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WHITE PAPER

SCHOOL MEALS AND FOOD SYSTEMS:

Rethinking the consequences for climate, environment, biodiversity and food sovereignty

Prepared by the Research Consortium for School Health and Nutrition, an initiative of the School Meals Coalition

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ABBREVIATIONS AND ACRONYMS

AR: average requirement
BAR-HAP: Benefits of Action to Reduce Household Air Pollution tool
BFN: Biodiversity for Food and Nutrition
BIG: Bio-intensive gardens
CRA: comparative risk assessment
CRC: Colorectal cancer
CVD: Cardiovascular disease
DGA: Dietary Guidelines for Americans
DGL: dietary guidelines
DPS: Dynamic Purchasing System
EIOD: Environmental Impact of Diets
EPA and DHA: eicosapentaenoic acid and docosahexaenoic acid (long-chain omega-3 fatty acids)
EPCs: Electric pressure cookers
ESD: Education for Sustainable Development
FBDG: Food Based Dietary Guidelines
FBS: farmer business school
FFLSH: Food for Life Served Here award,
FLX: flexitarian diet
FAOFBS: food balance sheets (Food and Agriculture Organization)
FSF: Future Smart Foods
GCNF: Global Survey of School Meal Programs
GDQS: Meal Global Diet Quality Score-Meal metric.
GHG: Greenhouse gas
GHGE: Green House Gas Emissions
GNR: Global Nutrition Report
GPP: Gulayan sa Paaralan Program
GWP: global warming potential
HGSF: home-grown school feeding
ICDS: Integrated Child Development Services
IEC: Information, Education and Communication
IMPACT: Model for Policy Analysis of Agricultural Commodities and Trade
INSET: in-service educational training
IPCC: Intergovernmental Panel on Climate Change
IQ COSAN: Quality Index of Nutritional Food Safety Coordination (Brazil)
ISNM: Integrated School Nutrition Model
LCC: Life Cycle Costs
LDL: low density lipoprotein cholesterol
LMIC: low- and middle-income countries
LNCSB: low- and no-calorie sweetened beverages
LOC: local procurement
LOMA: 'LOkal MAd' ('local food' in English).
LOW: low-cost procurement
LPG: liquefied petroleum gas
LVC: La Via Campesina
MDER: minimum dietary energy requirements
MEC(S): modern energy cooking (service)
MOA: Memorandum of Agreement
MPT: Meal Planning Tool
MUFPP: Milan Urban Food Policy Pact
NAPs: National Adaptation Plans
NDCs: Nationally Determined Contributions
NFC: near field communication (
NGS: nutrition guidelines and standards
NNR: Nordic nutrition recommendations
NRV: nutrient reference values
NSLP: National School Lunch Program
NUS: Native and underutilized species
ORG: organic procurement
PAA: Food Purchase Program (Brazil)
PCD: Partnership for Child Development
PEHEG: Educating with School Gardens and Gastronomy initiative (Brazil).
PIN: Product Innovations in Nutrition
PNAE: National School Feeding Program (Brazil)
PPP: Purchasing Power Parity
PSFN: Pacific School Food Network
PV: photovoltaics (solar)
SDGs: Sustainable Development Goals
SFNE: School-based food and nutrition education
SMC: School Meals Coalition
SMPT: School Menu Planning Tool
SNP: Supplementary Nutrition Program
SSB: Sugar-sweetened beverages
T2D: type 2 diabetes.
UNFCCC: United Nations Framework Convention on Climate Change
UPF: ultra processed foods
UV: ultraviolet light
VEG: vegetarian diet
VGN: vegan diet
WASH: Water, Sanitation and Hygiene program
WSFA: Whole School Food Approach

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Background to the paper

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About the Research Consortium for School Health and Nutrition

The Research Consortium for School Health and Nutrition is the independent research initiative of the School Meals Coalition, established at the request of SMC member states to fill the evidence gaps around school health and nutrition to inform robust policymaking. Coordinated by a Secretariat based at the London School of Hygiene & Tropical Medicine (LSHTM), the Research Consortium operates as a global network of academics and scholars, with research conducted through six Communities of Practice of thought leaders based around the world. The production of this White Paper was led by the Diet & Food Systems Community of Practice.

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About the School Meals Coalition

The School Meals Coalition is a country-led movement to ensure every child has access to a healthy, nutritious meal in school by 2030. Emerging from the UN Food Systems Summit in 2021, the SMC is made up of 90+ member states who have committed to investing in their school meals programs to rebuild from the impact of COVID-19 school closures on child wellbeing and learning outcomes.

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EXECUTIVE SUMMARY

The need for food systems transformation

Food is life. But the way we produce, consume, and market food is leaving millions either hungry or overweight, pushing the world towards environmental catastrophe and undermining public health. A different future is possible. This report sets out how school meals can help build a food system fit for the 21st century. New modeling work presented in this report shows that cultivating healthy and sustainable dietary habits is one of the best investments we can make for tomorrow.

Rethinking food systems, from production to consumption, has never been more urgent. The world is facing a global nutrition crisis, with malnutrition affecting most of the population, either as hunger, food insecurity, obesity, or diet-related diseases. Many countries experience multiple malnutrition burdens at the same time and very few are on course to meet nutrition related Sustainable Development Goals (SDGs).

At the same time, the need to feed an increasing population, coupled with prevailing agricultural practices and unsustainable food production and consumption trends, has altered the equilibrium of our planet, causing depletion and pollution of natural resources, habitat and biodiversity loss, deforestation, ocean acidification, and climate change. Food systems contribute to a third of all human-induced greenhouse gas (GHG) emissions. A third of all food is wasted along the value chain, accounting for 8%-10% of GHG emissions through its production. Food production accounts for 70% of freshwater use, and is the principal driver of biodiversity loss, mainly due to the conversion of natural ecosystems for crop production or pasture. These environmental changes affect our ability to produce high quality foods, further compromising food security and nutrition. These changes are especially damaging for countries in the Global South that will bear the brunt of the climate crisis sooner and more intensely than many other parts of the world.

School meals: a unique opportunity to address multiple food system challenges

The environmental and nutrition crises disproportionately affect children. Approximately 180 million school age children live with malnutrition and 1 billion children are at high risk of suffering from food insecurity. This threatens the education, growth, and development of children and adolescents worldwide, as well as increasing the risks of morbidity and mortality.

School meals are increasingly recognized as a key investment for governments, especially in the Global South, to tackle these challenges for children and provide a platform for food systems transformation. School meals programs are amongst the most established and extensive parts of public food systems worldwide, currently reaching 418 million children every day worldwide. Because the policy levers are in the hands of governments, and because of their reach and scale, national school meals programs provide an exceptional opportunity for the implementation of change to planet-friendly policies which have enormous co-benefits for child health and wider society.

The message that investment in well-designed and holistic school meals programs yields substantial returns in terms of healthier, better educated, and empowered individuals who contribute positively to the overall advancement of society was reinforced at the recent 2023 UN Food Systems Summit +2 Stocktaking Moment. Governments of member countries of the School Meals Coalition, a network created with the goals of enhancing the reach, quality, and sustainability of school meals, committed to support healthier diets, shorter and more sustainable value chains, and a more equitable smallholder farmers' and fishers' economy, especially for women. Implementing such sustainable and healthy school meals programs also acts as a catalyst for the creation of more resilient and sustainable food systems that benefit the local economy. This potential can be achieved especially when school food is linked to local and smallholder agriculture production such as in the home-grown school food (HGSF) approach, and when technical inputs and financial support are well targeted.

Two key areas where school meals programs can drive systemic change:

1. Schoolchildren and adolescents as agents of change

Growing evidence indicates the importance of nutrition for the health and development of children across the full age spectrum up to adolescence, throughout what is now called the "first 8,000 days", building on the crucial early investments during the first 1,000 days of life. Optimizing the synergistic potential of health and education investment during this sensitive developmental period helps ensure children achieve their full potential as adults, thus creating a nation's human capital. School meals programs provide the world's most extensive safety net for vulnerable children and, for many children, the food they are served at school represents the most nutritious and, for some, the only meal of the day.

The benefits of school meals go beyond nutrition: they improve school enrollment, attendance, attainment, and cognitive development, and reduce dropout rate, especially for girls. School meals programs help bridge socioeconomic disparities, ensuring that all children, regardless of their background, have equal access to quality nutrition and education. Importantly, planet-friendly school meals coupled with consistent and action-oriented food education can empower future generations by fostering healthier and more sustainable food habits at a critical age when life-long dietary preferences and social attitudes are formed and carried into adulthood. By taking these messages home, children can also influence the dietary preferences of their family, and coupled with a whole school approach, which actively involves communities, the broader food culture and values can also be positively influenced.

2. The power of procurement

Alongside the direct benefits for children, changes to the world's national school meals programs can also create demand-driven planet-friendly actions in local food systems. When properly designed and accompanied by adequate policy and regulatory frameworks, as well as support measures, sustainable school food procurement can promote the adoption of planet-friendly production practices, broaden the local food basket and stimulate crop diversity, along with other social and economic development outcomes. This is particularly true when school food demand is linked to local and smallholder agriculture production, such as in the home-grown school feeding (HGSF) approach. The link between school meals provision and local agricultural change is already established in many countries, and the mechanisms for policy change already exist. In Africa, for example, school meals provision is a specified demand in the African Union 2014 Malabo Declaration, and 42% of national school feeding programs currently have agriculture policy objectives, which include ecological elements such as agrobiodiversity and climate-smart foods. Government and community-led changes to national school meals programs can catalyze regenerative agricultural practices which, if appropriately designed, can promote biodiversity and climate change resilience. Procurement practices have also been shown to support food sovereignty.

Economic and financial implications of the policy changes

Policies that are environmentally sustainable are almost always economically sound, providing long-term returns especially to human capital and agriculture. Studies suggest that the returns from school meals programs are substantial, in the order of up to $8 for every $1 spent, because of the additive returns across multiple sectors, including returns to education, health, human capital, social protection, and agriculture. The additive long-term returns will be even greater if the investments are sustainable from the perspectives of agroecology, biodiversity, food sovereignty and climate, and especially if they contribute to regenerative agriculture.

Financial affordability may be of more immediate concern to policymakers, especially in resource-limited settings, and here too the analyses suggest positive outcomes. Careful choices of sustainable dietary change can be largely cost-neutral, as shown for fortification in low-resource settings, and for a switch to more sustainable programs in Finland and Sweden. In some cases, changes can reduce costs, for example: the move to flexitarian diets from those based on some current food standards; the switch from open fires to more fuel-efficient cooking stoves; and waste reduction procedures to make savings that effectively reduce the per-capita cost of food.

All change implies some costs, especially capital costs for start-up and transition, and here too there are positive options. The Sustainable Financing Initiative of the School Meals Coalition has supported the move by external donors to specifically target their support for school meals in low-income countries which seek to strengthen and launch national school meals programs, and in countries with established national programs which need marginal and temporary support to transition to sustainability. Other sources of support for planet-friendly school meals to tap into in creative ways are Debt Swaps that specifically target human capital creation and climate financing resources. For example, climate finance could be tapped into to support farmers, Micro, Small and Medium Enterprises (MSMEs), entrepreneurs, innovators and start-ups to deliver climate resilient foods for schools. However, so far, only 1.7% of total climate finance targets small-scale agriculture, which represents a third of all food produced globally.

A focus on two areas of policy change can create nutritious and sustainable planet-friendly school meals sourced from ecologically sustainable agriculture.

Systemic changes and collaboration between multiple actors across school food systems are required to move towards healthier school meals with lower environmental impacts. By starting with the meal and working backwards through the supply chain to the farmer and fisher, innovation can be driven across the entire food system using a ‘fork-to-farm’ approach.

This entails changes in two sets of policies:

1. **Policies directed at making immediate changes to school meals programs** for the benefits of all young people. Depending on the local demography, these changes will affect the lives of between 38% and 15% of the population, in low and high resource settings respectively. The biggest effects on population and planet health are made by policy changes in the following four priority areas: menus, energy, waste and education.
    - Menu changes which encourage dietary shifts which promote planetary and human health.
    - Clean and energy efficient cooking solutions.
    - Prevention of food loss and waste, and reduction of plastic use.
    - Action-oriented and holistic food education to help establish life-long healthier and more sustainable food practices.

2. **Demand-driven policies built on the power of procurement to promote food system transformation.** School meals programs can create demand from the agricultural sector for school foods from ecologically sustainable local farm systems, with the goals of stimulating local approaches to agriculture which are regenerative, and which can promote biodiversity, resilience, and food sovereignty.

Turning policy into action

There are two areas for action:

1. Policy changes to national school meals programs

- Nutrient rich diverse menus:
  - Establish context-specific, evidence-informed national nutrition and food standards for school meals that adequately integrate sustainability considerations.
  - Shift to nutrient rich, climate resilient, and culturally relevant foods, ensuring a diverse school diet including whole grains, legumes, fruits, and vegetables and small amounts of low impact animal foods, such as sustainable aquatic foods: there is a particular role here for menu planning tools which address crops which are indigenous, local, planet- and climate-friendly.
  - Support and engage with Micro, Small and Medium Enterprises (MSMEs) and other value chain actors to be able to better handle this diversity of food and ensure delivery in terms of quantity and quality.
  - Reduce meat, especially ruminant, where this is overconsumed, with the goal of shifting to predominantly plant-based diets. Our analyses show, for the first time for school-age children and adolescents, that relatively modest changes to standard school menus (a flexitarian diet) can reduce environmental impacts by 26% (and by 43% with a vegetarian diet). These changes need to be context specific and take into account the interdependence across global regions, with stronger imperative for reduction in meat on school menus in, for instance Europe and North America, while recognizing the desirability of more animal proteins for child nutrition in other regions of the world.
  - Use planning and monitoring tools to ensure nutrition and environmental targets are planned for and met.
  - Integrate sustainability aspects to the vocational training of chefs and kitchen personnel and invest in teaching planet-friendly recipes and cooking. Secure resources for further training and capacity building of chefs and kitchen staff responsible for school meals provisioning.
- Clean efficient energy for cooking:
- Ensure access to energy efficient, cooking solutions, with the goal of moving to modern energy cooking (MEC) services powered by renewable energy; in low-income settings, a switch from open fires to electric cookers can significantly reduce pollution with additional benefits for the health of the cooks and reduced deforestation.
- Minimal waste:
- Prevent food loss by using methods such as better storage, cooling and preserving methods, and ecological pest control.

- Reduce food waste at all stages, using monitoring and planning tools to control orders and portion size, and raise awareness among students to help take only what they will eat: halving food waste could reduce environmental impacts by 13%. It can also reduce costs and potentially reduce overweight and obesity.
- Adopt planet-friendly methods of disposing of food waste, such as share tables to redistribute surplus food to hungry students first and foremost, and then composting or food recycling for any foods that can't be rescued.
- Reduce package and plastic waste by using the Zero Waste Hierarchy, "refuse, rethink, redesign", and limiting packaged processed foods. Packaging, mostly for food and drink, accounts for 40% of global plastic waste, with enormous environmental damage, resource waste and potentially detrimental health impacts
- Food systems education:
    - Ensure that holistic food education is institutionalized in national school systems, designed with an action-oriented focus and implemented with regularity and available to all grades. Prioritize real-life and practical activities such as having students participate in food waste audits, farm visits, cooking produce from school gardens, taste sessions, and waste awareness.
    - Make mealtimes an integral part of the educational experience, as in for examples, Finland and Japan
    - Adopt whole school food approaches to help children and young people develop a new understanding of healthy and sustainable food environments and the role of food in their development.
    - Make the interconnectedness of food systems, climate change and environmental impacts part of the national curriculum to ensure a future generation is better prepared to make planet-friendly decisions.
    - Strengthen food education and sustainability aspects in the education of teachers.

2. Policy changes to promote sustainable farming practices and transform food systems.

- Recognize the potential of school food procurement as an entry point for local food systems transformation at policy level and promote policy coherency, including among nutrition, environmental, agriculture, and public procurement.
- Include climate and other environmental and social considerations in policies, recommendations and procurement rules guiding school meals provisioning at national, regional, and local levels.
- Ensure that the public procurement regulatory framework is aligned with the school meals sustainability objectives and provide the necessary instruments to support its implementation.
- Actively promote and formally give preference to agricultural production systems that ensure environmental sustainability and agrobiodiversity, such as regenerative or organic farming, agroecology and agroforestry (all defined within the local context) to source school meals ingredients.
- Where possible, prioritize and/or set specific targets for local procurement from smallholder farmers, support to and capacity building of farmers and their organizations to respond to demand for planet-friendly school meals, including

measures to support local smallholder farmers to increase, adapt and diversify production based on environmentally friendly production practices as well as to organize themselves collectively and participate in public food procurement processes.

- Link farmer organizations and cooperatives to the growing range of planet-friendly technologies and practices, climate services and knowledge products, tailored agro-advisory services, innovative insurance etc., promoting coherence among the different initiatives and programs. Support and capacity building of MSMEs, women and youth entrepreneurs, and other value chain actors, to respond to demand for planet-friendly school meals and adopting planet-friendly practices across supply chains including adoption of appropriate infrastructure.

1. SCHOOL MEALS: A UNIQUE OPPORTUNITY TO ADDRESS MULTIPLE FOOD SYSTEMS CHALLENGES

1.1. The need for food systems transformation

Food systems are complex entities encompassing the production, processing, distribution, preparation and consumption of food, as well as the outcomes of these activities which impact diets, health, socio-economic status and the natural environment. A key challenge for humanity is how to ensure that nutritious foods, produced with lower environmental impact, are made affordable and accessible, while also enhancing local and national economy.

Currently, the world is facing a global nutrition crisis with malnutrition, either as undernutrition (wasting, stunting, underweight), inadequate vitamins or minerals, overweight, obesity, or diet-related diseases, affecting most of the population. Many countries are experiencing multiple malnutrition burdens, and few are on course to meet any of the targets for maternal, infant and young child nutrition. Only one country is on course to reduce the prevalence of anemia among women of reproductive age, and no country is on course to halt the rise of obesity (GNR, 2022).

At the same time, the need to feed an increasing population coupled with prevailing agricultural practices and unsustainable food production and consumption trends has altered the equilibrium of our planet, causing depletion and pollution of natural resources, habitat and biodiversity loss, deforestation, ocean acidification, and climate change (Searchinger et al., 2018; Willett et al., 2019;). Food systems contribute to a third of all human-induced greenhouse gas (GHG) emissions. A third of all food is wasted along the value chain, accounting for 8%-10% of GHG emissions through its production (Alexander et al., 2017; Crippa et al., 2021). Food production accounts for 70% of freshwater use, and is the principal driver of biodiversity loss, mainly due to the conversion of natural ecosystems for crop production or pasture (Global Panel on Agriculture and Food Systems for Nutrition, 2023). These environmental changes affect our ability to produce high quality foods, further compromising food security and nutrition. Water resources are considered scarce for meeting present global needs and future projections show that climate change is expected to further increase water scarcity, especially in the subtropics. These changes are especially damaging for countries in the Global South that will bear the brunt of the climate crisis sooner and more intensely than many other parts of the world. As emphasized by the EAT-Lancet Commission on Food, Planet and Health, without substantial improvements in food production, dietary habits, and food waste it will be impossible for our planet to provide a healthy diet to the projected future population of 10 billion. And the future of generations to come will be compromised.

