Viewpoint: Rigorous monitoring is necessary to meet the food system transformation challenge in the countdown to the 2030 global goals

Supplementary Materials 1: Indicator Selection Criteria

1. Criteria specification process

To define the criteria for indicators to be monitored, we first reviewed previous publications with similar goals of monitoring progress toward systems-related outcomes through a set of priority indicators. Reports reviewed included the *Lancet Countdown on Climate Change and Health*, the *Lancet NCD Countdown 2030*, the *Countdown to 2015: Maternal, Child, and Newborn Survival,* and the indicator criteria for private sector contributions to the SDGs developed by the Inter-Agency and Expert Group on SDG indicators. Food system-specific reports and papers reviewed either provided a curated set of priority indicators or illustrated an approach by which priority indicators could be identified, including Herrero et al. 2020, *Metrics for Decision-Making in the Livestock Sector,* and *Béné et al.* 2019, "Global map and indicators of food system sustainability." We also reviewed literature comparing the validity and reliability of existing food security indicators, given the substantial body of literature focused on food security measurement.

A sub-committee of co-authors provided input and feedback regarding the indicator criteria. In addition to reviewing specific criteria, the sub-committee put forth the following guiding principles for indicator selection criteria:

- Criteria should be clearly defined, with vocabulary that can be understood across disciplines;
- Criteria should be applicable to all indicator domains, not just a certain set of outcomes or food system elements; and
- Required criteria should be delineated from criteria which are desirable but not required, recognizing the limitations of data and existing indicators.

1.1 Feasibility

Evident availability and accessibility of an indicator is a paramount requirement, beyond which we also would strongly prefer open access indicators and data sources. Where data gaps exist in food system elements or outcomes that are deemed essential to the monitoring framework, our research collaboration would consider undertaking indicator development or seeking support for data collection only when doing so would fill an essential gap and could be feasible in all countries within realistic budgets.

2. Indicator criteria

2.1. Relevant

Definition: The indicator measures something meaningful for food systems—including food system elements and processes, as well as the outcomes affected by food systems—across a variety of settings, during relevant time periods.

<u>*Required* conditions for the criteria to be met:</u>
- It should be possible for the indicator to be mapped to the food system framework shown in **Figure 1** of the *Viewpoint* article.
- Indicators should be non-redundant, meaning that only one indicator monitors a specific food system element. Where multiple indicators describing the same phenomenon exist, the most appropriate indicator will be selected based on the other criteria presented here and the process laid out in the article.
- Observing change in the indicator between now and 2030 will be possible. This means that the underlying phenomenon is not likely to be static over the course of the reporting period. It also requires indicators to be valid and reliable measures of those phenomena—which is detailed in the "high-quality" criteria.
- Data have been updated in the last 10 years and will be updated more than once before 2030. Tracking temporal trends in food systems is required to fulfill the monitoring function and will provide a more data-informed picture of how, and at what rate, food systems are transforming in different parts of the world. We also acknowledge, however, that requiring a specific number of data points within one decade would apply inequitably toward newer indicators where no prior data exist.

Desirable conditions for the criteria to be met:
- Prioritize indicators with high coverage across countries, including across different regions and income groups. Indicators that present best practices but are only available for a small number of countries could be included if the data gap is realistically possible to fill in other countries, as specified by the overarching feasibility requirement above.
- Indicators should be specific to food systems or clearly understood to be tied to food systems as drivers of change. Many indicators may need to be disaggregated for greater food system-specificity. For example, measuring the incomes of food system workers is preferable to that of the national workforce or the rural sector. We acknowledge such disaggregation often does not exist, and the goal is to include the best available approximation, including the most food system-specific data elements and excluding data that are not related to food systems.
- Preference for indicators that are already widely accepted and prioritized by policymakers, especially where these have already gone through consensus-building or expert-driven selection processes, and are already high on national data monitoring agendas, such as the 2030 Agenda SDG indicators.
- Preference for indicators that directly measure food system elements and outcomes over proxy measures, where direct observation of the phenomenon is possible.

2.2. High-quality

Definition: The indicator reflects best practices in data collection and aggregation, including quality controls and rigorous statistical methodologies.

