Future versions of the calculator may try to incorporate emissions factors from leading plant-based meat, dairy, egg, and fish substitutes as studies become more widely available.

- **Mixed items (e.g., pre-made burgers, meatballs, lasagna, stews, or other entrees):** Priority shall be given to reporting mixed items that make up a sizable amount of the signatory's total food purchases in the mandatory categories (Box 3), especially if they contain the highest-emitting foods (ruminant meats). There are two options for including mixed items:
  - Option 1: Classify the mixed food items according to their primary ingredient (e.g., 1,000 pounds of a pre-made beef lasagna would be classified under Beef), potentially adjusting the amount reported by the approximate proportion of this ingredient in the dish (e.g., if the 1,000 pounds of pre-made beef lasagna is only 75% beef, report 750 pounds in the Beef category).
  - Option 2: Assign percentages based on the estimated proportion of each mandatory food ingredient and multiply these by the total weight of each mixed food (e.g., 2,000 pounds of beef and bean stew that is composed of approximately 20 percent beef and 50 percent beans would contribute 400 pounds to the Beef category and 1,000 pounds to the Beans and Pulses category.)
  - If mixed items are highly processed, then (as with plant-based meat substitutes), Metric 2 will likely underestimate emissions from processing. As above, incorporating specific life cycle assessments of certain mixed items can increase accuracy.

ENDNOTES

1. All general references to greenhouse gas (GHG) emissions are in carbon dioxide equivalents (CO_2e), using a 100-year global warming potential, unless otherwise indicated.
2. However, reforestation is usually outside the scope of food providers' operations and would have to be advanced by other actors in the land use sector. Therefore, the 67 percent reduction target by 2050 was used to set the collective Cool Food Pledge signatories' target.
3. To hold warming below 1.5°C, these emissions reductions would have to be accompanied by large-scale reforestation. Searchinger et al. (2019) estimated that at least 585 million hectares (ha) of agricultural land would need to be reforested by 2050 in order to meet the more ambitious 1.5°C target. However, reforestation is usually outside the scope of food providers' operations and would be advanced by other actors in the land-use sector.
4. A 1.7 percent reduction per year over 15 years is approximately a 25 percent reduction in total.
5. This is not to suggest that the entire burden of reducing agriculture-related GHG emissions should fall on changing consumption patterns, as advances in agricultural productivity and climate-smart practices are also critical to meeting the sectoral emissions reduction target (Searchinger et al. 2019). However, it does suggest that if a food provider reduces emissions by this amount by 2030, it will have done its fair share.
6. As defined by WRI and WBCSD (2011), upstream emissions are indirect GHG emissions related to purchased or acquired goods and services, and are distinct from downstream emissions, which are indirect GHG emissions related to sold goods and services.
7. There is no perfect way to measure quantities of food. Section 3 has a discussion of the relative merits of measuring food by weight, by number of calories, or by other measures relevant to signatories' operations (e.g., meals). Here "calories" was used as the normalization factor for the intensity target because it is feasible and potentially easier to communicate (e.g., one can imagine 750 calories or 1,000 calories as a "meal" when communicating changes in emissions intensity over time).
8. Just as there is no perfect way to measure quantities of food, there is no perfect way to calculate the food gap. Another way to calculate the food gap is to look at the projected growth in direct calorie consumption by people (i.e., consumption of all foods, including crops as well as animal-based foods) between 2010 and 2050. It turns out that this gap is nearly the same as the crop calorie gap: world direct calorie demand is projected to rise by 55 percent between 2010 and 2050 (Searchinger et al. 2019).
9. 0.75 / 1.21 = 0.62, meaning a 38 percent reduction in food-related GHG emissions per calorie would be required to achieve a 25 percent reduction in overall food-related GHG emissions.
10. The GHG Protocol Corporate Accounting and Reporting Standard classifies GHG emissions into three "scopes": Scope 1 emissions (direct emissions from sources owned or controlled by the reporting organization), Scope 2 emissions (indirect emissions from the generation of purchased energy consumed by the reporting organization), and Scope 3 emissions (all other indirect emissions that occur in an organization's supply chain) (WRI and WBCSD 2011). Food-related emissions, the focus of the Cool Food Pledge, fall into Scope 3 as they occur in an organization's supply chain and are not emissions from purchased energy.
11. Figure 4 shows data from the average U.S. diet in 2013. Ranganathan et al. (2016) similarly found that animal- and plant-based proteins accounted for more than 80 percent of total food-related land use and GHG emissions for both the average U.S. diet and the average world diet in 2009.
12. Although recent papers (e.g., Pendrill et al. 2019 and Henders et al. 2015) highlight the high emissions of palm oil (linked to tropical deforestation, especially in Southeast Asia), on a per-calorie basis palm oil production is actually relatively low-emitting (Figure 2) because of its very high yields per ha and also high calorie content per kilogram. This points to the importance of analyzing potential substitutes: replacing palm oil with lower-yielding oils that require more land per kg (e.g., soy, rapeseed, sunflower) could actually be detrimental to forests and the climate. This also suggests that the best course for purchasers of palm oil is to demand deforestation-free product (Meijaard et al. 2018).
13. The technical term for the food purchase data in the GHG Protocol is "activity data," which are multiplied by emission factors to quantify Scope 3 emissions (WRI and WBCSD 2011).
14. In the case of a more recent "true" base year, there is no way to know if a signatory's emissions went up or down since the Cool Food Pledge base year of 2015. In addition, emissions reductions are urgent across all sectors between now and 2030. Therefore, signatories should still aim for an individual 25 percent absolute reduction in food-related GHG emissions by 2030, or an individual 38 percent relative reduction (GHG emissions per calorie) by 2030, even if their true base year is more recent.
15. Retail-level emissions would fall under Scopes 1 and 2. According to Poore and Nemecek (2018), globally the retail stage accounts for only 3 percent of global food-related emissions from cradle to retail, with agricultural production and land-use change accounting for 81 percent, processing 4 percent, transport 6 percent, and packaging 5 percent. Because of a lack of data, these authors did not account for post-retail stages.