The environmental crisis is disproportionately affecting children. Approximately 1 billion children are at an 'extremely high risk' of the impacts of the climate crisis (UNICEF 2021). At the same time, half of all those affected by food insecurity are children and more than half of young women in low- and middle-income countries are micronutrient deficient (UN, 2023). This puts children and adolescents' education, growth, and development at risk, as well as increasing morbidity and mortality risks.

In this paper we describe the policy changes that governments should consider that can immediately improve the sustainability of their national school meals programs for children and planetary health; we also describe the long-term benefits driven by innovative procurement policies.

1.2. School meals programs: a key investment for children health, education and development and a powerful tool for food systems transformation

There is growing awareness of the importance of nutrition to the health and development of children all the way through adolescence, what is called the first "8000 days" (Norris et al., 2022; Victora et al., 2022). Recognizing the value of school meals programs is crucial for policymakers, educators, and society at large, as their investment yields substantial returns in terms of healthier, educated, and empowered individuals who contribute positively to the overall advancement of society. School meals programs are beneficial for the physical, mental, and psychosocial development of school-age children and adolescents. Benefits of school meals on children and adolescents include reducing malnutrition, micronutrient deficiency and anemia, preventing overweight and obesity, improving school enrollment and attendance, reducing dropout rates, increasing cognitive and academic performance, and contributing to gender equity in access to education (Chakraborty & Jayaraman, 2019; Langford et al., 2014; Omwami et al., 2011; Snilstveit et al., 2017)

School meals programs help bridge socioeconomic disparities, ensuring that all children, regardless of their background, have equal access to quality nutrition and education. For example, evidence from a meta-analysis of school meals programs across 32 sub-Saharan countries showed on-site meals combined with take-home rations increased the enrollment of girls by 12% (Bundy et al., 2018).

School meals programs are cost-effective, especially when combined with educational programs. Evidence from 10 countries providing school meals, take-home rations or biscuits, showed that every US$1 invested brought a US$3 to US$8 economic return from improved health and education among schoolchildren and increased productivity when they become working adults (Gertler et al., 2014), thus contributing to a country's human capital and economic growth in the long run. Dietary patterns are established during childhood and track into adulthood, therefore planet-friendly school meals are an opportunity to establish life-long healthier and sustainable eating habits (Abizari et al., 2014).

The success of programs and interventions to improve child nutrition is dependent on healthy, resilient and sustainable food systems. Climate and environmental change have a reciprocal relationship with food systems in that each affects and is affected by each other (Bremer & Raiten, 2023). Our ability to actualize a goal of planet-friendly school meals programs is contingent on our understanding that food systems not only affect our physical environment including climate, but that climate affects the amount and quality of food produced. The former is often emphasized in efforts to develop and support sustainable food systems, but the latter is critical for food systems to meet the nutritional needs of the population. A synergy exists between the need to address those factors that influence the sources of nutrition, i.e., food systems, and the factors that influence the health and nutrition of the child. We can't address one without addressing the other.

A key challenge for enhancing school meals is how to move towards healthier diets with lower environmental impact while also enhancing local and national economy, including farmer incomes. This challenge needs to be addressed by pursuing systemic innovations (i.e., innovations that require collaboration between multiple actors across food systems using systems approaches (Midgley & Lindhult, 2021). By starting with a healthy, planet-friendly school meals and working backwards through the supply chain to the farmer, school meals programs can be catalysts for food systems innovation and transformation.

Food systems activities (e.g., agriculture, primary producing, processing, retailing and consuming food) should be differentiated from the food systems outcomes (e.g., nutritional status, environmental condition, and livelihoods and enterprises (Ingram, 2011). These are depicted in **Figure 1**.

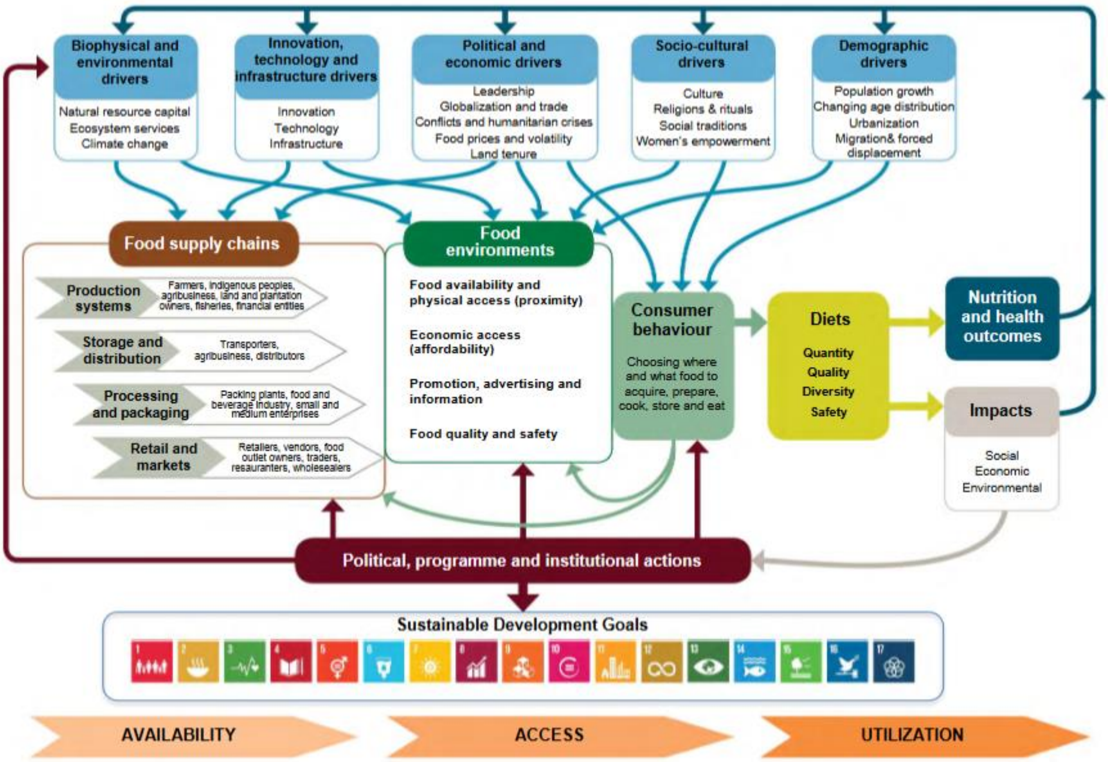

Figure 1: Conceptual frameworks of food system for diets and nutrition (from HLPE, 2017)

To enhance school meals requires the recognition that the primary focus should be on outcomes, to transform a child's nutrition from sub-optimal to optimal whilst maximizing positive environmental outcomes. To deliver these desired outcomes there needs to be an adaptation of several dependent food systems activities. For example, adapting school catering will be influenced by the availability, quality and price of ingredients delivered by the supply chain, which in turn will be affected by policy and market opportunities (**Figure 1**).

Changes to the world's national school meals programs can create demand-driven planet-friendly actions in local agriculture, with added benefits for the environment and the planet. Government-led changes to the national school meals programs can promote ecologically sustainable farming systems and agricultural practices which, if appropriately designed, can promote biodiversity, climate resilience and food sovereignty. By linking school demand to the local and smallholder agriculture production, it can also become an instrument to support the local agriculture production, to trigger production diversification, and to stimulate community economic development.

1.3. Shifting to holistic and planet-friendly school meals guidance

Policies, laws, and standards around school food can form a supportive structure to steer school meals programs in a positive direction. Guidelines on school food standards are a key component of school food policy and a fundamental initial step in enabling policy makers, caterers, and schools to serve healthy and sustainable school meals. If countries lack guidance, or if guidance is conflicting with the scientific evidence on what is best for human and environmental health, this could have negative influence on government procurement food policies and children's diet and health.

Dimensions of sustainable school food policies and guidance

The 2021 Global Survey of School Meal Programs (GCNF, 2022a) found that 125 countries reported having at least one large scale school feeding program; a large majority (80%) of countries had a national school feeding policy, with no evident pattern across income levels (GCNF, 2022a).

However, the likelihood of a nutrition policy related to school feeding does increase as wealth increases, and the same is true for policies related to health and to food safety. For example, while 41% of low-income countries report a food safety policy, this is the case for 56%, 63%, and 67% of lower middle income, upper middle-income, and high-income countries respectively. This reveals a relative gap in policies of nutrition, health, and food safety in lower-income settings (GCNF, 2022b).

A recent systematic review of existing sustainability dimensions covered in school feeding policies (dos Santos et al., 2022) identified several domains, with the most frequently mentioned being school gardens and other educational activities. Other actions, such as menu planning and purchase of local or organic foods, vegetarian/vegan menus, reduction of organic and inorganic waste, were also mentioned. This points to the limited dimensions of currently considered actions to improve school feeding sustainability, and the need for the systematic introduction of robust evidence-based sustainability guidance for school food policies.

How government policies, guidelines and standards can incorporate sustainability and planetary health

There is an urgent need to incorporate environmental sustainability objectives in school food policies (dos Santos et al., 2022; Oostindjer et al., 2017). However, there is little validated, comprehensive guidance at a global level on how and when to execute this integration in a reliable, transparent, and data-driven manner. A pivotal juncture for meaningfully incorporating environmental objectives is during the development or revision of school meals nutrition guidelines and standards (NGS) and Food Based Dietary Guidelines (FBDG). The recent Initiative on Climate Action and Nutrition (I-CAN) report revealed that of 70 FBDG reviewed, only 8% had commitment to mobilizing resources and had plans to take action to connect climate and nutrition.

However, some pioneer countries, such as the Nordic countries (Blomhoff et al., 2023) and Finland (see *new Nordic nutrition recommendations* case study in the Annex) have already embarked on this process and others are laying the ground to do so. In planning for such an endeavor, it is important to consider potential challenges that can impair the quality of the process as well as the implementation fidelity of the standards. These include lack of an enabling environment for the development or revision of NGS that incorporate environmental sustainability objectives; lack of context-specific, good quality and comparable individual dietary intake data of school children and adolescents, and of food composition and environmental footprint data of locally available foods; and difficulties in the operationalization of the NGS such as capacity, infrastructure, and logistics.

Taking into account the main challenges, the Food and Agriculture Organization of the United Nations (FAO) and the World Food Program (WFP) are currently devising a global methodology that countries can adapt and use to formulate nutrition guidelines and standards for their school meals programs, incorporating environmental objectives. The methodology applies a food systems and human rights lens and has been preliminarily structured around seven phases, each with a series of iterative steps[2] (FAO, n.d.). The methodology is accompanied by a manual which provides guidance on how to operationalize the nutrition guidelines and standards through the procurement process and including sustainability considerations (FAO, n.d.).

Figure 2 showcases such steps and highlights concrete ways in which environmental sustainability can be considered in the processes.

See case study in Annex:

- **The new Nordic nutrition recommendations**
- **Promotion of minor millets in schools and public procurement in India**
- **Planet-friendly School Meals provided by the City of Malmö**
- **Dordogne Department, France**
- **Sustainable Diets & Nutrition in cities: the Milan Urban Food Policy Pact experience**

Figure 2: Preliminary phases and steps of the FAO-WFP methodology to develop holistic school meals nutrition guidelines and standards (in blue) with key ways in which environmental sustainability can be considered in the processes (in green).

2 The phases and steps may change as the methodology is still in the process of development.

Balancing dietary requirements, nutritional needs, and environmental boundaries

Evidence suggests that the links between school meals and child-level health, nutrition and education outcomes typically involve a direct pathway centered on the contribution of school meals to daily food and nutrient intake, which critically depends on the quality of the school meals and on what children eat throughout the day, both at home and outside the home (Kristjansson et al., 2007). In addition, school meals programs are increasingly being designed to also include objectives related to smallholder agriculture and environmental sustainability, though to date these links have yet to be extensively studied (Singh & Fernandes, 2018).

Developing quality standards is an important step in realizing the multiple benefits from the program. Some of the processes involved in the optimization of school meals provision to meet quality standards include food and nutrition requirements, alongside food safety, cost, smallholder sourcing, and environmental considerations (**Figure 3**). Crucially, the optimization process requires careful cross-sectoral coordination to manage decisions on the key trade-offs involved.

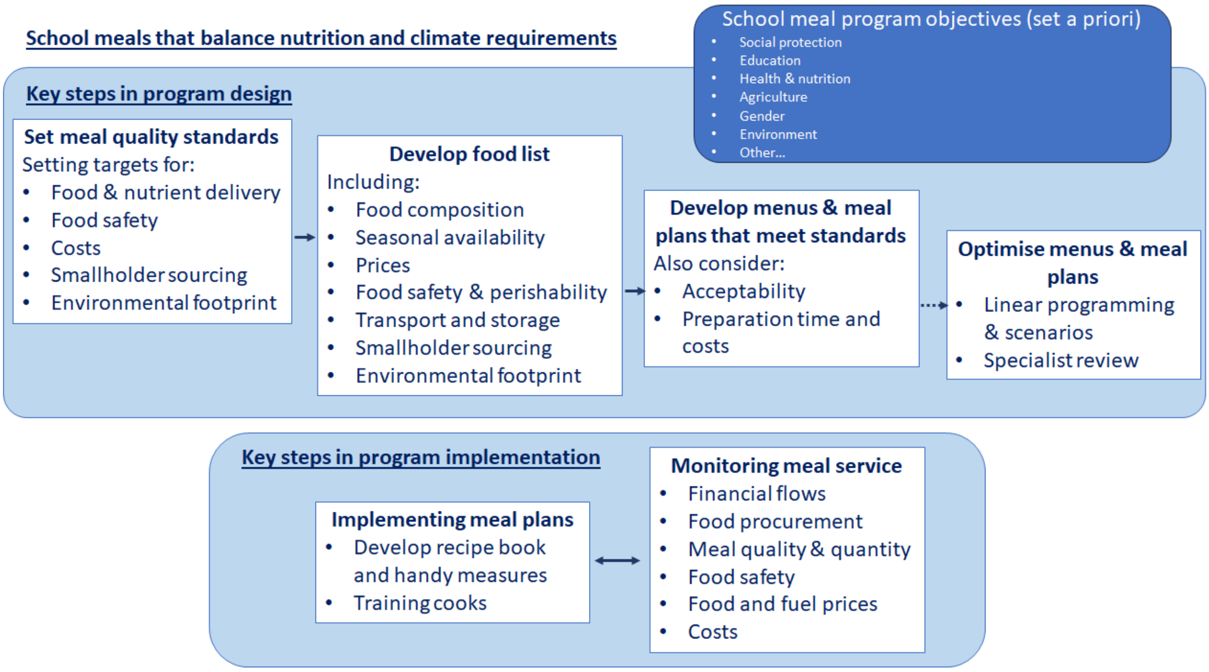

Figure 3: A framework illustrating the key steps required in balancing nutrition and climate requirements in the design and implementation of school meals (Source: adapted from Galloway, 2010).

The starting point in this process involves setting the quality standards, or requirements, for the school meals service. Typically, these standards will include information on food and nutrient based targets for school meals (**Appendix 1**). For example, food-based targets build on food-based dietary guidelines, which are designed to promote healthy food choices. Nutrient-based targets reference the daily macro- and micronutrient intake requirements in specific age groups and populations. In addition, the standards can also include targets for food safety, costs, smallholder sourcing and environmental footprint. Testing the acceptability of the menu will also be an important step, for example through taste sessions or trial periods with kids at school.

Once targets are set, the next step is to operationalize these standards through the development of meals and menu plans. This first step entails developing a food list, including a database with information on food composition and food groupings, seasonal availability, food prices, costs of transportation and storage and cooking facilities. Other important elements to consider include food safety measures and equipment (e.g. refrigeration) and metrics on viability of small holder sourcing, and environmental footprint. Obtaining reliable metrics for some of these dimensions may be challenging and remains an important area of ongoing research, including the development of the Environmental Impact of Diets (EIOD) metrics.

When completed, these menus and meal plans can also provide the basis for optimization analysis, where linear programming is used to identify solutions that balance the different dimensions covered by the meal quality standards (Eustachio Colombo et al., 2019). Scenarios can also be used during the optimization analysis to examine the influence of different constraints. Once reviewed and validated by nutritionists and other program specialists, the menus and meal plans can be operationalized and integrated into the school meals program implementation. This typically entails developing training materials for school caterers, including recipes and standard measurements to be used when serving the school meals.

The following step regards the operationalization of the menus and meal plans through procurement. It is through the procurement process that menus and meal plans are translated into actual food items and bulk quantities, the suppliers are selected, and the delivery of the food is ensured. There are various instruments that can be used to integrate environmental sustainability within the procurement process and those in charge of procuring the food or catering services should be taken into consideration. These include environmentally friendly minimum requirements and award criteria. The WHO publication "How together we can make the world's most healthy and sustainable public food procurement" (WHO, 2022a) presents good guidelines in this regard. It is important that proper policy and legal instruments are available together with practical guidelines and appropriate Human Resources (HR) capacity to ensure proper implementation and integration of sustainability aspects within the distinct phases of the procurement process (FAO & WFP, *forthcoming*). Chapter 3 of this publication explores more broadly the power of school food procurement as a demand-driven intervention to trigger food systems transformation and contribute to strengthening local agriculture production, improve biodiversity and foster food sovereignty. The last step in the cycle centers on monitoring the quality of the meal service provision, including data on financial flows, food procurement, meal quality and quantity, food safety, prices (food and non-food) and financial and opportunity costs (Gelli & Suwa, 2014; Vieux et al., 2013). Integrating the environmental sustainability perspective into existing methods and metrics developed to support the design, implementation and monitoring of school meals programs is an important area of ongoing work (**Figure 3**).

1.4. The importance of involving stakeholders at all levels

School food is often close to people's hearts. Progressive governments have long recognized the power and potential of engaging key stakeholders in the creation and implementation of ambitious action plans or strategies. Identifying important stakeholders in local or national school food systems can be done through, for example, stakeholder mappings exercises and analyses (R4D, 2022)[3]. Stakeholder categories relevant for school meals include meal planners, dietitians, procurers, chefs, meal managers, food service and catering businesses, caregivers/parents, local politicians and policy makers, headmasters, teachers, pupils, farmers, wholesale companies, logistics and transportation companies, idea-driven organizations, Civil society organizations (CSOs)

3 MSP toolkit (rikolto.org)

and non-governmental organizations (NGOs), researchers as well as local or regional experts on sustainability, health, education, and social justice just to mention a few. They are all important parts of our respective school food systems.

The involvement of students is crucial when designing policies or interventions targeting school meals. If the aim is to achieve a critical behavior change towards more sustainable, planet -friendly and healthy diets in schools we need to understand our target groups. This can be done through multi-stakeholder processes and dialogues or through co-design processes. Another key category is the farming sector, in particular medium to small-scale producers. Connecting food consumption to the land where food is produced makes for food systems built on relationships and respect.