Required conditions for the criteria to be met:
- Indicators must present well-documented methodologies, data sources, and metadata. The methodologies and data sources are appropriate to measure the desired food system element and are reasonably standardized across country contexts.
- The indicator is grounded in accepted theory, facts, or established practice. By this we mean, for example, the theory underpinning academic social science disciplines such as, but not limited to, anthropology, economics, political science, sociology; accepted theories, laws, and facts defined by the natural and life sciences; or standard practices in specific practitioner communities such as the measurement of anthropometry.

Desirable conditions for the criteria to be met:
- Indicators should provide a valid measure of the food system phenomenon they are intended to measure. Indicators with peer-reviewed validation studies are highly prioritized. There are multiple forms of validity often considered in such studies, and the terminology and importance placed on the different types often differs by discipline, context, and purpose. The quality and utility of the validation study should be carefully considered and any limitations carefully documented.
- Indicators should provide reliable measures, meaning that they are precise and consistent across different geographical and temporal scales. Prioritize indicators with peer-reviewed reliability studies, though with recognition that this may be difficult to achieve in cases where measurement techniques and sources of data vary across countries or where the data are newly becoming available.
- Preference for indicators that include confidence intervals or standard errors along with point estimates. This information will also help to assess the precision of the indicator.
- Measures of latent traits that have been rigorously and empirically validated strongly preferred over any that have not been validated.

2.3. Interpretable

Definition: A clear, desirable direction of change can be associated with the indicator, and changes in indicator measures are easily communicated in terms of their likely implications for food systems and desired outcomes.

Required conditions for the criteria to be met:
- Indicators must be quantitative, meaning they can be assessed in terms of changes and variation across countries in a standardized way. Qualitative assessments may produce important

contextual information and a means of triangulating findings from different quantitative indicators. However, qualitative outputs are not interpretable as measures.

- A change in the indicator value should have a clear interpretation with respect to the nature of the food system phenomenon or outcome it is intended to measure. This interpretation may be informed by hypothesized food system transition pathways and linkages with diet or other outcomes; ideally these linkages will have an established evidence base in related literature. The desirable direction of change may differ by context, at a minimum the indicator should have a target or target range (upper and lower bounds) relevant to all countries.

Desired conditions for the criteria to be met:
- Monotonicity in the desired direction of change where possible and relevant, meaning that either an increase or decrease in the indicator's value can be interpreted as positive across all places, but not both. However, it is also recognized that many indicators may have desired targets that are neither extremely positive nor negative values, and that the desired direction of change for some countries may be an increase, while for others, a decrease (e.g., in the case of animal-source food consumption).
- Indicators should be easily communicated to varied audiences, including policy, practitioner, research, and civil society communities. Aim to avoid complex indicators with interpretations that can only be grasped by researchers with specialized expertise.
- Summary or composite indicators that combine multiple indicator values into a single value should be easily disaggregated into coherent components so that the drivers of change are evident.
- For indicators drawing on diverse data sources to measure a phenomenon (e.g., water use for agriculture, using data on food production and water footprint per unit of production), those separate data sources should be updated on similar timelines. If only one data source is updated while the other remains static, it may be difficult to argue that variation in the indicator is reflecting changes in the overall phenomenon (water use from agriculture), as opposed to one component (food production).

2.4. Useful

Definition: The indicator meets articulated information needs, and the scale and rate of change in indicator values align with policy and decision-making processes.

Required conditions for the criteria to be met:
- The indicator must address an issue over which target food system entities (including government, civil society, and private sector) have at least some ability to influence change.
- The indicator adds value to existing data and reporting mechanisms, meaning not solely comprised of indicators widely reported in other reports. Where indicators are also reported elsewhere, the ability to relate the indicator to and interpret change from the perspective of food systems is essential.

Desired conditions for the criteria to be met:
- It should be possible to identify risks associated with not reaching target values for an indicator, or for achieving slower-than-desired change in the indicator's value.
- Selection of indicators should be demand-driven, meaning that information attained from an indicator would satisfy the expressed needs of policymakers and other decision-makers. Some needs may not be possible for a global food system monitoring effort to address, at least immediately (e.g., sub-national data or more granular data related to specific supply chains or food commodities). Ideally, however, the initial selection of indicators provides a foundation to address those needs in the future, at least from a content perspective (i.e., comprehensiveness of indicators included) and recognizing that some data gaps will remain.