16. These meta-analyses include many of the same primary studies (of certain food types in certain countries), but because they use different life cycle assessment boundaries and averaging methods (among other assumptions) the comparison between them is imperfect. For example, more than 80 percent of the primary studies included in the meta-analysis of Heller et al. (2018) were from Europe, North America, and Oceania, with less than 20 percent of studies from developing countries. The approach of Poore and Nemecek (2018), which weights primary studies by share of national and global production, likely leads to higher global GHG emission factors than the other two meta-analyses in Table 1 because it gives more weight to less efficient production systems in developing countries. Poore and Nemecek's North America regional averages are also shown to demonstrate how they are closer to the "global" averages in the other two meta-analyses (which are dominated by primary studies in developed countries).
17. Searchinger et al. (2018) estimated that 32 percent of global pastureland was originally forest, with 11 percent originally woody savanna (30–60 percent tree cover), 6 percent originally savanna (10–30 percent tree cover), and 52 percent originally grassland (5–10 percent tree cover).
18. In general, as Metric 3 (food-related land use) rises or falls, Metric 4 (food-related carbon opportunity costs) will also rise or fall, reflecting that higher agricultural land use usually implies higher carbon opportunity costs and vice versa. However, these two metrics are not directly related as they come from data sets from two different studies (Poore and Nemecek 2018 and Searchinger et al. 2018), which, while sharing many common approaches, differ in certain parameters and assumptions.
19. Many life cycle assessments only consider carbon costs if land is cleared in a specific year and place to produce a specific food type (e.g., soybeans in Brazil in 2010), effectively assigning a value of zero land-use costs to all other food production. However, demand for all foods in all years and places determines aggregate agricultural land demand, meaning that, at the margin, changes in demand for any food type anywhere (whether positive or negative) will change agricultural land demand with resulting effects on land-use-change emissions. The carbon opportunity cost metric attempts to capture these marginal effects.
20. More precisely, the calculation applies a 4 percent discount rate over 100 years, which effectively amortizes the one-time land conversion emissions over a 33-year time period. This amortization period is similar to how U.S. and European biofuel analyses balance calculations of GHG emissions caused by one-time land conversion and ongoing annual agricultural production. See additional discussion of this metric in Searchinger et al. (2018).
21. One exception is rice, which has relatively high production emissions per kg for a plant-based food (because of methane emissions from rice paddies).
22. Adding in carbon opportunity costs can also better capture the climate benefits of other land-sparing strategies, such as reducing food loss and waste or sourcing from more land-efficient food producers.
23. Searchinger et al. (2018) provided emission factors per kg of fresh weight, which this note's authors converted to emission factors per kg of retail weight using conversion factors in Poore and Nemecek (2018).
24. Reduced agricultural land use (and pressure on forests) is necessary but not sufficient for forest protection and restoration to actually occur—although whether that forest protection and restoration occurs is usually outside the scope of a food provider's activities. See discussion in "Course 3: Protect and Restore Natural Ecosystems and Limit Agricultural Land-Shifting" in Searchinger et al. (2019).
25. WHO (2015) recommends that, in order to maintain a healthy body weight and limit dental diseases, added sugars (monosaccharides and disaccharides added to foods, plus sugars naturally present in honey, syrups, and fruit juices) should be limited to less than 10 percent of total energy intake and possibly even less than 5 percent of total energy intake.
26. FAO's "Food Balance Sheets," for most countries and food types in the world, contain estimates of the quantity of a given food in the country's food supply in weight (kg/capita/year) and in calories (kcal/capita/day), allowing for estimates of country-, region-, or world-level conversion factors from kg to calories for different food types. To match the reference year in Poore and Nemecek (2018), the conversion factors from the year 2010 are used in the Cool Food Calculator.
27. In addition, certain production systems, such as slow-growing chickens, can come at greater environmental cost (e.g., land use, water use, GHG emissions per kilogram of meat) than conventional systems (Elanco Animal Health 2016). If signatories shift toward such systems for animal welfare reasons, a concurrent shift toward plant-based foods can counteract some of these higher environmental costs.
28. Because this method and calculator assume regional-average values for upstream emissions related to food losses (during harvest, transport, processing, and packaging stages) by food type, signatories who work with their suppliers to reduce upstream losses may wish to alter the relevant value in the calculator. However, as of now, the calculator does not contain the level of detail that would allow a signatory to do this easily.