As many actors as possible must get on board to push for the transformation of food systems and the shift towards more inclusive and sustainable school food systems. Involving stakeholders at all levels will be a critical ingredient in addressing the complex challenges we face in public health, territorial resilience, social justice, and environmental sustainability, for the future of our children and our planet. Catalyzing action requires working with a range of stakeholders and actors (see **Figure 4**). Key to achieving this is enabling stakeholders to work in a cross-sectoral way that acknowledges and embraces the intimate interrelationship between biodiversity, nutrition and climate outcomes. The guidance on mainstreaming biodiversity for nutrition and health that broadly encompasses the five critical steps identified in the Global Nutrition Report 2018 for speeding up action to end malnutrition in all its forms is one example of a framework that can help guide this process (GNR 2018). For example, countries could prioritize and promote a more climate change-responsive approach to school feeding in their Nationally Determined Contributions (NDCs), National Adaptation Plans (NAPs) and long-term strategies under the United Nations Framework Convention on Climate Change (UNFCCC).

Figure 4: Stakeholder groups required for a more climate-responsive approach to HGSF (reproduced with permission from authors).

2. PLANET-FRIENDLY POLICY CHANGES TO NATIONAL SCHOOL MEALS PROGRAMS FOR GOVERNMENTS CONSIDERATION

In this chapter we highlight the key policy areas where the greatest benefits to children, communities and planetary health can be achieved in the shorter term. These actions can be acted upon in a short space of time by making changes to national school meals programs and school procurement policies. The key areas for immediate action include shifting to menus that promote children and planetary health, adoption of clean and energy efficient cooking solutions, prevention of food loss and waste and reduction of package use, and integrated holistic food education.

2.1. Menu changes that promote planetary and population health

Nutritious foods meeting growing children's dietary needs

Meals planned and provided for children must take into consideration their nutritional needs. While nutritional requirements don't need to be met at every meal, it is important that they are met over weeks and months. A school lunch, one of the main meals of the day, eaten regularly for potentially many years, will contribute significantly to long-term overall nutritional intake. If this replaces alternatives such as a less nutritious lunch from home, a lunch consisting of snacks or even nothing at all, the benefits are even greater, and proportionally more so for children without consistent access to nutritious meals at home.

Good nutrition promotes optimal growth and development, learning and health. Poor diets and malnutrition damage children's health, school performance and learning capacity, thus setting them on a path for lower future productivity and earning potential (FAO, 2019a). The school years are an important period for the physical, mental, emotional, and social development of children. The foundations of "good health and sound mind are laid during the school age period" (Srivastava et al., 2012).

Numerous factors affect the impact of school meals on nutrition outcomes, including regularity, safety, diversity and composition of the meals; and whether complementary strategies are in place that address other determinants of nutrition (such as education, deworming, WASH, micronutrient supplements, parental support, physical activity, restrictions on the sale of energy dense ultra processed foods) (FAO, 2019a). Thus, multidimensional school food programs are preferable to address multiple outcomes (Aliyar et al., 2015).

Considering the current state of global malnutrition, the nutritional objectives for school-age children should be focusing on energy and protein adequacy (avoiding excesses), decreasing deficiencies of iron, iodine, vitamin A, vitamin D, calcium, zinc, and folate, and avoiding excesses of simple sugars and sodium (Saavedra & Prentice, 2023).

In settings where micronutrient deficiencies are more widespread, in the short term, fortification supplementing nutritious school meals should be considered. Nutritious and fortified school meals have been have been found to improve micronutrient intake (mainly iron, zinc, and vitamin A), specifically in children with low baseline indicators (Jomaa et al., 2011). However, the ultimate goal should be to enable the availability of local resilient and seasonal nutrient-rich diverse foods that can cover deficiencies year-round.

In many countries children do not consume enough fruits, vegetables, legumes, fatty fish and foods rich in wholegrains. In contrast, in some countries, particularly high and upper middle-income countries, the intake of red and processed meat is often higher than recommended. These habits account for a large portion of the global burden of disease which is attributed to diet. More planet-friendly school meals menus are likely to replace some meat with foods from these other groups and are therefore highly likely to address both these positive and negative imbalances, at a time of life when dietary habits are still being formed.

See case studies in Annex:

- Phytase-rich school meals for enhanced micronutrient bioavailability
- High-quality and safe fermented staple foods for nutrient-rich school meals
- The Global Diet Quality Score-Meal Metric: An Innovative Metric for Measuring Meal Quality
- Transforming Ghana's Food Processors into Catalysts for Change

What is a planet-friendly diet? Nutritious, diverse, climate resilient, culturally relevant whole foods

A planet-friendly diet means access to healthy foods for all, produced and consumed in ways that do not pollute or overexploit natural resources, such as land and water, and that protect biodiversity. Globally, to achieve this goal, populations should consume a variety of nutrient rich and locally relevant fruits, vegetables, whole grains, legumes, and nuts alongside small portions of low impact animal foods (Willett et al., 2019) (see **Appendix 2**). This message has been reinforced by the Intergovernmental Panel on Climate Change (IPCC), whose reports state the importance of nutritious whole foods produced in resilient and sustainable systems. This diet presents major opportunities for climate change adaptation and mitigation while generating significant co-benefits in terms of human health (IPCC, 2020).

This requires shifting the focus on the quality, type and diverse range of food rather than merely on the quantities produced and addressing the currently unequal global food systems. Healthy and planet-friendly diets are context-specific, and their availability and cost differ at the global and regional levels. This is especially important in the context of policy actions: although high income countries have contributed most of the food systems-related emissions, the negative effects of climate change and resource degradation will be felt most in low- and middle-income countries (LMICs), that already face high levels of food insecurity, malnutrition, and disease. In these contexts, planet-friendly school meals programs should aim to shift menus to include foods that are drought-resistant, or flood-tolerant (as local conditions require), which add nutrients to the soil and that interact positively with the local growing conditions, weather, and environmental situation. This is best accomplished by diversifying the types and sources of foods served at school, incorporating principles of agrobiodiversity, and acknowledging the importance of indigenous peoples and their traditional knowledge as custodians of biodiversity (IPCC, 2019, FAO, 2022a).

In other parts of the world, where overconsumption of food, particularly processed and animal foods, is causing the greatest damage to planetary health, significant reductions in the consumption of these food groups will be necessary, together with a shift to whole foods. Processed and especially ultra processed foods (UPF) can lead to a range of adverse health outcomes, including cardiometabolic disease, in children and adults (Elizabeth et al., 2020). Reducing highly processed foods is not only fundamental for health; it would also significantly reduce emissions from industrial food systems, which are highly energy intensive and heavily reliant on fossil fuels. According to the new report from the Global Alliance for the Future of Food (Global Alliance for the Future of Food, 2023), processing and packaging account for 42% of energy use across the food chain globally. Production of ultra processed foods commonly consumed by children, such as snacks and drinks, can be up to 10 times more energy intensive than the whole food equivalent (Ladha-Sabur et al., 2019), due to energy-intensive equipment, refrigeration, and transport necessary to process, handle and preserve foods from farm to table in industrialized food systems dominated by multinational firms.

Scaling up adoption of traditional and indigenous foods in school meals to increase agrobiodiversity, nutritional value, climate resilience and cultural heritage

Incorporating traditional and indigenous diets into school meals provides a unique opportunity to improve child health, promote agrobiodiversity, foster a sense of connection to heritage and enhance the livelihoods of communities. Traditional and indigenous diets emphasize the use of locally sourced, seasonal ingredients, aligning with sustainable food practices. This entails the adoption of neglected and underutilized plant species and varieties, also known as “lost”, “native”, “orphan” and “indigenous” (IFPRI, 2023). These nutrient-dense plant foods, including varieties of grains such as millet and sorghum, vegetables such as amaranth and other green leafy vegetables, fruits such as baobab, roots and tubers and pulses, can play a pivotal role for improving children's diets, while protecting biodiversity and promoting local agriculture and food security (Hunter et al., 2020a). The crucial role of neglected crops as a way to solve both the food and climate crises, is increasingly being recognized, with the UN declaring 2023 the year of millet (FAO, 2023).

Introduction of a range of local and neglected varieties of species is a crucial addition to school meals to reduce micronutrient deficiencies and malnutrition. Many neglected food species and varieties are significantly more nutrient dense than the few dominant varieties consumed today, with higher levels of micronutrients, such as iron, zinc, potassium, calcium, vitamin C, vitamin A, and amino acids (Akinola et al., 2020; Avallone et al., 2007; Hunter et al., 2019; IFPRI, 2023; Randrianatoandro et al., 2010). Endemic crops are also more climate resilient due to their natural adaptation to the local environment. They can withstand droughts and infertile soils and require little or no chemical input (IFPRI, 2023). Yet, most countries fail to use this natural wealth, partly because yield and profitability have driven the rise of large-scale monoculture in recent decades. From an estimated 5,000 species that have been consumed by humans, only 150-200 have been cultivated, and 17 make up 75% of the worlds’ food (Hunter et al., 2019).

Consuming a diverse range of species and varieties of foods should be a requisite of dietary guidelines, such as those adopted by Brazil (Ministry of Health of Brazil, 2015). To actuate these recommendations, the Brazilian government has incorporated neglected local foods into school meals (see the case study in the Annex). In India, through the National Food Security Act (Government of India, 2013), nutritious and climate resilient minor millets have been incorporated into school meals to benefit millions of school children. In Kenya, pilot projects linking local farmer groups to school markets at the county and district level have enabled the introduction of nutritious leafy African vegetables in schools (see the case study in the Annex).

Multiple stakeholder collaboration with local communities, farmers and nutrition experts is pivotal for incorporating traditional foods into school meals guidelines and programs to shift diets to be more nutritious, diverse, and resilient.

See case studies in Annex:

- Promoting native and underutilized food: the Biodiversity for Food and Nutrition project in Brazil
- Native and underutilized foods in Nepal
- Fostering Nutritional Diversity in Zambian School Meals through Traditional Foods

A shift to more plant-based foods in the diet would bring the greatest health and environmental benefits in contexts where meat is overconsumed

Overconsumption of meat, especially ruminant meat, has the highest negative impact on environmental and human health (Godfray et al., 2018). Land use, eutrophication, GHG emissions and acidification of ruminant meat production are up to 100 times greater than a plant-based diet (Clark & Tilman, 2017). Reducing red meat where this is overconsumed and eliminating processed meat intake would offer significant co-benefits for human health, preventing multiple non-communicable conditions, including cardiovascular disease, colorectal and breast cancers (Desmond et al., 2018). About 8 million deaths globally were attributable to unhealthy diets, with red and processed meat increasing the risk, and fruit, vegetables, whole grains, legumes, nuts, and seeds being protective (Vos et al., 2020). For human and planetary health, the EAT Lancet advises a maximum of 98 grams of red meat (pork, beef or lamb) a week and suggests sourcing meat from regenerative farming[4]. While reducing animal foods, it is important to substitute it with whole unprocessed plant foods, such as fruit, vegetables, legumes, nuts, seeds and whole grains, which are all currently under consumed in most parts of the world[5.] Legumes, in particular, offer an opportunity to shift the protein and vegetable component of diets towards healthier and sustainable plates.

The finding that meat, in particular ruminant meat, is a major contributor of total carbon emissions in food and catering services is widely acknowledged. Minimizing beef and dairy products in school menus can lead to a 22% reduction in global warming potential (GWP) (Petruzzelli et al., 2023), without any compromise to nutritional quality. Low-carbon school menus, defined as more plant-based, have potential to not only halve carbon emissions but also to positively impact on land use, water use and energy demand (Batlle-Bayer et al., 2021).

Active work is underway to increase the proportion of plant-based food in many countries, especially in Europe, where many municipalities have significantly reduced meat in school menus with consequent emission reductions (see European Case Studies in the Annex). In 2023 the Nordic Nutrition Recommendations (see case study and **Appendix 3**), used as the basis for dietary guidelines for Nordic and Baltic countries, made recommendations for both health and the environment (Nordic Co-operation, 2023). In France, the 2021 “Climate and resilience” law mandates that vegetarian meals should be served at least once a week (République Française, 2018). However, recent modelling analyses based on French menus showed that serving three vegetarian meals a week as well as eliminating ruminant meat would result in significant reductions in environmental impact, including 50% GHG emission reductions, while maintaining good nutritional quality (Poinsot et al., 2022). Some cities go even further than the law, offering a daily vegetarian alternative which has the effect of including children with dietary restrictions. In Finland, in addition to weekly vegetarian meals, schools are recommended to serve an optional

4 (https://eatforum.org/lancet-commission/eatinghealthyandsustainable/).

5 (https://ourworldindata.org/grapher/average-per-capita-fruit-intake-vs-minimum-recommended-guidelines).

vegetarian meal accessible daily to all (NNR 2023). The Ministry of Agriculture and Forestry has also invested in the vocational training of kitchen personnel on new plant-based recipes. When introducing the new menus and foods, it is important to take the pupils along to the recipe-development and testing (Kaljonen et al., 2019; see also case study in the Annex). This can help to adjust the school menus more prominently to the changing food habits of children; whilst giving possibility to sustainability education in the meantime.

See case studies in Annex:

- OPTIMAT ™ - school meals optimized for climate, nutrition, cost and taste
- Strength2Food Research Project
- BeanMeals
- ProVeg UK's School Plates Awards
- Healthy and sustainable school meals in Milan

Aquatic foods: an opportunity to incorporate small amounts of animal foods with high nutritional value and lower environmental impact

Aquatic foods play a significant role in promoting nutrition and sustainability in school meals, as they are rich in essential fatty acids, micronutrients and animal protein, as well as produced more sustainably than other animal source foods (Bianchi et al., 2022; Hallström et al., 2019).

Aquatic food is a broad term that encompasses all food for human consumption grown in or harvested from water, including fish, crustaceans, mollusks, other aquatic animals, and algae (FAO, 2022b). Incorporating aquatic foods into school meals has potential to offer numerous benefits for the well-being of children and the environment. Aquatic foods can play a crucial role in meeting different populations' nutritional needs. For example, the role of consumption of aquatic foods in the first 1,000 days is well recognized for improved birth outcomes, as well as physical and cognitive growth of young children, while there is growing recognition of the role of aquatic foods for an additional 7,000 days throughout adolescence (Hallström et al., 2019; Marinda et al., 2018; Toppe et al., 2021).

Analyses of aquatic foods based on nutrient density and greenhouse gas emissions reveal certain species as top performers, excelling in both nutrition and climate impact (Bianchi et al., 2022; Hallström et al., 2019). Species such as small pelagic fish (for example, anchovies and sardines, which are often consumed whole) and mollusks are particularly nutrient rich while having relatively lower greenhouse gas emissions compared to farmed species such as catfish. Nutrients such as iodine, selenium, zinc, iron, calcium, phosphorus, potassium, vitamins A and D, and several B vitamins, which are concentrated in bones, eyes, and viscera, are found in significant levels when the whole fish is consumed (Sroy et al., 2021). Aquatic food is a unique source of iodine and long-chain omega-3 fats (EPA and DHA), both of which are vital for optimal brain development in children (Øyen et al., 2018; UN Nutrition, 2021). Larger fish can also provide the same nutrients if by-products such as heads, bones, eyes, and viscera are consumed, as these parts are particularly nutrient-rich. However, this is much less common since more advanced processing technologies, which may not be accessible to small-scale producers, are needed to transform these parts into edible options. It is also worthwhile to note that it is advisable to consume larger predatory fish that are higher in the food chain in moderation, as they can accumulate more environmental contaminants.

Beyond the reasons already stated in relation to the lower environmental impact of production of aquatic animal-source foods, utilizing the whole fish in school meals minimizes waste and maximizes nutrient utilization, further supporting sustainability objectives (Toppe et al., 2021; UN Nutrition, 2021). A comprehensive understanding of the accessibility of aquatic foods across various dimensions, geographic, economic, and social, is essential. By harmonizing choices of aquatic foods with local dietary traditions, nutritional requirements, and acknowledging the diversity of available species, we can optimize the nutritional benefits and seamlessly integrate these choices into a healthy diet (Tlusty et al., 2019).

A study conducted in two Oregon (USA) school districts in 2019 emphasized the benefits of connecting students and the school community with local food sources. It underscored the importance of dedicated leadership, partnerships, grant funding, and resource creativity while also highlighting challenges, such as securing sustainable funding and addressing the higher cost of aquatic foods. In conclusion, this study provided valuable insights and resources for educators aiming to establish or sustain fish to school programs, emphasizing the necessity for comprehensive support and innovative approaches to enhance program viability and sustainability, not only in Oregon but also across states with similar initiatives (Virta & Love, 2020).

In Brazil, a proactive effort to promote aquatic food consumption is overcoming cultural and operational challenges, driven by strategic policies. This initiative aligns with the crucial goal of instilling lifelong healthy eating habits from an early age. The inclusion of aquatic food in school meals emerges as a pivotal strategy, offering a gateway to sustainable food practices. Research findings highlight the acceptability of aquatic food products, such as fish burgers, fish balls, fish nuggets, and fish-enriched cakes, for school menus, despite complexities in national food policies (Fonseca et al., 2017).

Through a successful pilot study, FAO has demonstrated the seamless integration of fish into school meals, leveraging public procurement strategies. By prioritizing locally sourced ingredients, this approach not only encourages health-conscious diets but also nurtures sustainable practices. The collaborative experiences from countries like Angola, Honduras, and Peru underline the importance of multisectoral committees, uniting governmental and non-governmental entities to effectively integrate fish into school meals programs. This collaborative approach generates affordable, locally accepted fish products while enhancing awareness of their nutritional benefits (Toppe et al., 2021).

It is important to mention some of the challenges here. Overfishing, especially at the commercial level, has become a problem and significantly depleted some fish stocks. Some aquatic foods, such as farmed prawns, have a very high environmental footprint and have led to large ecosystem destruction, such as mangrove habitat in South East Asia (DeWeerdt, 2020). Choosing sustainable aquatic foods, such as small pelagic fish, or non-fed aquaculture types, such as clams, mussels and seaweeds, require minimal inputs and can even improve the water quality. Aquatic food still offers substantial environmental and nutritional advantages compared to land farming if we choose high-performing blue foods and improve production methods (Gephart et al., 2021).

See case study in Annex:

- Scaling nutrition-sensitive fisheries technologies and integrated approaches in Odisha, India

Increasing children-healthy foods consumption by making planet-friendly choices the easy choices

Persuading children to choose and consume healthier food, even when these are available in school meals, is challenging (Evans et al., 2012). Food choice is influenced by a range of factors including sensory, social, cultural, physical environments, biological, psychological, cognitive factors, and has been conceptualized using many theoretical models (Chen & Antonelli, 2020). Public health interventions have mostly focused on knowledge-based theories, providing education with the expectation that advice translates into action (Ajzen, 1985). Automaticity and habits are also especially relevant to food choice. Healthier habits are dependent on both the environment as well as on individual conscious factors (Riet et al., 2011; Sheeran & Webb, 2016).