Figure 1: Food system components, drivers, and outcomes
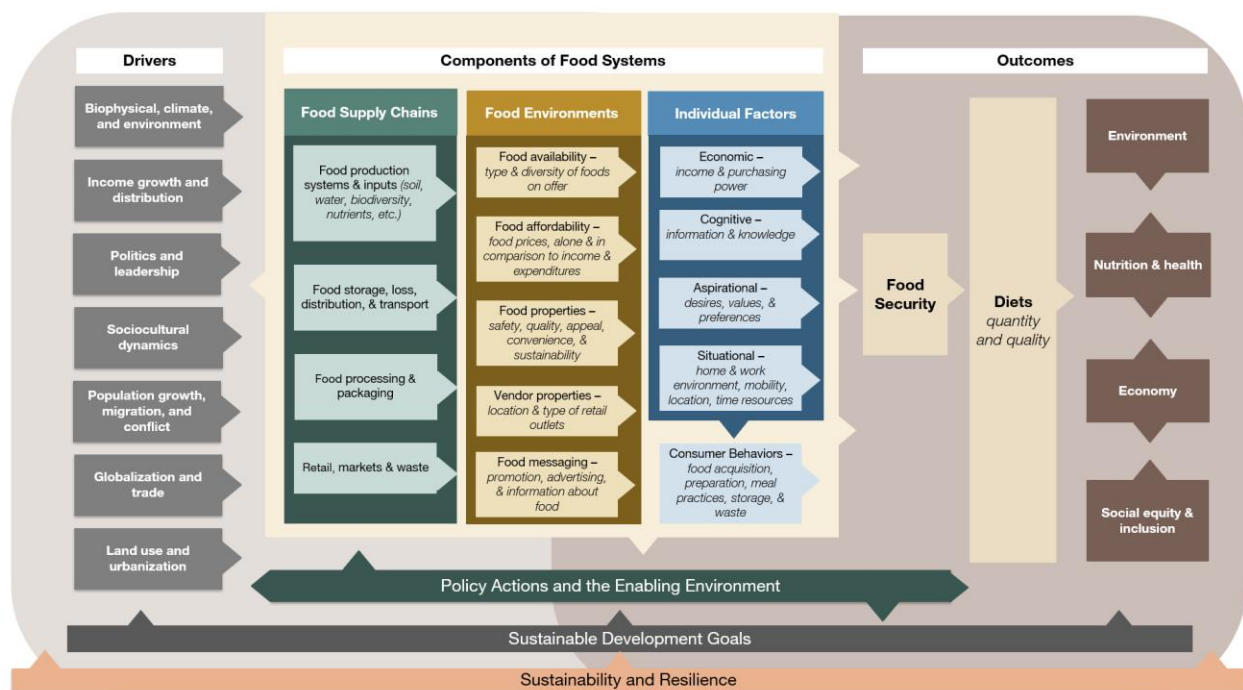
Legend: This figure depicts the drivers, components, and outcomes of food systems; though static in representation, we emphasize that the drivers are processes, and the components have feedback loops with each other and with the drivers and outcomes. Though not explicit within this figure, power dynamics shape interactions and outcomes throughout food systems—such as by shaping whose voice is heard in politics and leadership, and whom is benefited or harmed by globalization and trade (Anderson, 2008; Gereffi et al., 2005; Klassen and Murphy, 2020; Leach et al., 2020; Walls et al., 2020). Similarly implied is that this schematic reflects a single food system, but food systems exist at multiple scales and interact with one another.

Supplementary Materials 2: Named existing indicators and data sources by working group and indicator domain

The following is a reference for the specific indicator and dataset examples mentioned in the paper. It is not an exhaustive or comprehensive list.

Working Group 1: Diets, nutrition, and health

Diet quality
    Minimum Dietary Diversity for Women (MDD-W) (FAO, 2021a)
    Dietary diversity scores for children 6-23 months (World Health Organization and the United Nations
        Children's Fund (UNICEF), 2021)
    Global Diet Quality Score (Intake – Center for Dietary Assessment, 2021)
Food security
    Prevalence of undernourishment (FAO, IFAD, WFP, UNICEF, WHO, 2020)
    Food insecurity experience scale (FIES) (FAO, IFAD, WFP, UNICEF, WHO, 2020)
    Affordability of healthy diets (Herforth et al., 2020)
Food environments
    Food availability (FAO, 2021b)
    Food affordability (FAO, 2021c; Herforth et al., 2020)
Policies affecting food environments
    International Network for Food and Obesity/NCDs Research, Monitoring and Action Support (INFORMAS)
        protocols and datasets ("INFORMAS: Benchmarking Food Environments," n.d.; Swinburn et al., 2013)
    Access To Nutrition Index (ATNI) ("Access to Nutrition Global Index," 2021)
    FAOLEX (FAO, n.d.)
    World Health Organization (WHO) Noncommunicable Disease (NCD) Progress Monitor report (WHO, 2020)