29. See, for example, the list of "sustainable agriculture" certifications in the AASHE Stars Technical Manual (AASHE 2019), which also recommends sourcing from small producers and short supply chains (which, again, have unclear or complex links to land use or GHG emissions).
30. Similarly, in a study focused on the United States, Weber and Matthews (2008) found that 83 percent of the average U.S. household's food-related emissions came from food production, with 11 percent coming from transport.
31. This yield gap can differ by crop type and management practice: Seufert and Ramankutty (2017) note it can range from 5–9 percent to 30–40 percent, and Kniss et al. (2016) found in the United States that although the overall yield gap was 20 percent, several crops did not have a significant yield gap and that for some hay crops, organic yields even surpassed conventional.
32. Garnett et al. (2017) note that variables for soil carbon sequestration potential are highly context-specific and include "climate, terrain, soil quality, grass species composition, past land use and management, and present management approach." Additional limitations cited include availability of nitrogen for plants to grow and therefore for soils to sequester carbon, as well as leakage. Soil amendments—such as manure, mulch, or crop residues—applied on one specific plot of land may be at the cost of its application elsewhere, such as animal feed or household energy.
33. The GHG Protocol's Corporate Value Chain (Scope 3) Accounting and Reporting Standard (WRI and WBCSD 2011) considers kilograms of product purchased and quantity of money spent on product purchased as two valid examples of activity data used to quantify GHG emissions. However, although some models convert food spending data directly to GHG emissions, the Cool Food Calculator does not use this approach as food prices fluctuate from year to year.

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ABOUT WRI

World Resources Institute is a global research organization that turns big ideas into action at the nexus of environment, economic opportunity, and human well-being.

Our Challenge

Natural resources are at the foundation of economic opportunity and human well-being. But today, we are depleting Earth's resources at rates that are not sustainable, endangering economies and people's lives. People depend on clean water, fertile land, healthy forests, and a stable climate. Livable cities and clean energy are essential for a sustainable planet. We must address these urgent, global challenges this decade.

Our Vision

We envision an equitable and prosperous planet driven by the wise management of natural resources. We aspire to create a world where the actions of government, business, and communities combine to eliminate poverty and sustain the natural environment for all people.

Our Approach

COUNT IT

We start with data. We conduct independent research and draw on the latest technology to develop new insights and recommendations. Our rigorous analysis identifies risks, unveils opportunities, and informs smart strategies. We focus our efforts on influential and emerging economies where the future of sustainability will be determined.

CHANGE IT

We use our research to influence government policies, business strategies, and civil society action. We test projects with communities, companies, and government agencies to build a strong evidence base. Then, we work with partners to deliver change on the ground that alleviates poverty and strengthens society. We hold ourselves accountable to ensure our outcomes will be bold and enduring.

SCALE IT

We don't think small. Once tested, we work with partners to adopt and expand our efforts regionally and globally. We engage with decision-makers to carry out our ideas and elevate our impact. We measure success through government and business actions that improve people's lives and sustain a healthy environment.