Beyond the key role of food education, changing the micro-environment cues to make school food more attractive and available has been proven effective at increasing consumption of healthy foods, especially fruit and vegetables. In high income settings, evidence shows that school meals interventions altering placement or convenience and using attractive language to describe foods coupled with offering healthier and tastier options from which students could choose are positively associated with increased selection and intake of healthy foods (Cohen et al., 2021; Marcano-Olivier et al., 2020; Metcalfe et al., 2020). This is important as many schools might be reluctant to shift existing menus in the fear that children won't eat the new offering, hence wasting already limited school resources.

See case studies in Annex:

- The School Menu Planning Tool: SMP PLUS
- Seoul, South Korea: planet-friendly free school meals
- Does the US need to do more to achieve planet-friendly school meals?
- ProVeg UK's School Plates Awards
- Food for Life: championing every child's right to healthy and sustainable school food

Fortification

Anthropogenic CO_2 emissions threaten human nutrition via two pathways: i) disrupting the global climate system thereby impacting food production; and ii) altering the nutrient profile of staple crops (Smith & Myers, 2018). Rising CO_2 levels will cause crops to become less nutritious by cutting plants' nitrogen concentrations, leading to an increase in mineral deficiencies. This will add burdens on global food security: one-third to half of the world's population suffers from micronutrient deficiencies leading to loss of economic productivity and unrealized human potential.

Fortification is a powerful, low-cost, and planet-friendly intervention for improving micronutrient intake at scale. Currently, 51% of all school meals programs serve fortified foods, with far higher rates in lower income settings and much lower in high income settings, with the most common fortifications being for vitamin A (74%), iodine (52%), iron (50%), vitamin D (39%), and zinc (34%), reflecting the most common nutritional deficiencies in children (GCNF, 2022a).

A Cochrane review suggested that multiple micronutrient fortification reduces iron deficiency anemia and micronutrient deficiencies including iron, vitamin A, vitamin B2, vitamin B6 and others, depending which micronutrients foods are fortified with (Das et al., 2019). With anticipated climate changes, fortification programs can enhance the nutritional quality and affordability of sustainably produced healthy diets by making plant-source foods more nutrient-dense and supplying micronutrients at a more affordable price than animal-source food.

Fortifying food products with essential micronutrients can facilitate the transition to healthier and more sustainable diets (Fatemi et al., 2023). According to a recent study that modeled the effects of fortifying various diets, to meet nutrient and Green House Gas Emission (GHGE) 2030 targets for Dutch adults, it would require a substantial increase in consumption of legumes and plant-based alternatives; however, when plant-based diets are fortified with essential micronutrients, it would need smaller dietary shifts (Grasso et al., 2023). Fortification of food, for example of rice and wheat flour, brings nutrient-adequate diets more within economic reach and is also a way to address dietary micronutrient deficiencies while limiting environmental impacts (de Pee et al., 2021).

In low- and middle-income countries, fortification can help achieve multiple sustainable development goals of health and nutrition (SDG 2 and SDG 3), sustainable consumption (SDG 12), and environment (SDG 13). Providing fortified staple foods in school meals and in-kind social assistance (i.e., distribution of fortified rice through food-based social assistance programs in India and Bangladesh) can substantially increase the micronutrient content of the school meals and family diets, lowering the risk of micronutrient deficiencies and reducing the economic burden to households. In Burundi, where 70% of households could not afford the lowest cost nutrient-adequate diet, the school meals with fortified maize flour provide substantial amounts of daily requirements of B-vitamins, folic acid, and zinc to children (Fill the Nutrient Gap Burundi, 2019). Fortification of staple foods provides an opportunity for school meals to be more planet-friendly as it provides some essential micronutrients, lowering the need for the addition of animal-source foods with higher GHGE and at higher cost. A recent analysis in Cambodia shows that the fortification of rice reduces the cost, GHGE, and water footprint of nutrient-adequate diets because it lowers the requirement for higher-cost animal-source foods (Fill the Nutrient Gap – Cambodia, forthcoming).

See case study in Annex:

- Fortified whole maize meal replacing refined maize meal in school meals in Rwanda

2.2. School food preparation: clean energy, efficient cooking and empowered trained staff

Cooking solutions: switching to clean cooking

2.3 billion people around the world still lack access to clean, efficient, convenient, safe, reliable, and affordable cooking energy (UN, 2023); mainly relying on traditional cooking systems, using high emissions fuels such as firewood, charcoal and kerosene, burned inefficiently on open fires or simple stoves (see Appendix 4) causing massive environmental, economic, social, gender and health impacts (WFP, 2021a). Emissions from traditional cooking systems contribute to the increase of greenhouse gases. Household air pollution from cooking causes more than 2 million people to die each year globally from illness and respiratory diseases, including lung cancer and pneumonia, with women and children being the most affected (WHO 2022b). Schools are contributors to inefficient cooking due to the large quantities of food cooked and prepared for school meals (WFP, 2021a). According to the latest GCNF report (GCNF, 2022a) open cooking and charcoal or wood stoves are utilized in more than 85% of schools in low income countries, while access to electric stoves in schools is non-existent in low income and less than 20% in lower middle income countries. Improving the efficiency of cooking in schools is an important step in addressing these issues. In low and middle-income countries, cooking fuels are usually supplied by children and their families. They either collect or purchase firewood which is considered an economic burden and time-consuming affecting school performance and attendance (Bisaga & Campbell, 2022). Developing and integrating innovative sustainable energy solutions for school feeding programs, especially when coupled with efforts to encourage the use of those solutions more broadly (e.g., at the household level), is crucial to reduce the massive impacts of traditional polluting fuels. Evidence shows that modern energy cooking technologies, consisting of biogas, LPG, electricity, ethanol, natural gas and direct solar cooking can reduce carbon emissions and contribute to multiple SDGs (including SDG 3, SDG 5, SDG 7 and SDG 13) (Mazorra et al., 2020; Rosenthal et al., 2018).

Large electric pressure cookers (EPCs) have been found to be suitable for cooking a large proportion of meals, durable and safe and thus ideal in school settings (Batchelor, 2021). The findings of both the Lesotho and Kakuma pilot projects (see case studies in the Annex) indicate that EPCs can improve the work environment and well-being for women and address gender inequalities given that the school staff members are predominantly female. Cooking with EPCs is less stressful compared to other fuels, saves time, reduces the burden and severe health risks of traditional cooking systems, and requires less supervision which enables staff members to conduct other productive activities, specifically that some teachers and headteachers participate in cooking and preparing school meals alongside their teaching responsibilities.

Electric cooking solutions and technologies for schools require supporting enabling environments, reliability and accessibility of the grid or off-grid electricity infrastructure, value chains and business models (Bisaga & Campbell, 2022). There is a potential to attract more funding for school feeding programs by switching from traditional cooking fuels to modern energy cooking technologies and monetizing carbon emission savings, gender, and health co-benefits of modern energy cooking technologies (WFP, 2021a). Holistic approaches, context-based solutions and cross-sectoral planning are needed to ensure a robust and sustainable transition to modern energy cooking technologies in schools.

Health and environmental impact of switching to clean cooking

Indoor air pollution in the household context has been the focus of attention for reducing the negative impact on health of traditional cooking, with emphasis gradually shifting from the fuel-saving benefits possible with more efficient improved biomass cookstoves to transitions away from polluting fuels altogether (Bisaga & Campbell, 2022). Application of the WHO's Benefits of Action to Reduce Household Air Pollution (BAR-HAP) tool for transition from charcoal to electric cooking in Kenya (Leary et al., 2021) shows the economic benefits of reduced mortality and morbidity is of similar magnitude to GHG emissions reduction benefit.

The use of biomass in school cooking also causes indoor air pollution, affecting the health of cooks and other staff working in and around institutional kitchens (McCord et al., 2017). It is challenging to estimate the national or global scale of these issues, as the potential exposure of staff is highly dependent on the local context, in terms of the kitchen staffing, fuels, stove types, chimneys and ventilation. Some of the case studies provide anecdotal evidence from affected staff about the air quality benefits of shifting to modern cooking solutions.

Improvements in school feeding may bring a reduction in exposure to air pollution for school children, as they spend less time in polluted home kitchens. The potential for health improvements for staff and children associated with air quality improvements are not quantified here but do reflect significant socio-economic benefits of institutional cooking transitions. Further research and assessment should be a priority to allow this aspect to be integrated into the development of school feeding strategies.

Transitions in the fuel and stoves used for cooking will lead to additional environmental benefits. However, as for health effects from pollution, the opportunities for, and impacts of, transition to modern energy cooking are highly context dependent. For example, transitioning from firewood to electric cooking will reduce burdens on forestry, but the significance of that change will depend on the ecological sensitivity of the forests exploited, and the net GHG emissions will depend on whether the wood harvested is classified as non-renewable. This is another priority area for work, as for example carbon finance could be useful to help overcome the first-cost barrier to purchase of EPCs but relies on the traditional biomass coming from largely non-renewable sources.

See case studies in Annex:

- Electric pressure cookers in Lesotho
- Large electric pressure cookers in Kenya
- Accelerating a Clean Cooking Transition in Schools in Tanzania

Energy efficient kitchens

Where modern energy cooking solutions are already adopted in schools, the emissions from cooking and kitchen appliances are relatively low compared to other school meals components, such as poor menu choices and waste. Nevertheless, in a German study measuring energy emissions across 22 primary schools, kitchen related emissions accounted for nearly a quarter of the overall school menu GHG emission (Speck et al., 2021). These emissions could be quickly reduced by adjusting the behavior of the kitchen staff and optimizing the technology being used.

By equipping and using the kitchen wisely, it is possible to achieve an energy-efficient kitchen with a good working environment. In demonstration projects, a more efficient, shorter, and more systematic route from oven to mouth provides both higher quality food, reduced energy use and a better working environment.

The following kitchen behavioral changes strategies offer examples of how investment in kitchen staff training could save energy at school level:

- Measure the energy use to see what effect your changed routines have and make sure to distinguish the kitchen from the rest of the building.
- Start energy-demanding kitchen machines in sequences, preferably with 5–10-minute intervals.
- Don't start fan covers or ovens until it's time to start cooking. The startup functions make sure that pre-heating is unnecessary.
- Lower the temperature of the dishwasher if possible.
- Make an inventory of the energy requirements of different dishes and factor energy tradeoffs in determining menus.
- Try to reduce the use of hot water as much as possible.
- Use the residual heat from the switched off stove or oven.
- Assign a person to be responsible for the energy and education of the staff in correct usage of the kitchen machines and how different behaviors affect energy.
- Develop and monitor energy use in a simple and visually clear way, such as by using a display that shows energy use per day, per machine, or per portion produced.

- Employ diligence, user-friendly machines, and energy-based, simple and easily accessible user instructions for each machine.
- Revise the electricity contract. Is it possible to renegotiate? What are the conditions, is it a variable electricity price or fixed?

Ovens, refrigerators, freezers and dishwashers are the most energy-demanding equipment in the kitchen. But there are opportunities here. These include:

- Well-insulated cold- and freezer rooms reduce heat loss.
- Doors with curtain stripes counteract energy losses when the door to the fridge and freezer needs to be open.
- Frequency-controlled cooling machines reduce energy use significantly.
- The residual heat from cooling machines can replace a large part of the building's needs for, for example, district heating.
- Space-efficient stoves and ovens adapted to the amount of food being cooked greatly reduce energy use.
- Hot water recycling, functions to ensure full trays and technology that starts rinsing only when a basket is in the rinsing zone reduce the energy demand of the dishwashers.

Relivs network, financed by the Swedish Energy Agency (Energimyndigheten) provides further recommendations on how to reduce energy use in the kitchen by focusing energy-efficient equipment's and tackling power peak issues.

Very few requests to commercial kitchen suppliers are specifically about energy-efficient equipment. A Life Cycle Cost (LCC) calculation is recommended when procurement of commercial kitchen equipment is to be made, to include all costs during the equipment's life cycle. This entails choosing not only the cheapest equipment but taking into account the whole life cycle perspective, energy costs being the main operational parameter. Choosing equipment with a low LCC cost often means choosing equipment with lower energy consumption and less climate impact. There are some energy efficiency labels that can be used to compare equipment’s performance: for example, Energy Star (administered by the U.S. Environmental Protection Agency) for commercial ovens, griddles and dishwashers, and the EU-energy label for commercial fridges and freezers.

From an energy use perspective, school kitchens have a big impact on the buildings’ total energy consumption and have a characteristic load profile that leads to power peaks during the meal-preparing hours. The cumulative effect of those power peaks from many schools could be problematic if the electricity network is not robust enough and could, in the worst of cases, lead to power shortages.

Tackling power peak issues (peak shaving) implies either behavioral changes in the kitchen or use of control equipment. A scheduling strategy is needed to turn on equipment in sequence and not all at once (for example if there are several ovens that need pre-heating). Furthermore, some equipment has “reduced power” mode that can be very useful. The routines in the kitchens can be affected, but not significantly.

Experiences from Sweden show that, when several school organizations work together and share knowledge with each other, it can be possible to achieve significant energy use reductions.

Shift to renewables-based cooking and storage technologies

Around two-thirds of global GHG emissions is attributed to fossil fuel energy supply and use (IPCC, 2014) Moving away from fossil fuels and investing in renewables-based technologies for storage, cooling, cooking and kitchen appliances can have multiple co-benefits. Together with moving to clean cooking solutions, it is essential to decarbonize the energy grid to facilitate the transition to sustainable energy. It is estimated that renewable energy, especially solar and wind energy, can supply two-thirds of the total global energy demand. (Gielen et al., 2019).

See case study in Annex:

- Harnessing technology and innovation: Food for Education, Kenya

Engaging, training and empowering food preparers

In terms of the role of catering staff in sustainable school meals, previous studies have found that staff morale and job satisfaction are linked to service management regimes. For example, in the UK, job satisfaction was found to increase for staff involved in Food For Life certified services (Kimberlee et al., 2013). In terms of the need for procurement decision-making to be integrated with other functions and policy areas, Bratt et al., (2013) note the risk of siloed thinking in the specification of procurement contracting criteria, while Le Velly and Bréchet (2011) reveal the ways in which decisions on physical school infrastructures can inhibit development of more sustainable meals (e.g. lack of kitchen facilities for on-site scratch cooking, bread-making or yoghurt-making). It is often difficult to arrange training for school caterers as they are typically only paid to work during school hours when they are always extremely busy preparing and serving school meals. Therefore, training is limited to in-service educational training (INSET) days which typically occur just before or after term begins or ends. However, school caterers are often deep cleaning kitchens at the end of term, or getting set up for the new term, so training can be less of a priority.

See case study in Annex:

- Dordogne Department, France
- Fortified whole maize meal replacing refined maize meal in school meals in Rwanda
- BeanMeals
- Planet-friendly School Meals provided by the City of Malmö

2.3. Prevent food waste and reduce plastic and package use

One third of all food is lost or wasted

Around 14% of the world food (valued at $400 billion per year) is lost after it is harvested and before it reaches retailers (FAO, 2019b). A further 17% is wasted in retail and by consumers, particularly households (UNEP, 2021). The lost and wasted food could feed 1.26 billion people every year. Food loss and waste also account for 8-10% of global GHGs. The UN target 12.3 of the sustainable development goal aims to "By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chain".

In high income setting food waste occurs mainly at consumption level. For example, schools in the UK waste around 80,000 tons of food, most of which is avoidable waste (WRAP, 2011). A study in Italian schools estimated food waste to be 20-29% of prepared foods (García-Herrero et al., 2019). Food waste in school is also associated with waste of resources, both natural and economic, and compromises the nutritional needs of school children.

The 2021 Global Survey of School Meal Programs (GCNF, 2022a) found that many school meals programs (79%) are striving to limit food waste. Programs in high-income settings are most likely to extend an effort to limit food waste.

Preventing school food loss

School meals programs can be designed and implemented so as to reduce on-farm and post-harvest food losses to insects, birds, rats, contamination by foreign matter, bacteria, aflatoxin or other fungi and molds, etc. through improved pest control, harvesting, gleaning, salvaging, drying, storage, preservation, preparation, reuse, and disposal methods.

Non-toxic pest control including biocontrol and integrated pest management for crops (Baker et al., 2020) and birth control for rats (Memudu & Oluwole, 2020). Use of Aflasafe (IITA, 2023), where available, to treat fields and/or low-cost solar drying (Kamran, 2022) and hermetic storage systems used post-harvest can significantly reduce losses to aflatoxin and damage due to insects and humidity (Okolo et al., 2017; Okori et al., 2022). Timely and careful threshing can reduce losses to damage, humidity, and pests, and simple winnowing, screening, and/or sifting systems can remove some types of foreign matter.

The policy makers and managers of school feeding programs can work with relevant agricultural officials, community members, and private sector entities to ensure that safe and effective methods and products are routinely used. Again, the purchasing power of school meals programs could be substantial enough to drive changes in the post-harvest arena to ensure that food is not lost once harvested, and that the methods and products used to reduce losses are climate friendly.

Lack of sustainable cold chains, including freezers and refrigeration, directly results in 526 million tons of food production loss every year – approximately 13% of all food produced (IIR, 2021). Challenges become more acute in communities with limited access to electricity, due to the energy needs of refrigeration and cold chain equipment as well as the typically high first cost of many sustainable solutions. The price of food requiring cold storage can also be a challenge with research showing that calories from nutritious foods are often as much as 10-times more expensive than cereals or grains in caloric terms, and when faced with significant reductions in income vulnerable groups typically prioritize less nutritious foods with higher caloric value (Headey & Alderman, 2019).

Refrigeration capacity could allow schools to store perishable, highly nutritious food products such as fruits, vegetables, eggs, and dairy for longer periods, supporting a more vitamin-rich, balanced diet compared to cereals that are typically lower cost and do not require refrigeration. Achieving these social benefits requires not only sustainable cooling solutions in schools but improved functionality of 'cold chains' that carry products from point of production to consumption.

The development of drying technologies, for example the solar drying of fruit and vegetables, is another effective method to help prevent school food loss through the value chain (Bradford et al., 2020).

See case study in Annex:

- Tackling aflatoxin for safer school meals and to reduce food loss

Reducing food waste

The basis for reducing food waste is to start measuring. Food waste quantification is an essential first step to identify existing issues and for subsequent checks on whether interventions made have had the desired effect (Eriksson et al., 2019). What is measured is also seen. This will help identify in which category food is wasted. Food waste in school kitchens can be divided into three groups: kitchen waste, comprising storage, preparation, and cooking; serving waste, for food that is served but does not reach the plate; and plate waste, everything thrown away from diners' plates. Several factors account for food waste within each group. **Appendix 5** illustrates the various areas that should be addressed to reduce the various types of food waste according to the Swedish Food Agency, which has made efforts to reduce food waste in schools by developing a national measurement method and a handbook for reducing waste (Swedish Food Agency, 2020). Menu planning, serving size calculation and forecasting, reduction of serving sizes and using leftover are effective measures to reduce serving waste (Malefors et al., 2022; Swedish Food Agency, 2020) Improving the dining environment, for example by allowing sufficient lunch time, and raising awareness of food waste with students can reduce plate waste (Swedish Food Agency, 2020)

One important lesson from case studies where food waste has been reduced (see case study in the Annex) is that communication and involving everyone who is affected, especially kitchen staff is a prerequisite for success. As is collaboration between those who cook and are responsible for the food and those who are involved when the food is served and eaten in schools. The meal staff can influence the kitchen and serving waste and educators/ teachers can influence the serving and plate waste. Start by gathering everyone who is affected and telling them why it is important to reduce food waste. In some countries, for example the UK context, there is often a division of responsibilities between kitchen and canteen with catering providers' responsibilities stopping 'at the counter', which means the key job of supervising children and encouraging them to eat is left to others. Closing that gap would help reduce waste reduction.