Working Group 2: Environment and climate

Land use
    Land statistics (FAO, 2021d)
    System of Environmental-Economic Accounting for Agriculture, Forestry and Fisheries (SEEA AFF) (FAO and
        UN, 2020)
Greenhouse gas emissions
    Greenhouse gas emissions (GHG) data from the United Nations Framework Convention on Climate Change
        (UNFCCC) (United Nations Framwork Convention on Climate Change (UNFCCC), n.d.)
    FAO Global Emissions from land use and agriculture (FAO, 2021b)
Water use
    AQUASTAT (FAO, n.d.)
Pollution
Biosphere integrity

Working Group 3: Livelihoods, poverty, and equity

Poverty and income
    Livelihoods key indicators ("Key indicators - Livelihoods Centre," n.d.)
    Poverty indicators (Alkire et al., 2015; World Bank, 2021, 2017)
Employment
    International Labour Organization employment statistics (ILOSTAT) (ILO, n.d.; ILOSTAT, 2020; World Bank, n.d.)
    Eurostat (Eurostat, 2020)
Social protection
    World Bank Social Safety Nets Reporting (World Bank, n.d.)
Rights
    The Food and Agriculture Organization of the United Nations (FAO) Gender and Land Database (FAO, n.d.)
    Social Institutions and Gender Index (SIGI) (OECD, 2019)
    Sustainable Development Goals (SDG) indicator data (Our World in Data, n.d.)

Cross-cutting Working Group 4: Governance

Shared vision
    International Fund for Agriculture Development (IFAD) Rural Sector Assessments (IFAD, 2019)
    Varieties of Democracy (V-Dem) civil society index ("Varieties of Democracy (V-Dem)," 2021)
Strategic planning and policies
    Hunger and Nutrition Commitment Index (HANCI) ("Hunger and Nutrition Commitment Index," n.d.)
    Healthy Food Environment Policy Index (Food-EPI protocol) (Swinburn et al., 2013)
    Bertelsmann Transformation Index (BTI) ("Bertelsmann Transformation Index," n.d.)
Effective implementation
    HANCI
    Scaling Up Nutrition (SUN) (Fracassi et al., 2020)
    Global Network against Food Crises (Global Network Against Food Crises, 2021)
    Comprehensive Africa Agriculture Development Program (CAADP) government expenditure on agriculture (Department of Rural Economy and Agriculture, African Union, 2020)
Accountability
    CAADP's Agricultural Transformation Scorecards (Department of Rural Economy and Agriculture, African Union, 2020)
    Access To Nutrition Index (ATNI) ("Access to Nutrition Global Index," 2021)
    World Benchmarking Alliance (WBA) Food and Agriculture Benchmark (World Benchmarking Alliance, 2020)
    V-Dem ("Varieties of Democracy (V-Dem)," 2021)
    Freedom House (Freedom House, 2021)
    Open Budget Initiative (International Budget Partnership, 2019)

Cross-cutting Working Group 5: Resilience and sustainability

Exposure to shocks
    EM-DAT: International Disaster database (Centre for Research on the Epidemiology of Disasters-CRED, n.d.)
    Global Disaster Information System (GDIS) (Rosvold and Buhaug, 2021)
Resilience capacities
    FAO Dietary Sourcing Flexibility Index (FAO, 2021c)
Agrobiodiversity
Food security stability
    FAO Price volatility index ("Food price volatility," n.d.)
    FAO per capita food supply variability (FAO, n.d.)
Food system sustainability index
    SDG Indicator 2.4.1 - Proportion of agricultural area under productive and sustainable agriculture (FAO, n.d.)
    Human Development Index (HDI) (UNDP, 1990)
    Planetary Pressures-Adjusted Human Development Index (PHDI) (UNDP, 2020)
    Global Hunger Index (GHI) (von Grebmer et al., 2020)
    Food System Sustainability Index (FSI) (The Economist Intelligence Unit, 2016)

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