Planet-friendly methods of food waste disposal

Leftover food that has been cooked and served in the canteen, but that has not reached pupils plates can still be used, for example by incorporating it in new dishes or by making it available to children to eat later through share tables or redistributing it locally (USDA, 2016a). Food that is left on plates or can't be recovered should be managed and disposed of in sustainable ways. Food waste that is disposed of to landfill sites or incinerated can generate methane and other emissions causing environmental pollution and potentially posing public health risks (HPA, 2011). Indeed, the choice of food waste disposal method has a significant impact on the overall school meals emissions. As showed in the Strength2Food' study (ref study), a European comparative study procurement and waste disposal methods, emissions from food waste disposal varied the most across the cases. Those with 100% landfill disposal had the highest emissions, representing as much as one third of total emissions of the meal. Emissions from waste disposal were much smaller in other cases, due to 100% use of composting or anaerobic digestion. Anaerobic digestion approach could also be used for energy, or nutrient production, which could be used in school gardening or other activities further supporting sustainability practices and opportunities for integrated education (Paritosh et al., 2017).

Environmental and health impact of package and plastic waste in schools

Package waste, including cartons, plastic contains and wrappings, is a significant problem in schools. For example, nearly half of municipal solid waste from the U.S. schools is food packaging waste generated by school foodservice (Minnesota Pollution Control Agency, 2010).

Globally, close to 400 million metric tons of plastic waste are generated every year, the rate of which is set to almost triple by 2060 (OECD, 2022). Just 9% of plastic waste is actually recycled into secondary plastics, the rest is disposed of through landfill (46%) and industrial incineration (17%), whilst more than a fifth of plastic waste ends in open burning, unregulated open dumpsites and environmental leakage (OECD, 2022).

Packaging accounts for 40% of global plastic waste generation (OECD, 2022), most of which relates to food and drink packaging (Lau et al., 2020). School meals are likely an important contributor to plastic waste, through widespread reliance on packaged food items and single-use service ware. Studies from the United States of America, India and Ireland suggest 0.005 – 0.02 kg of plastic waste per child may be generated in schools every day (Browne et al., 2023; Minnesota Pollution Control Agency, 2010; Ramamoorthy et al., 2019). This would account for between 2% – 50% of the corresponding national-level daily per capita plastic waste estimates (Jambeck et al., 2015), making schools an important focus for plastic waste reduction efforts.

Children are exposed to potentially toxic plasticizers and plastic chemical additives in food and drink, with evidence of higher concentrations in pre-packaged school meals compared to unpackaged foods (Cohen et al., 2023).

Global reliance on single-use plastics is unsustainable and contributes to plastic pollution in all its forms, not least in terms of greenhouse gas emissions. Over 99% of plastic is still derived from fossil fuels, with billions of tons of greenhouse gases emitted throughout the plastic life cycle each year (Center for International Environmental Law, 2019).

In devising strategies to reduce plastic and package waste, the 2021 Global Survey of School Meal Programs (GCNF, 2022a) found that 89 out of 183 programs were actively trying to reduce packaging waste in their meal provisions. Of these, around 45% were doing so through reusing bags and containers, 44% through recycling materials and about 25% by using compostable materials (GCNF, 2022a). In France, the school meals program delivers more than 1.1 billion meals per year, with around 75% of schoolchildren receiving at least one meal per week. As of 2025, From 2025, a law will ban plastic cooking, heating or serving containers in school canteens, as part of an ambitious effort to eliminate plastic pollution. (WFP, 2022). Efforts to limit packaging waste include the re-use of packaging and containers and, as in the case of Swatini's National School Feeding Program, the re-sale of bags and containers to raise money for the program. In France, efforts to limit packaging waste include the use of stainless-steel trays (GCNF, 2022a). Similarly, in Israel, efforts to reduce plastic waste include switching to buffet style eating instead of trays. Collaboration with Israel's Ministry of Environment has made it possible to reduce plastic waste by providing schools with dishwashers and encouraging the use of reusable utensils.

Increasing formal evaluations and data sharing on waste reduction strategies within school environments is critical to informing best practice and more widespread action to eliminate pollution and climate change impacts of plastics used in school meals programs [6].

The Zero Waste Hierarchy (Zero Waste International Alliance, 2022) is a prioritized framework for eliminating plastic waste across sectors. The aim of the framework is to guide decision making that promotes the "conservation of all resources by means of responsible production, consumption, reuse, and recovery of all products, packaging, and materials without burning them and with no discharges to land, water, or air that threaten the environment or human health" (Zero Waste International Alliance, 2022).

In the context of school meals, the selection of waste reduction approach(es) must ensure continued effective and safe provision of quality food and nutrition to school children (WFP, 2019, 2022). Minimizing plastic packaging and increasing support for on-site cooking ('from scratch' i.e., using non-packaged ingredients) in schools has been suggested to reduce child exposure to plasticizers and chemical contaminants (Cohen et al., 2023), which would also reduce plastic waste and pollution, and eliminate life cycle emissions associated with these same plastics. However, strategies need to be considered alongside context-specific food safety and hygiene concerns (WFP, 2019), emerging concerns such as chemical migration from recycling and reusing plastics (Geueke et al., 2023), and any emissions resulting from material substitutions or alternative meal delivery and preparation systems.

2.4. Action oriented and holistic food education to help establish life-long healthier and sustainable food practices.

Whole school approach

An ingredient that has been long missing in the world's school meals programs as well as in national strategies is integrated food education in schools on a systematic level. Multiple cities and actors are now simultaneously raising their voices in a joint policy wish to bring food education into schools and make lunch time an integrated part of the schools' pedagogic mission (WWF 2021). A perceived barrier to implementation is the lack of recognition and connection by national and federal education governance between school meals and educational benefits or values. However, it's important to bear in mind that during a child's school career, lunchtime represents thousands of learning opportunities.

Education for Sustainable Development (ESD)[7] is not a school subject or a What. It is not about specific content that is to be taught during certain lessons. ESD is the How. How do we design all teaching and all activities in school so that the students develop an increased action competence for sustainable development? To bring about real change, all staff, all subjects and, not least, the school management, must be active in the work with ESD. In the work with ESD a Whole School Approach[8] is a way of structuring and clarifying the importance and involvement in activities, by all staff and all students at the school but also by parents and the wider community. A Whole School Approach needs to be infused in the vision, mission and other policies of the school, making it central in the leadership, structure, management, planning and monitoring as well as in the teaching and learning. This makes sustainability the guiding theme of all activities and operations of the school, gradually developing into a school culture norm-setting attitude.

6 from work funded through the Innovative Methods and Metrics for Agriculture and Nutrition Actions (IMMANA) programme, led by the London School of Hygiene & Tropical Medicine (LSHTM).

7 www.unesco.org/en/education-sustainable-development

8 www.wwf.se/utbildning/wwf-education/whole-school-approach/

The FAO advocates for school-based food and nutrition education (SFNE) (FAO, 2020), an action-oriented and school-based approach that foresees opportunities for direct experience and practices related to food consumption, nutrition, cooking and agriculture in real-life settings such as school gardens, farmers visits to the school or vice versa, food markets, etc. This approach advises involving the whole person: the head (knowledge and understanding), the heart (motivation) and the hands (practice and skills); and promotes interaction with the social and physical food environments. FAO also promotes a 'Whole School Approach' to SFNE, actively involving all people that interact in the school setting, including children, their families, teachers, school staff, local farmers, foodservice staff, food vendors, and government staff.

Across Europe and other OECD-countries different approaches have been implemented to adapt a whole school approach with food as the core theme. The Czech and Slovakian model Truly Healthy Schools[9], the Food for Life concept by the UK Soil Association[10], the Belgian GoodFood@School programme by Rikolto[11], the Healthy Eating & Food Literacy Teacher Resource Kit in Australia[12], and the American National Farm to School Network[13] are a few examples to be mentioned.

The EU-funded project SchoolFood4Change[14,15] builds upon and advances above mentioned practices. Notably, it launched a comprehensive action-oriented framework known as the Whole School Food Approach (WSFA) developed by partners from 12 EU countries, including municipalities, schools, teachers, caregivers and pupils with Rikolto taking the lead. As an example of systemic innovation designed to bring about behavioral changes in creating a sustainable and healthy school food environment, WSFA positions schools, spanning from preschools to secondary schools, as pivotal change agents. Through this approach, the aim is to not only transform the school food system but, through food education, to contribute to the key outcome of fostering the health and well-being of children.

As such, WSFA integrates food and education by focusing on four pillars of real-life intervention: (A) Policy & Leadership, (B) Food & Sustainability, (C) Education & Learning, and (D) Community & Partnership. Each pillar, designed for place-based interventions geared toward catalyzing systemic change, aims at tackling issues such as access to healthy food for all children, reduction of food waste, multi-level governance and food culture that emphasizes the imperative of reducing inequalities in students' diet and health.

These pillars encompass a spectrum of collaborative actions with all stakeholders in the food systems, addressing, for example, the composition of school meals, designing the dining atmosphere, and optimizing the operational aspects of school canteens, which include procurement and staff training. Furthermore, the WSFA extends its impact through experiential learning activities such as farm twinning, gardening and cooking in schools empowering children and youth to take food futures in their own hands. Indeed active participation from both pupils and teachers lies at the heart of WSFA, broadening its influence to involve the entire school community, encompassing caregivers, small scale farmers, sustainable food businesses, and civil society.

Given that all children go to school, school canteens serve as pivotal places where food and education can wield a cascading impact on planetary health diets. As such, the main driver of the

9 https://www.skutecnezdravaskola.cz/

10 https://www.foodforlife.org.uk/

11 https://www.rikolto.org/projects/goodfoodschool

12 https://fuse.education.vic.gov.au/Resource/

13 https://www.farmtoschool.org/

14 https://cordis.europa.eu/project/id/101036763

15 https://schoolfood4change.eu/

WSFA is planned to be rolled out in approximately 500 pilot schools across Europe, impacting potentially 600,000 students in the coming years.

See case study in Annex:

- LOMA-Local Food in Schools
- Engaging students to the development of sustainable school meals in Finland

Integrated food systems education

A transformative approach for children around the world to meaningfully learn about the interconnectedness between food systems, health, wellbeing and the environment and to develop the capacity to act upon this learning, is a fundamental aspect of sustainable development (FAO, 2020; dos Santos, et al., 2022).

However, institutionalizing this kind of school-based food and nutrition education is not an easy task, as there are important challenges that can impair its integration, implementation fidelity and effectiveness. Main challenges include weak policy support and coordination, lack of regular training opportunities for teachers, competition and lack of dedicated curriculum time, no specific budget line available for high quality materials and activities, pervasive use of ineffective learning approaches, disconnect with other interrelated subjects and with the wider school culture, incoherence with the school food environment, and lack of meaningful parental and community involvement (FAO, 2021).

Planning for a new or revised sustainable food and nutrition education initiative thus requires reflection of such challenges from inception, as well as a careful consideration of the most relevant school entry points to maximize the possibilities of a cost-effective investment. The table in **Appendix 6** provides a summary of common entry points for the integration of sustainable food education into school systems, along with main considerations on the potential for long-term impact.

It is recommended that before deciding on one or more entry points, a good assessment be conducted to obtain an overall picture of existing capacities, gaps and strengths at the policy, organizational and individual levels of the school system relevant to food and nutrition education (see Capacity Needs Assessment Tool, 2021).

Once the most feasible entry points have been identified and a snapshot of the capacity and readiness of the system has been obtained, a sustainable food and nutrition education initiative can be designed. The following design process has been adapted from the FAO model to integrate effective food and nutrition education into school systems. The model has been built informed by robust evidence (see references in FAO, 2020) and programmatic best practices from countries around the world and defines an iterative, non-rigid process that should be co-created with students themselves. The minimum steps or sub-processes include:

- Description of the context and assessment of learning needs: this involves contextualizing and localizing the main characteristics and environmental, socio-economic and health outcomes of current food systems. Most importantly, it requires a good learning needs assessment to define baseline understanding, common behaviors, issues, interests and beliefs among children and adolescents and the wider society, regarding sustainable food systems and the role that education plays or should play in this transformation.

- Definition of core competences: identifying and formulating the core set of motivation, skills, knowledge and behaviors that are needed by students to support them towards more sustainable food practices and outlooks (as current consumers and as future food system actors). This step is critical as the core competences will not only guide the contents and best learning approaches but can also become the foundation or the manifesto for setting a sustainable school food culture. It is also critical that the set of core competences is explicitly aligned with the educational standards of the subject or set of subjects where food education will be integrated.
- Development of a competence-based curriculum: with scope and sequence charts organizing the learning pathways, throughout the schooling, needed to support the achievement of the competences defined. Ideally the curriculum should show how each competence is expected to be achieved, and how the learning in one grade is built upon on the next.
- Operationalization of the curriculum into concrete lesson plans, projects, teaching supports and meaningful activities underpinned by the type of learning approaches and platforms2 that will support the development of competences. These approaches are action-based and centered on identifying and building on what is of value to the learners, on local problem solving, and on dealing with complexity, beyond only increasing knowledge. Most importantly, the learning approaches must consider the interactions between individual and collective action (with their limitations), and on how such interactions are placed within the broader framework of food system influences.
- Planning and implementation of transversal elements, namely systemic capacity development, monitoring and evaluation. These are essential for the institutionalization, adaptability and continuous improvement of food education curricula.

See case studies in Annex:

- Harnessing technology and innovation: Food for Education, Kenya
- Changing food education in the UK: Taste Education (TastEd)
- BeanMeals

School food gardens: an opportunity to learn about food, health and the environment

Schools play a pivotal role in the holistic development of children and in combating malnutrition. They offer a deliberate and focused avenue for administering nutrition interventions to students, with indirect benefits extended to their immediate families and communities. School gardens have served as educational tools used in many countries, imparting knowledge to students and caregivers on agriculture, nutrition, and sustainability through education. It also offers additional education functions, helping children understand science, nature, and the environment. Furthermore, garden-based learning is recognized as a compelling approach to fostering healthy and sustainable dietary habits among children (Oro et al., 2018).

School gardens offer students various benefits, including a deeper comprehension of the agriculture and nutrition sectors, positive shifts in behavior and attitudes towards food, increased awareness of healthy eating and diets, preservation of agrobiodiversity, and enhanced understanding of the impacts of climate change on agriculture and food production, among other advantages (Hunter et al., 2020b). Indigenous varieties of vegetables are adapted to specific marginal soil and climatic conditions, and often can be grown with minimal external inputs (Durst & Bayasgalanbat, 2014). Local crops perform well under low-input conditions compared to commercially available crops produced under optimum conditions.

Highlighting the impact of school gardens to school meals, studies indicate that garden-based learning conducted in schools has exhibited a positive effect on the dietary inclinations of school children towards increased consumption of fruits and vegetables. A study, supported by the CGIAR FRESH initiative[16], mentioned that several gardening activities are being introduced in schools as part of agrobiodiversity conservation and to promote production and consumption of diverse traditional and indigenous fruits and vegetables among students and parents (Anunciado et al., 2023). Agrobiodiversity conservation in schools can provide students with knowledge on the importance of growing diverse, nutrient-dense traditional and indigenous fruits and vegetables to ensure food security and good nutrition. In the Philippines, lighthouse schools, in operation for more than 5 years, have effectively promoted diversified garden systems, conserved cultivars of traditional and locally adapted vegetables which enhance dietary diversity and consumption of nutrient-dense fruits and vegetables (IIRR 2023; see also case studies in Annex).

The Philippines, like many emerging economies in Southeast Asia, is in a "nutrition transition", which involves a downward trend in the consumption of fruits and vegetables and an increased consumption of meat, fats and oil, milk, and sugars (Popkin, 2001) Nutrition transition, together with intensive agriculture and environmental pressures, is also a result of reduced dietary diversity as well as loss in agrobiodiversity and associated traditional knowledge (Burlingame & Dernini, 2012)

Losses in agrobiodiversity and dietary diversity are leading to increasing rates of malnutrition among Filipino children. Obesity rate among school-aged children (5-10 years old) has increased over the years, from 9% in 2013 to 14% in 2021. The Philippines ranks 5th in the Asia-Pacific Region with a high prevalence of stunting (27% in 2021) (FNRI-DOST, 2022). Connections of children and communities to backyard gardening and family farming where agrobiodiversity has been traditionally practiced is being lost, knowledge of grandparents who relied on a diversity of plants and animals for food and nutrition is not being passed on to the new generation. Children and youth are not anymore familiar with the many nutritious vegetables, fruits, nuts and seeds available in the wild or in traditional systems (Luci-Atienza, 2021).

See case study in Annex:

- Pacific School Food Network
- School Gardens in the Philippines

16 https://www.cgiar.org/initiative/fruit-and-vegetables-for-sustainable-healthy-diets-fresh/

3. ESTIMATING THE IMPACT OF POLICY CHANGES TO EXTEND SCHOOL MEALS, IMPROVE MENUS AND REDUCE FOOD LOSS AND WASTE

3.1. Aims and methods

Here we assess the impacts that extending school meals programs could have on health and the environment in different countries. The health assessment integrates analyses of changes in the prevalence of undernourishment that could result from having an additional meal per day, especially in low-income countries, as well as changes in diet and weight-related risk factors that become important determinants of health in adulthood in all regions. The environmental assessment quantifies the environmental resource use and pollution associated with the provision of school meals, including food-related greenhouse gas emissions, freshwater use, and land use, and it analyses options to reduce their impacts such as changes in the composition of meals and reductions in food waste in school canteens. A detailed methodology is available in **Appendix 7.**

These modelling analyses utilize published and derived data where those were not available (such as detailed information on the composition of school meals). We are happy to work with countries to estimate the impact of these changes in their specific context and utilizing more detailed context specific sets of data.

3.2. Results

Health impacts

Increasing the coverage of school meals programs can have immediate impacts on the nutritional status of school children and, where undernourishment is a persistent problem, also on the associated households, e.g., by allowing foods distributed to other family members. We estimated that if school meals were provided in addition to current diets in at-risk regions, then energy intake at the population level could increase by 9% in low-income countries and 3% in middle-income countries (SI Table 2 in Appendix 7). This, in turn, would reduce the prevalence of undernourishment in low and middle-income countries by 25% on average (with range of 23-28% across specific income groups), and the number of undernourished people by about 120 million (**Figure 5**). At a country level, the relative reductions were largest for Senegal (-69%), Malaysia (-68%), Niger (-64%), Uganda (-61%), and Cambodia (-54%).

Providing school meals can have additional health impacts later in life. By forming preferences for healthy meals, school meals programs can contribute to reducing diet and weight-related risk factors and the associated non-communicable diseases (NCDs) in adulthood. Assuming dietary preferences are maintained, we estimated that 2.2-3.0 million annual deaths could be avoided in the original cohort of children, representing reductions in the total number of deaths in the school cohort of 12-16% (**Figure 6**, SI Table 3 in Appendix 7). reductions were greater for adherence to the relatively more comprehensive recommendations for healthy and sustainable diets (flexitarian, vegetarian, or vegan diets). Across regions, the reductions ranged from 8-12% in low-income countries to 16-20% in high-income countries where baseline diets are relatively more imbalanced and levels of overweight and obesity are higher. At a country level, the reductions were largest for Slovakia (54%), Lithuania (42%), Bulgaria (38%), Estonia (38%), and Poland (36%) for the example of meal compositions in line with healthy and sustainable flexitarian dietary patterns.

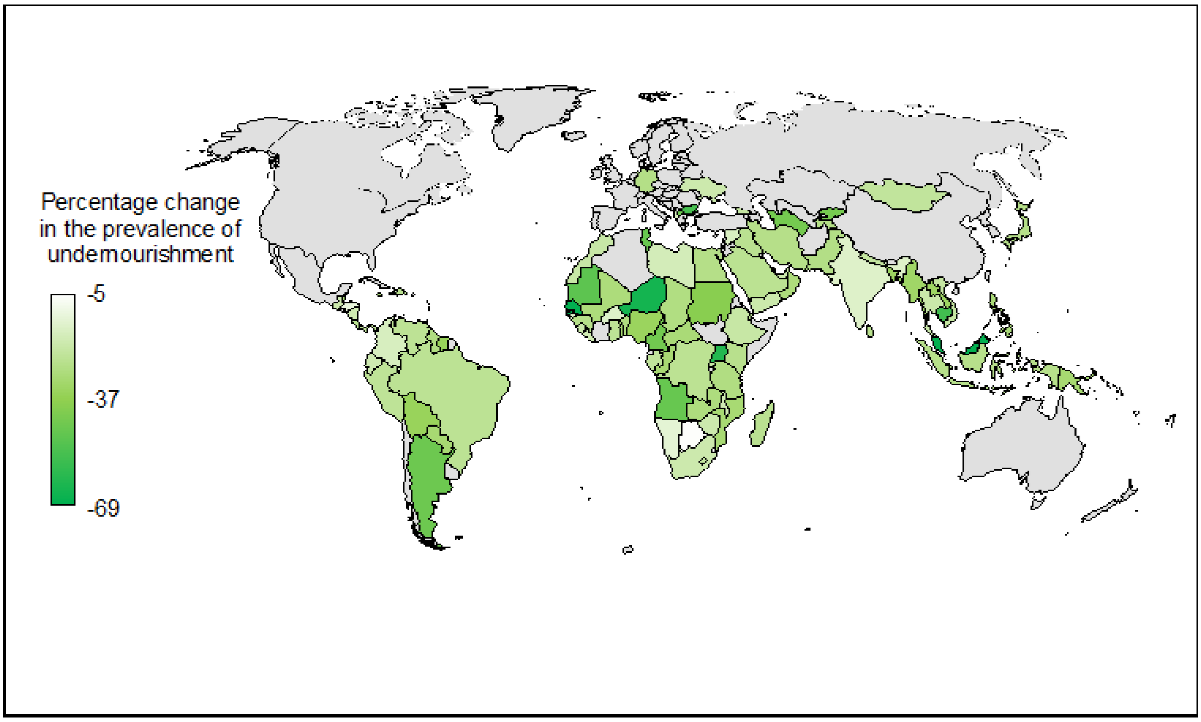

Figure 5: Changes in the prevalence of undernourishment (%) for meeting the School Meals Coalition pledge of providing every child with a meal at school by 2030. The analysis is independent of school meals composition.

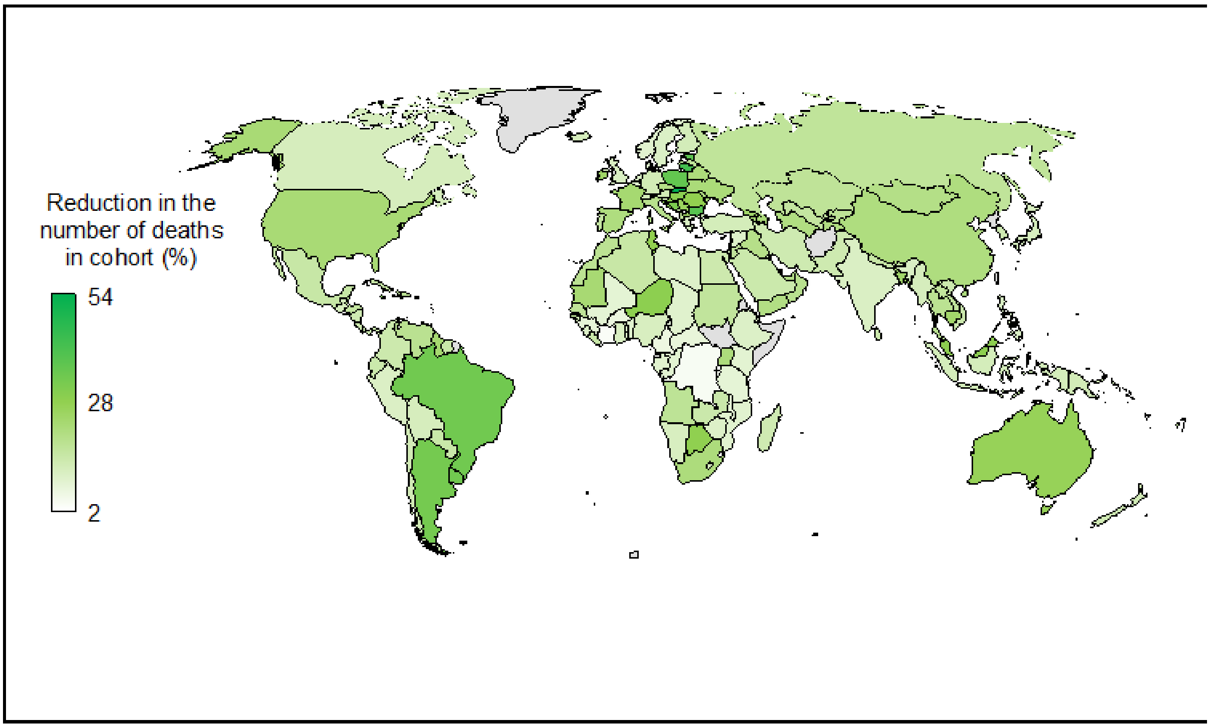

Figure 6: Reductions in the number of dietary and weight-related disease deaths as a proportion of all deaths within the cohort of former school children. The analysis assumed that dietary habits at school are proportionally maintained into adulthood.

Environmental impacts

Expanding school meals programs would increase the ratio of environmental resource use and pollution that can be addressed through changes in the composition and provision of school meals. According to our estimates (SI Table 4 in Appendix 7), universal coverage with school meals would triple the coverage of food-related environmental impacts, if a country's average diet was provided at school, from 1% in 2020 to 3-4% in 2030. This includes changes in GHG emissions (from 170 to 630 MtCO2eq), land use (from 550,000 to 2,600,000 km2), freshwater use (from 25 to 110 km3), and eutrophication potential (from 710 to 2,800 ktPO43eq). The increases in environmental impacts across the different environmental indicators ranged from factors of 3-4 in high-income and middle-income countries to factors of 16-27 in low-income countries.

Changes in meal composition and reductions of food waste can reduce the environmental resource use and pollution of school meals programs, either by reducing the demand for foods with high environmental impacts such as meat and dairy, or by reducing the overall demand for foods. We estimated (SI Table 5 in Appendix 7) that providing meals in line with recommendations for healthy and sustainable dietary patterns could reduce environmental impacts on average by 26% (12-42% across the environmental indicators) for flexitarian meals, 43% (18-62%) for vegetarian meals, and 52% (23-81%) for vegan meals, in each case with greatest reductions for land use, followed by GHG emissions, eutrophication potential, and freshwater use. The reduction potential was substantial in all income regions, including 33-55% across the dietary patterns in high-income countries and 19-47% in low-income countries. In contrast, providing meals in line with national or WHO guidelines – which often include less ambitious recommendations on limiting the consumption of foods with high environmental impacts such as meat and dairy – had little mitigation potential (-1% on average) and similar impacts as providing meals in line with a country's average diet.

Reducing the amount of food wasted in school meals programs can reduce the overall demand for foods and the associated environmental resource use and pollution. We estimated (SI Table 5 in Appendix 7) that halving food waste could reduce environmental impacts on average by 13% (10-14% across environmental indicators), with similar reductions across income regions. Combining reductions in food waste with changes in meal composition resulted in combined reductions of 13% on average for meals in line with national or WHO guidelines, and of 35-57% for meals in line with recommendations for healthy and sustainable dietary patterns, with greatest reductions for vegan meals, followed by vegetarian and flexitarian meals (**Figure 7**).

Discussion and conclusions

Refer to **Appendix 7** for a full discussion of the results. At present, only a minority of children benefit from school meals programs. Our analysis suggests that extending school meals coverage from currently one in five to all school-aged children by 2030, as envisaged by the School Meals Coalition's pledge, could be associated with substantial health and environmental benefits. For food-insecure populations, we estimated that the additional meals provided at school could reduce the prevalence of undernourishment by a quarter. By shaping dietary habits in the early years, healthy school meals could also help reduce dietary and weight-related risks in adulthood, which we estimated could prevent up to 3 million cases of non-communicable diseases per year in all countries. Finally, we estimated that the environmental impacts of school meals can be more than halved relative to meals following a country's average diet if they adhered to recommendations for diets that are both healthy and sustainable diets and food waste was reduced, thereby making important contributions to making food systems more sustainable.

Our analysis has important caveats we want to highlight. Those regard especially the assumptions we made in each component of the analysis (**Appendix 7**). Nevertheless, our analysis suggests that the health and environmental benefits of providing healthy and sustainable school meals to every child by 2030 are substantial.

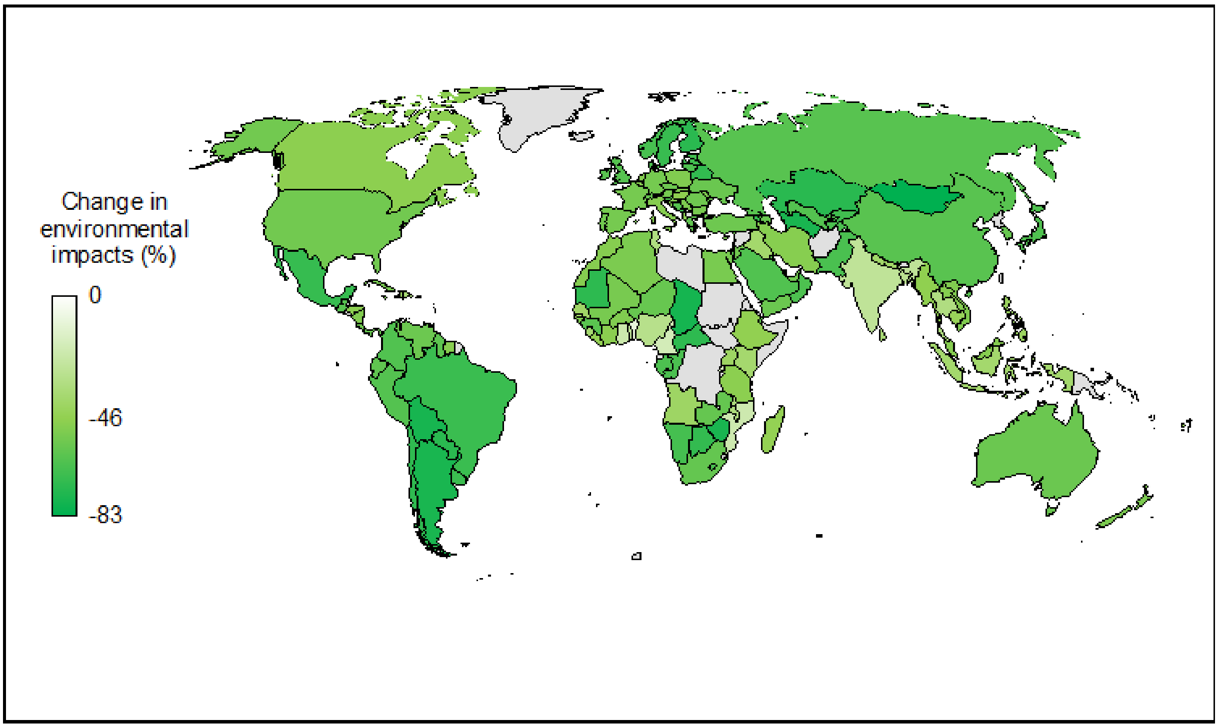

Figure 7: Percentage change in the average environmental impacts of halving food waste and providing healthy and sustainable school meals to every child of school age in 2030 compared to current waste levels and providing meals following a country's average diet.

4. THE POWER OF PROCUREMENT: LEVERAGING SCHOOL MEALS AS A TOOL TO STRENGTHEN LOCAL AGRICULTURE PRODUCTION, IMPROVE BIODIVERSITY AND FOSTER FOOD SOVEREIGNTY

In this chapter we highlight the demand-driven benefits that can be leveraged from well planned and implemented policy changes to national school meals programs and related public procurement strategies. By requiring school meals to be planet friendly as well as meeting children's nutritional needs, governments can create demand for more sustainably produced foods and act as catalysts for food systems transformation (Swensson et al., 2021). School meals typically represent 70% of a nation’s food that is under public control.

School food procurement thus has the power to promote a shift towards the adoption of sustainable farming practices that regenerate soil and ecosystem health, and promote biodiversity, and resilience. Local procurement from smallholder farmers when accompanied by adequate supporting measures can also contribute to boost local agricultural development, strengthen local food systems, stimulate crop diversity, and move people out of poverty.

4.1. The potential of school meals procurement in driving sustainable food systems transformation

School food procurement is part of a broader global approach to sustainable public food procurement, which is expressly recognized by the SDGs (Target 12.7) as a key instrument to promote more sustainable consumption and production patterns. It is a concept/instrument recognized by national and regional policies in both high- and low-income countries including for instance, the European Farm to Fork and Green Deal strategies, the African Union Malabo Declaration and the Climate Change and Resilient Development Strategy and Action Plan.

One key characteristic of school food procurement – and of sustainable public food procurement in general – is that it can be used to achieve different (social/economic/environmental) goals according to specific government priorities and contexts. This flexibility makes it a unique policy instrument that can, and is being, tailored and adapted to very different contexts and objectives, in both high, medium and low-income countries (FAO et al., 2021; Swensson et al., 2021). By changing the practices of school food procurement and creating a demand for planet-friendly food, governments have the power to set a positive trend. They can send a signal about their ambitions on the future directions of the food systems that has the power to incentivize those involved in the supply chain to align their values accordingly, accelerating a transition towards more sustainable food consumption and production patterns (Foodlinks, 2013; Tartanac et al., 2019).

School food procurement can target food that is produced in a specific way and use its purchasing power to support and promote forms of agricultural production that ensure environmental sustainability and agrobiodiversity. This includes, for instance, the purchase of food from organic, regenerative and agroecological production. School meals programs can also target food that is produced locally by smallholder farmers and small and medium enterprises (SMEs), becoming an instrument to support the local agricultural production, to trigger production diversification, and to stimulate community economic development (FAO & WFP, 2018). Several studies demonstrate that public institutions’ regular and predictable demand for smallholder farmers' products can encourage, facilitate and reduce the risk of investments by farmers to increase and also diversify their agriculture production, contributing to crop diversification and related biodiversity gains, as well as to increased smallholder producers incomes (Drake et al., 2016; FAO & WFP, 2018; Kelly & Swensson, 2017; Singh, 2021). Linking school food procurement to the local and smallholder agriculture production can also contribute to strengthen local and regional food systems, and to the valorization of traditional, seasonal, and climate-resilient food.

These approaches address various sustainability benefits, including reduced CHG emission, dependency on pesticides and chemicals, lower dependency from fossil fuels, enhanced air quality, and the establishment of resilient regional food systems.

The potential of school food procurement to achieve various sustainability outcomes is present in both low- and high-income countries, although the focus may change according to the context. In particular, in high-income countries there is a longer traditional to use public food procurement to achieve environmental outcomes, while in low- and medium-income countries, the focus has been traditionally on social ones (UNEP, 2022; Swensson et al., 2021). Nevertheless, this has been changing considerably, with the great recognition of the importance and potential of school food procurement to contribute to environmental outcomes also in low- and medium-income countries. One example is the African Union Climate Change and Resilient Development Strategy and Action Plan (2022-2032) that identifies 'enhancing the role and influence of public procurement in food purchasing to support diverse and nutritious diets for example home-grown school feeding' as a priority intervention and action area (African Union, 2022). Similarly, there an increasing integration of social considerations, including linkages with the local territory and smallholder food producers, also in high income programs, within a more holistic approach.

At the national level, more than 80% of the countries surveyed in the I-CAN report (I-CAN & GAIN, 2020) factored climate into food procurement decisions for food in public settings at the lowest level of integration, but only 3% of countries reached the highest level of commitment. Regionally, Western and Northern European countries, in particular Scandinavian countries, had the most in-depth levels of climate considerations in their procurement strategies. Many municipalities across Europe have adopted sustainable school food procurement strategies. Nordic cities such Copenhagen and Malmo have long-standing commitments to sustainable food procurement, with high shares of organic and seasonal foods. In Italy and France, many municipalities offer sustainable and healthy school meals with a share of 30-100% organic foods, seasonal and fairtrade products and sustainably sourced aquatic foods (FAO et al., 2021). In Italy, since 2020 the legislation imposes minimum environmental criteria for public food procurement for catering services, including the linkages with the territory (Decree 10 March 2020). Strategies such as subdividing tenders, collaborating with regional organic networks, and implementing Dynamic Purchasing Systems have been adopted to amplify the integration of locally sourced and organically produced food in schools.

Across Europe, there is an increasing desire to find a balance between fair competition and fair food systems. EU non-discrimination procurement rules across the single market conflict with widespread view that local/regional food purchases contribute to climate resilience and protection, food security, waste reduction and support for the regional culture and economy (EU FPC, 2021). It also conflicts with existing initiatives, such as the school fruit, vegetables and milk scheme which supports fruit, vegetables and milk distribution to schools across the EU and explicitly mentions that "EU countries may encourage local, short supply chain, organic and quality scheme products if they wish"[17].

There is also a growing recognition that local, and smallholder (or family) farmers could play an important role in the transition to just and sustainable food systems (Santacoloma & Zárate, 2021). Many Latin American and Caribbean countries have adopted public food procurement from family farming strategies as powerful policy instruments to enable food systems transformation.

17 School fruit, vegetables and milk scheme (europa.eu)

Examples of this approach are the school feeding public programs in Colombia, Guatemala, Honduras, Paraguay, and Peru, the procurement system in Uruguay, and the Brazilian National School Feeding Program (FAO, 2017; FAO, 2021; Soares et al., 2021; WFP and IDB, 2023). In Brazil, at least 30% of the food purchased through PNAE with federal funds must be bought directly from family farmers, prioritizing purchase from settlers of the agrarian reform, quilombolas and indigenous communities. These programs also give priority and provide a price premium for foods produced through organic or agroecological production practices.

Sourcing from local farmers can enhance diet diversity. For example, according to an analysis performed by the GFNS of the relationship between food sourcing and food basket diversity, food programs that rely on foreign donations serve fewer food categories (an average of 5.9) compared to those that rely on domestic markets/production (an average of 7.1) (GCNF, 2022a).

Building the link between school meals and the local and smallholder agriculture production is also at the core of the concept of Home-Grown school feeding, which is defined as school feeding programs designed to provide children in schools with safe, diverse and nutritious food sourced locally from smallholders (FAO and WFP, 2018). Although this model is implemented mainly on low- and medium-income countries, the linkage with the territory and with small scale food producers, including farmers and SMEs, is being increasing recognized also in high-income countries, as demonstrated in the example of some European cities.

One key aspect and common denominator of all these experiences is that the sole creation of the demand through the school meals programs is not enough to achieve all these potentials. Planet-friendly approaches for school meals programs must be supported by adequate and integrated policies and regulatory that sets the policy objectives and provide adequate instruments for implementation (Swensson & Tartanac, 2020); capacity building of implementers (i.e. procurement officers) to be fully aware and able to translate the policy objectives into practice through the procurement process; and support to farmers and SMEs to allow them to upgrade and respond to the new planet-friendly school food demand. Indeed, as assessed by FAO, school food procurement can even be detrimental for smallholder producers if not accompanied by adequate support measures (Prifti et al., 2021). These may include measures to support smallholder producers to increase, adapt and diversify its production based on environmentally friendly production practices as well as to organize themselves collectively and participate in public food procurement process. In this sense, school meals programs – and specially those characterized by HGSF approach – can constitute a great platform and entry point to support farmers in this process.

The

See case studies in Annex:

- Healthy and sustainable food procurement for the Brazilian National School Feeding Program
- Transforming Ghana's Food Processors into Catalysts for Change
- Promotion of minor millets in schools and public procurement in India.
- Examples of successful procurement models in Europe
- Strength2Food Research Project
- Planet-friendly School Meals provided by the City of Malmö
- Engaging students to the development of sustainable school meals in Finland
- Seoul, Soth Korea: planet -friendly free school meals

4.2. Home Grown School Feeding (HGSF) approach: linking school food demand to the local and smallholder agriculture production resilient production, climate smart agriculture

Home-Grown School Feeding (HGSF) evolved in the early 2000s as the Millennium Development Project, the African Union, the World Food Program and others realized that by structuring the large-scale and predictable purchasing of food to intentionally support smallholder farmers, school feeding programs could contribute to improving rural household livelihoods and the agricultural system more broadly (NEPAD, 2022; World Bank 2012). It provides an important framework for cross-cutting action for transforming food systems to improve child and adolescent health, whilst contributing to achieving global climate and biodiversity goals (Hunter et al., 2022a). Indeed, this is being recognized at a policy and strategy level, for example the African Union Climate Change and Resilient Development Strategy and Action Plan (2022-2032) as mentioned above (African Union, 2022).

Households, local smallholder farmers and food producers can benefit from the guaranteed demand from school markets, while school children benefit through more diverse diets that include culturally appropriate and nutrient-rich foods. HGSF offers the opportunity also to create a demand for indigenous foods. These foods can encompass a broad range of agrobiodiversity, e.g., the diversity of African leafy vegetables which in addition to the nutritional and cultural value are considered climate-resilient crops (Borelli et al., 2021) (See section 2.1).

It can also facilitate the identification and integration of more local climate-resilient agrobiodiversity in school meals including drought-resistant crops, e.g. millets (Satyavathi et al., 2021), or flood-tolerant crops, e.g. rice (Panda & Barik, 2021), as local conditions require, or which add nitrogen to the soil, e.g., legumes (Kebede, 2021) or otherwise interact positively with the local growing conditions, weather, and environmental situation. The emphasis on local food purchases also generally involves shorter supply chains to help reduce transport emissions.

There are also additional positive multiplier effects that can be achieved along the HGSF value chain, e.g., local catering businesses, many led by women, traders and transporters and rural small and medium rural enterprises (SMEs) who can achieve higher incomes (FAO & WFP 2018).

For HGSF approaches to work well procurement directly from individual smallholder farmers is often impractical and is most effectively addressed through farmer organizations or cooperatives (WFP 2014). This helps overcome the barriers to market entry that often face smallholders by facilitating aggregation of small quantities of food, access to services such as inputs, credit and transport, while reducing transaction costs and enhancing bargaining power and capacity to negotiate contracts and tenders. Farmer organizations and cooperatives also provide effective platforms to deliver technical support and training and improve management, organizational, marketing and entrepreneurial skills. Using farmer field schools and business schools in this context can enable smallholders to improve their technical knowledge and business management skills (FAO & Procasur, 2021). For example an adapted farmer business school approach was recently used in Kenya to strengthen farmer organization, negotiation, entrepreneurial and market skills while also delivering agroecology training to produce more crop agrobiodiversity for school meals, which also included addressing limited knowledge of the nutritional value of climate-resilient African indigenous vegetables and their post-harvest handling, quality and food safety and long-term biodiversity conservation (Borelli et al., 2021)

Acknowledging the need for more climate change responsive approaches to school feeding (FAO & WFP, 2018; WFP, 2022) and finding ways for school procurement and menus to emphasize more climate-resilient foods (GCNF, 2021; Gelli & Aurino, 2021; Singh & Conway, 2021) makes HGSF platforms a strategic entry point for a stronger climate resilience component in school feeding especially when integrated with national climate actions and other national agricultural support efforts linked to nutrition-sensitive agriculture that better harness the use of agrobiodiversity (Singh, 2021). Such HGSF platforms could promote innovation and behavior change concerning climate-sensitive agriculture, influencing how smallholders and communities and other actors along the HGSF value chain respond and adapt to climate change. For example, incorporating experiences and lessons learned from the past work of the CGIAR and partners in co-designing innovation platforms such as Climate-Smart Villages and Local Technical Agro-Climatic Committees could make HGSF platforms a focus for climate action and scaling up adaptation options in agriculture supporting the production of climate-resilient foods (Aggarwal et al., 2018; Andrieu et al., 2019; Loboguerrero-Rodriguez et al., 2018; Osorio-Garcia et al., 2019). Including climate-smart agricultural value chain approaches would broaden the focus to target other value chain actors, including SMEs, and create awareness of the impacts of climate change along the different stages of the HGSF value chain and reveal additional opportunities for adaptation (Mwongera et al., 2019). Better linking to climate services including climate forecasting, tailored agro-advisory services and innovative insurance would further underpin HGSF with more climate-resilient farmer organizations, cooperatives and SMEs, bankable and investible when it comes to school food provision.

In addition to smallholder farmers and producers, it is equally important to identify and support social entrepreneurs and micro, small and medium enterprises (MSMEs) as key change-makers in the school food systems transformation and not simply as operators in the value chain (Kane-Potaka et al., 2022). It is often these actors, sometimes referred to as the 'hidden middle', who are the pioneers in influencing consumer preferences and they need as much attention, capacity building and policy support as farmers when it comes to handling and delivering a wider range of agrobiodiversity to consumers. Unless they are equally involved and supported, climate resilient, nutrient rich agrobiodiversity is unlikely to be widely available, affordable, accessible and demanded by schools and other consumers.

Diversifying public food procurement and value chains also often requires novel infrastructure to handle and deliver more agrobiodiversity reliably and successfully. The lack of such infrastructure for smallholder farmer production or community-based food systems – termed the 'infrastructure in the middle' – is often limited or missing unlike in more vertically-integrated commodity markets or direct markets. This 'infrastructure in the middle' can be defined as resources, facilities and machinery and networks and is central to creating a critical mass and enabling alternative food producers to address the requirements of public institutions (Stahlbrand, 2021). It is also crucial for this infrastructure to be powered by low carbon energy sources.

See case studies in Annex:

- Linking farmers and schools to improve diets and nutrition in Busia county, Kenya
- Home grown school feeding in Armenia
- Pacific School Food Network

4.3. Agrobiodiversity and biodiversity

We currently rely on 12 plant and animal species for approximately 75% of our food needs, at the expense of many traditional crops and livestock, local varieties and breeds, and associated indigenous knowledge. Fewer plant varieties are being cultivated and fewer breeds raised, whilst large-scale trade and the market dynamics are driving less diverse, less healthy diets and more highly processed foods. This is accelerating poor nutrition and public health costs as well as environmental and climate change impacts. These diet transitions are themselves indirect drivers of food biodiversity loss, as they are decreasing global demand for traditional crops and livestock as well as local varieties and breeds (IPBES Global Assessment Report on Biodiversity, Diaz et al., 2019).

The State of the World's Biodiversity for Food and Agriculture report (FAO, 2019c), the first global assessment of biodiversity for food and agriculture worldwide, warns that, despite the growing evidence of biodiversity's key role in food security and nutrition, the diversity of production systems worldwide is in decline. Of the thousands of plant species cultivated for food, fewer than 200 contribute substantially to global food output and only nine account for 66% of total crop production.

Food biodiversity or agrobiodiversity (the global wealth of plants, animals and other organisms used for food, both cultivated and from the wild) is a critical resource for food systems transformation and climate resilience (Bioversity International, 2017). Typically, rich in nutrients and adapted to local ecosystems, this biodiversity has been utilized by humanity throughout history, but is largely disregarded by our current agriculture and food systems.

Climate change will likely reduce crop yields and animal productivity (Bioversity International, 2017), with the risk being greatest for the world's most vulnerable and marginal populations. Rising carbon levels and temperatures in certain geographical regions may lead to certain crops not being cultivated in the future (FAO, 2017), and reduced levels of protein, iron, zinc and other micronutrients in certain grains and legumes (FAO, 2017; Myers et al., 2014).

The Intergovernmental Panel on Climate Change (IPCC) Special Report on Climate Change and Land (IPCC 2019), clearly articulates the need to change the types of food we grow and raise, the way in which we grow it and what we eat. One of the clear messages from that report is that a better future is within our reach if we transform food production and delivery to be more diversified, that improves soil health and is biodiversity and environmentally friendly. Among the key urgent actions highlighted by the IPCC's Special Report are:

- Diversifying what we put on our plates to send a clear market signal that translates to more diversity of crops on the land:
- Diversifying what we grow and produce through our food systems, including a shift to more biodiversity-friendly approaches, such as regenerative and agroforestry practices, that enrich soils and soil biodiversity as well as agricultural landscapes
- Diversifying the types and sources of foods in public procurement programs to help realize multiple benefits across all spheres of the environment, economy and society:

The Biodiversity for Food and Nutrition (BFN) in Brazil is one example of an innovative way countries, considered biodiversity hotspots, were able to better harness and use their agrobiodiversity by prioritizing nutrient-rich, climate-resilient food crops and species (Hunter et al., 2020a, also see case study in the Annex).

See case studies in Annex:

- Promoting native and underutilized food: the Biodiversity for Food and Nutrition project in Brazil
- Native and underutilized foods in Nepal
- Fostering Nutritional Diversity in Zambian School Meals through Traditional Foods
- The role of diversity and locally available fruit trees in school gardens
- The Agrobiodiversity Index - A tool to monitor agrobiodiversity in school feeding programs

4.4. Food sovereignty

Over the last two decades a significant body of work on food sovereignty has evolved along several different disciplinary and ideological axes to create a compelling and increasingly influential narrative (Godek, 2021; Zimmerer et al., 2020). Food sovereignty began as a farmer and peasant led movement as a counter to increasingly globalized neoliberal agri-food networks. Its present form is primarily attributed to a politically transformative peasant movement, La Via Campesina (LVC) that began in South America in 1980s. The primary objective of all food sovereignty movements is to create socially and ecologically equitable and healthy food systems that are also resilient and sustainable. This definition and concept of food sovereignty evolved over time, from the right of self-reliance of nations (1996), to the rights of people to define domestic production and trade (2002) to the current definition which was formalized in the Nyéléni Declaration of 2007 in Mali, as the right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems. Fifteen countries have laws to implement food sovereignty and it is included in the national constitution of seven countries namely Bolivia, Venezuela, Ecuador, Nicaragua, Mali, Senegal, and Nepal.

Food sovereignty interventions can help in both climate change adaptation and mitigation through multiple pathways related to food production, supply chains, dietary habits, farm technologies etc. Home Grown School Feeding programs can contribute' to enabling food sovereignty through four components.

- Indigenous knowledge and farming systems – Indigenous or traditional farming practices and systems refer to a range of production systems and practices specific to particular geographic regions as well as applying methods developed over generations which are best suited to local ecologies and cultures. Indigenous systems also represent an important link with crops that are culturally accepted and well suited to local agroecological conditions and dietary practices.
- Agroecology – The definition and understanding of agroecology in the context of food sovereignty is seen as a set of principles and practices that can be applied at the field, farm and whole food systems scale (Bezner Kerr et al., 2021). Agroecological practices seek to enhance efficiencies of ecological processes and minimize social-ecological costs from agriculture such as soil degradation, water contamination, greenhouse gas emissions and inequitable social structures.

- Localization – Enabling local food systems in terms of scale and power distribution is a core element of food sovereignty.
- Small farm systems – A core component of food sovereignty in practice is the supporting of small farm systems which are reservoirs of agrobiodiversity and associated indigenous knowledge, and as a source of livelihoods for millions of households in the poorest parts of the world.

The IPCC Special Report on Climate Change and Land (IPCC, 2019) also acknowledges the importance of Indigenous peoples and their traditional knowledge as custodians of biodiversity and as stewards of territories and lands: Agricultural practices that include indigenous and local knowledge can contribute to overcoming the combined challenges of climate change, food security, biodiversity conservation, and combatting desertification and land degradation (IPCC, 2019). Indigenous Peoples often reside in areas rich in biodiversity and possess knowledge preserved for generations. Indigenous peoples' food systems are also rich in biodiversity and practices that provide important insights on sustainability and resilience from the front line of climate change. They can be leveraged to provide culturally appropriate foods to improve diets through interventions that aim to identify nutritionally rich traditional foods that promote, mobilize and deliver these foods to target populations, ensuring the benefits are shared with indigenous communities (Hunter et al., 2020a). Not only do these food-based approaches potentially improve nutrition and health in a sustainable manner, they also revive traditional knowledge, biocultural heritage, contribute to the conservation of biodiversity, and ultimately strengthen food sovereignty (FAO & Procasur. 2021; Kuhnlein et al., 2009).

4.5. The Water food nexus: Ensuring access to clean water in a time of increasing water scarcity

Freshwater resources underlie several human activities, including domestic, industrial, energy production and agricultural use. Agriculture, primarily food production, accounts for the largest share of global freshwater use that is the 70- 80% of total water consumption (UN-Water, 2021; D'Odorico et al., 2018; Mekonnen and Hoekstra, 2012). Food production is heavily dependent on water resources, as water is a critical component in various stages of the agricultural and food processing supply chain. All food production requires water, it can be used directly as in the case of plant food production or indirectly as in the case of animal-derived food production. In the latter case the water is used directly for the production of animal food (feed) (D'Odorico et al., 2018). The goal of food security cannot ignore the understanding of the link between food production and water availability. Unregulated human activities including poor water management and the excessive withdrawal and contamination of freshwater and groundwater sources have led to water scarcity and deterioration of water ecosystems This, in turn, affects human health, economic activities, and food and energy supply (UN, 2022; Caretta et al., 2022). Climate change is further impacting water in multiple ways: from disrupting precipitation patterns to melting ice sheets, to increasing floods and drought and rising sea levels (UN Water, 2020). Climate change and environmental degradation will also impact water quality by increasing water pollution in the form of sediments, pathogens and pesticides from floods, heat and industry (Bates et al., 2008). Guaranteeing water resources is therefore one of the challenges of our century. Currently, about two billion people globally lack access to safe drinking water (UN, 2022) and this is predicted to worsen with climate change and population growth. About 1 in 3 primary schools lacks basic sanitation and water access. Lack of access to drinking water, sanitation and hygiene (WASH) services in schools affects student health by increasing risk of infection and diarrhea, dignity, particularly for girls, and student learning and attendance (UNICEF, 2022). The inclusion of SDG WASH in school (targets 4.a, 6.1, 6.2) represents a key step in raising awareness and commitment to WASH services. Improving water use will not only help food security and protect health and the environment; it will also promote a just access to clean energy, build water smart cities and resilient economies and help achieve the SDGs.

In the face of these global challenges, understanding the connection between water and food therefore becomes fundamental to improve sustainable management of the agricultural system, aimed at preserving the natural resources of our ecosystem and in turn sustainable food security (D'Odorico et al., 2018). A comprehensive community development strategy can be implemented to improve overall well-being by addressing issues related to water, food production, food security, school meals, and school interventions. These communities can provide students with access to clean water, a healthy diet, and an education—all of which are critical for their development and future prospects.

5. POLICY ACTIONS

Turning policy into action

There are two areas for action:

1. Policy changes to national school meals programs

- Nutrient rich diverse menus:
  - Establish context-specific, evidence-informed national nutrition and food standards for school meals that adequately integrate sustainability considerations.
  - Shift to nutrient rich, climate resilient, and culturally relevant foods, ensuring a diverse school diet including whole grains, legumes, fruits, and vegetables and small amounts of low impact animal foods, such as sustainable aquatic foods: there is a particular role here for menu planning tools which address crops which are indigenous, local, planet- and climate-friendly.
  - Support and engage with Micro, Small and Medium Enterprises (MSMEs) and other value chain actors to be able to better handle this diversity of food and ensure delivery in terms of quantity and quality.
  - Reduce meat, especially ruminant, where this is overconsumed, with the goal of shifting to predominantly plant-based diets. Our analyses show, for the first time for school-age children and adolescents, that relatively modest changes to standard school menus (a flexitarian diet) can reduce environmental impacts by 26% (and by 43% with a vegetarian diet). These changes need to be context specific and take into account the interdependence across global regions, with stronger imperative for reduction in meat on school menus in, for instance Europe and North America, while recognizing the desirability of more animal proteins for child nutrition in other regions of the world.
  - Use planning and monitoring tools to ensure nutrition and environmental targets are planned for and met.
  - Integrate sustainability aspects to the vocational training of chefs and kitchen personnel and invest in teaching planet-friendly recipes and cooking. Secure resources for further training and capacity building of chefs and kitchen staff responsible for school meals provisioning.
- Clean efficient energy for cooking:
  - Ensure access to energy efficient, cooking solutions, with the goal of moving to modern energy cooking (MEC) services powered by renewable energy; in low-income settings, a switch from open fires to electric cookers can significantly reduce pollution with additional benefits for the health of the cooks and reduced deforestation.
- Minimal waste:
  - Prevent food loss by using methods such as better storage, cooling and preserving methods, and ecological pest control.
  - Reduce food waste at all stages, using monitoring and planning tools to control orders and portion size, and raise awareness among students to help take only what they will eat: halving food waste could reduce environmental impacts by 13%. It can also reduce costs and potentially reduce overweight and obesity.

- Adopt planet -friendly methods of disposing of food waste, such as share tables to redistribute surplus food to hungry students first and foremost, and then composting or food recycling for any foods that can't be rescued.
- Reduce package and plastic waste by using the Zero Waste Hierarchy, "refuse, rethink, redesign" and limiting packaged processed foods. Packaging, mostly for food and drink, accounts for 40% of global plastic waste, with enormous environmental damage, resource waste and potentially detrimental health impacts

- <u>Food systems education</u>:
  - Ensure that holistic food education is institutionalized in national school systems, designed with an action-oriented focus and implemented with regularity and available to all grades. Prioritize real-life and practical activities such as having students participate in food waste audits, farm visits, cooking produce from school gardens, taste sessions, and waste awareness.
  - Make mealtimes an integral part of the educational experience, as in for examples, Finland and Japan
  - Adopt whole school food approaches to help children and young people develop a new understanding of healthy and sustainable food environments and the role of food in their development.
  - Make the interconnectedness of food systems, climate change and environmental impacts part of the national curriculum to ensure a future generation is better prepared to make planet-friendly decisions.
  - Strengthen food education and sustainability aspects in the education of teachers.

2. Policy changes to promote sustainable farming practices and transform food systems.

- Recognize the potential of school food procurement as an entry point for local food systems transformation at policy level and promote policy coherency, including among nutrition, environmental, agriculture and public procurement.
- Include climate and other environmental and social considerations in policies, recommendations and procurement rules guiding school meals provisioning at national, regional, and local levels.
- Ensure that the public procurement regulatory framework is aligned with the school meals sustainability objectives and provide the necessary instruments to support its implementation.
- Actively promote and formally give preference to agricultural production systems that ensure environmental sustainability and agrobiodiversity, such as such as regenerative or organic farming, agroecology and agroforestry (all defined within the local context) to source school meals ingredients.
- Where possible, prioritize and/or set specific targets for local procurement from smallholder farmers.

- Support and capacity building of farmers and their organization to respond to planet friendly school meals’s demand, including measures to support local smallholder farmers to increase, adapt and diversify its production based on environmentally friendly production practices as well as to organize themselves collectively and participate in public food procurement processes.

Evidence gaps and research priorities

In the preparation of this document several areas of uncertainties and knowledge gaps have emerged. These include a lack of context-specific, good quality and comparable individual dietary intake data of school children and adolescents; and lack of food composition and environmental footprint data of locally available foods in multiple global regions.

Data on food loss and waste is also scarce, especially at school level where resources are limited. Availability of locally relevant, accurate, reliable and up to date measures of children's dietary intake, nutrient availability and environmental impacts of diets is key in planning and developing school food guidance and policies.

Indigenous and neglected and underutilized crops which are key for agrobiodiversity and biodiversity goals, represent a large, diverse group of food species which globally receive little attention in research and development and remain marginalized in the food system. Most research over the last few decades highlights disconnected projects contributing to divisions in the community, confusion around terminology, scattered knowledge and data often not in readily useable formats. This results in piecemeal data collection for national statistics on production and consumption and makes assessing metrics and indicators difficult. To date there is no universal database or knowledge hub addressing both climate action and nutrition, which might be a gamechanger for NUS. The challenge is how relevant existing data can be consolidated and in identifying gaps and connection points where the NUS, climate, and nutrition communities can effectively come together on this.

There are important knowledge gaps related to sustainable school food procurement. There are very few data about the number of countries recognizing this at policy level, information about key barriers for implementation from both the demand and the supply sides as well as on effective impacts.

Knowledge gaps in respect to sustainable agriculture and food production are also a significant barrier to implementation, partly because of the numerous tradeoffs that need to be taken into consideration in systemic changes. Multiple stakeholders need to be included to address challenges and opportunities across different dimensions of sustainability, including health, environmental, economic, social, political dimensions. Another area of knowledge gap is estimating the costs of implementing school meals policies. In planning cost-efficient school meals programs, governments should take into consideration not only the immediate budget of implementing these programs, but also the future saved costs as human capital is enhanced. Furthermore, there is a need to build appropriate value and metric systems that account for natural capital value and integrate this into decision making processes.

ANNEX:
Case studies

LONDON SCHOOL of HYGIENE & TROPICAL MEDICINE

Research Consortium for SHN

6. ANNEX: CASE STUDIES

The School Menu Planning Tool: SMP PLUS

Partnership for Child Development (PCD), Imperial College London has been implementing a comprehensive Menu Planning Approach for school feeding since 2008. As part of this approach, PCD developed a menu planning software called 'School Menu Planning Tool (SMPT). SMPT is an easy to use, free open access software with an online and offline version. It was first piloted in Ghana in 2012 and used to design meals for the national program. It provided costed menus using national food composition tables and pricing data. SMPT has been used by national school feeding programs in Nigeria, Zanzibar, Nepal, Mali, Madagascar, and Kenya.

In 2020, WFP, PCD and AUDA came together to develop and test a joint meal planning tool with new features including a nutrition and cost optimization function. It also provides users with options for menu management and integration of communities into the menu design process.

The new tool called SMP PLUS was launched in 2021 and has since been applied in several countries.

Given the increasing recognition of school feeding as a platform for food systems transformation, there is a need to develop a meal development approach with specific food systems engagement pathways including gender, carbon footprint, water use, climate change adaptation. The development of a new tool to reflect this approach is being led by the Diet & Food Systems Community of Practice of the Research Consortium. The first version of the proposed tool will provide outputs on nutrition, food diversity, costs, carbon footprint and water usage. It will also include features to highlight neglected and underutilized species including local landraces. The tool will be informed by the findings of this white paper.

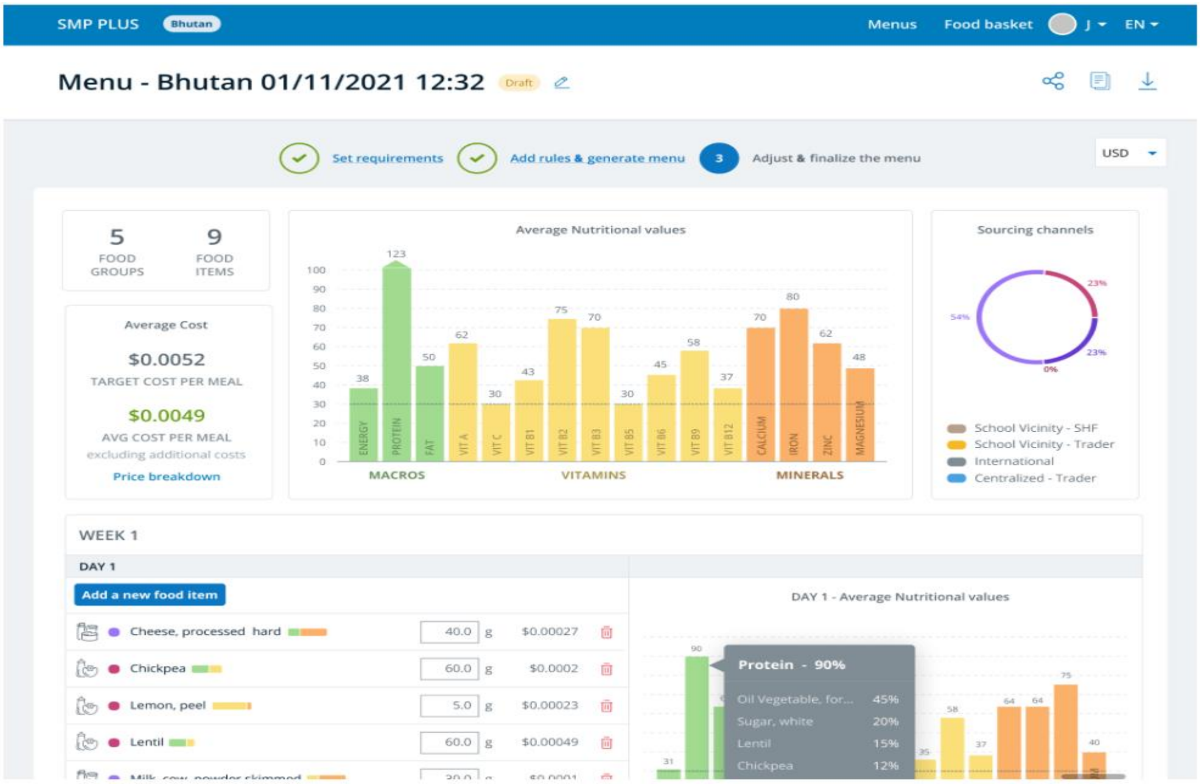

Figure 8: Example of the SMP Plus interface

Healthy and sustainable food procurement for the Brazilian National School Feeding Program

In 2009, an innovative law was enacted that requires 30% of the national transfers to local and state governments must be used to procure foods to the Brazilian National School Feeding Program (PNAE) directly from family farmers (Hawkes et al., 2016). To remove known barriers from family farmers to access public procurement programs (Lozano et al., 2016), the 2009 PNAE law innovated by dropping the requirement for public biding for procurement directly from family farmers (Coutinho et al., 2022) Such innovation inspired countries in Africa and Central America (Sidaner et al., 2013).

But innovations to the program did not stop there. In May 2020, a new requirement for food procurement was enacted, mandating local and state governments to devote no more than 20% of the national transfers for the school feeding program to procure processed foods and ultra-processed foods (UPFs); 75% of these national transfers must be used to procure unprocessed and minimally processed foods and 5% to procure culinary ingredients such as salt, oil, and sugar to prepare freshly prepared meals (Canella et al., 2022). These new requirements further aligned PNAE with the Brazilian Food-Based Dietary Guidelines, which combine cultural aspects of food and the environmental, economic, and social sustainability of dietary patterns (Monteiro et al., 2015)

Although still in its early implementation phase due to delays caused by the COVID Pandemic when schools were closed in Brazil for more than 12 months (Colón-Ramos et al., 2022) restrictions to processed and ultra-processed foods in school meals across the country are promising. Using microdata from food procurement of locally run public schools in all 5,570 Brazilian municipalities in 2019 (Duran et al., 2023) have found that 40% of the Brazilian municipalities were ready to meet the new procurement restrictions before they were enacted, as well as overall reductions in the share of the national funds used to procure UPFs between 2015 and 2019.

These early findings suggest that complying with the new requirements is not only feasible but is already a reality in Brazilian schools. Considering the growing evidence that links UPFs to increased risk of weight gain (Hall et al., 2019), diabetes (Chen et al., 2023), cancer (Kliemann et al., 2023), and cardiovascular and all-cause mortality (Zhao et al., 2023) , among many other health outcomes, as well as greater environmental impact (Prescott et al., 2023; Seferidi et al., 2020), Brazil is ready to set the stage again by concomitantly protecting students from UPFs and promoting more sustainable school meals.

The new Nordic nutrition recommendations

The new Nordic nutrition recommendations, released in 2023 (NNR, 2023), integrate environmental aspects to the food based dietary guidelines. The guidelines underline the mutual health and environmental benefits gained from moving towards more plant- and fish-based diets. At the population level, and for most individuals, the NNR2023 recommends an increased intake of vegetables, fruits, berries, pulses, potatoes, whole grains, nuts and seeds, and fish, and reduced intake of red and processed meat, and foods containing high amounts of added fats, salt and sugar, and alcohol (**Table 1**). Refined cereals should be replaced by whole grain products, butter and butter-based spreads should be replaced by vegetable oils and vegetable oil-based fat spreads, while high fat dairy should be replaced by low-fat dairy. Red meat and processed meat consumption should be reduced in favor of plant foods, such as legumes, and fish from sustainably managed stocks.

The general guidelines concerning consumption of the food groups cereals, vegetables, fruits, berries, nuts and seeds, red meat, eggs, fats and oils, sweets and alcohol are supported both by their effects on health outcomes and their environmental footprint. The recommendations to increase consumption of potatoes and legumes, and to reduce white meat (poultry), are mainly based on their environmental footprints. For fish, the health-based advice for increased consumption should be primarily from sustainably managed stocks. For milk and dairy, a moderate intake is suggested which may be in conflict with the environmental impact.

The Nordic nutrition recommendations give science advice on health and environmental effects of food for the national authorities in the 8 Nordic and Baltic countries. Certain country-specific aspects, including public health challenges, food consumption patterns, food availability, sociocultural and socioeconomic aspects, need to be also considered when translating the NNR to national FBDGs.

Table 1: Dietary changes that promote a healthy and environmental-friendly diet in Nordic and Baltic populations (Blomhoff et al., 2023, p.98)

Increase	Exchange	Limit
Vegetables	Refined cereals → whole grain products	Processed meat Red meat
Fruits and berries	Butter and butter-based spreads → vegetable oils, vegetable oil-based spreads	Sugar-sweetened beverages
Pulses	High-fat dairy → low-fat dairy	Processed foods with high amounts of added fats, salt and sugar
Potatoes	Processed foods with high amounts of added fats, salt and sugar → whole foods and varieties containing low amounts	Alcohol
Whole grains		
Nuts		
Fish		

Seoul, Soth Korea: planet -friendly free school meals.

The Seoul Metropolitan Government has successfully developed a food procurement model, able to connect government, citizens, and farmers. Moving from the frequent food poisoning incidents caused by low-quality ingredients used by outsourced facilities, the city of Seoul decided to introduce, in 2011, a planet -friendly free school lunch program for fifth and sixth graders of elementary schools. Since then, the program has been expanded to all elementary, middle and high schools.

The Seoul Metropolitan Government started embracing school meals as part of the educational curriculum, promoting dietary education among schoolchildren, making sure they become healthy citizens.

At the same time, the city established a public procurement system called the planet -friendly distribution center, which signed a direct contract with 11 planet -friendly producer organizations to deliver fresh agricultural products to schools every day. The school meals procurement system led by Seoul is a role model for urban and rural co-prosperity. It serves as a stable source of income for planet -friendly farmers by arranging a direct contract between consumers and producers. Thanks to this initiative, the city ensured that more than 70% of the planet -friendly ingredients are used in school meals.

The city is currently able to serve around 825,000 students from 1,352 elementary, middle, and high schools and 789 kindergartens.

The city is also part of the Milan Urban Food Policy Pact and this practice has been presented also during the Milan Pact Awards (see below).

Fortified whole maize meal replacing refined maize meal in school meals in Rwanda

One of the staples in Rwandan school menus, known as *kaunga* locally and as *ugali* in Kenya and Tanzania, is a solid maize meal similar to the Italian polenta. Prior to 2021, kaunga served in most Rwandan schools was prepared with refined, unfortified maize flour – a calorie-dense, nutrient poor food. A collaborative initiative of the Rockefeller Foundation, the World Food Programme, Vanguard Economics, and Gardens for Health International undertook to test the hypothesis that refined kaunga could be replaced by fortified whole grain kaunga in school meals in a budget-neutral way and with good acceptance by the school community (WFP, 2022). This would bring significant nutritional benefits to schoolchildren, as fortified whole maize flour is overall five times more nutritious than its refined counterpart across a range of macro- and micronutrients[18]. Taken to scale, this innovation would also be planet-friendly, as the same amount of maize flour can be produced with 20-30 percent fewer grains and a proportionally smaller environmental footprint.

After a year of consumer research-informed product development by a local miller, a pilot program was run in 18 schools in Southern Rwanda serving 13,765 lower and upper primary students in the September—December 2021 term. Comprehensive social behavior change communication was deployed to educate children, parents, teachers, and school staff on the importance of a healthy diet and the benefits of the shift to fortified whole grain foods. Cooks were trained on how to prepare the whole grain kaunga.

By the end of the pilot, the entire school community had embraced this budget-neutral switch, with 77 percent of the children actually preferring the new kaunga. This innovation has since been expanded to 81 schools serving 74,000 learners and added to the country's school feeding guidelines[19]. Conversations are under way with the Government of Rwanda and other stakeholders to scale up fortified whole kaunga to reach all 4M students in Rwanda – with another 245,000 schoolchildren in Burundi and Kenya already also benefitting from fortified whole grains.

Figure 9: The case for fortified whole grain foods in school meals

18 Comparison based on USDA FoodData Central data and micronutrient fortification levels from the East African Standard EAS 768:2019 on fortification of staple foods.

19 WFP, Rockefeller Foundation and Vanguard Economics. The Fortified Wholegrain Initiative: Igniting an Institutional Shift to Fortified Wholegrains (FWG) in Rwanda. April 2022. Available at https://fwg-alliance.org/download/fortified-whole-grains-in-school-feeding-in-rwanda/.

Harnessing technology and innovation: Food for Education, Kenya

Food for Education is the response to the nutrition and education challenges facing young learners in Kenya. Starting in 2012, founder Wawira Njiru noticed the difficulties children were having in schools and observed the most significant was simply a lack of food. Her decision to set up a small kitchen to provide school meals in Ruiru led to the exponential growth of what would become a sustainable and scalable school feeding model serving 165,000 children every school day in over 900 schools and delivering over 21 million meals cumulatively by 2023.

Food for Education (F4E) exemplifies how technology and innovation can create immediate impact. The F4E's model embeds efficiency and sustainability by merging near field communication (NFC) technology with a hub and spoke implementation. The first feature of the F4E model is the hub and spoke approach. F4E operates high-tech, high-efficiency central kitchens, primarily powered by eco-briquettes (compressed biomass) and water saving steam cooking technology, to deliver hot meals to schools within a 20km radius. Meals are cooked in the early morning hours in the centralized kitchens, stored in sealed containers and distributed by a fleet of school feeding trucks. This model allows for standardization and efficiency, whilst offering a significant reduction in energy and capital expenditure, thereby reducing cost per meal and reducing the size of its carbon footprint. Once the food reaches the schools, F4E's technology kicks in.

The innovative 'Tap2Eat' technology is a fintech solution pioneered by F4E and applies NFC to enable parents to pre-pay for their children to access school meals. It is a micro-contribution platform that renders physical cash nonessential. In essence, each child in the F4E program is issued with a wristband linked to their parents' virtual wallet account. When the child receives a meal, an F4E agent operating a digital device 'taps' the wristband and a cashless payment is made. By using technology like this, not only does the model allow for data-driven, real-time decisions that improve cost-effectiveness and enhance operations, it also provides parents with the flexibility to pay on a daily or weekly basis, as their economic circumstances allow.

F4E's unique features, in conjunction with sourcing fresh, nutritious, local ingredients have allowed F4E to provide meals at a low cost to a wide base of learners and scale effectively to a team of 1800. A rigorous M&E is currently underway with preliminary data revealing a 75% decrease in absenteeism in pre-primary classes, reduced incidences of illness, and fainting in adolescent girls. A food wastage of under 2% indicates that the children enjoy the plant-based meals provided. Through its advocacy, particularly during the election year, school feeding was referenced as an agenda item in the manifestos of the two most popular political parties, thereby solidifying it as a national agenda for the incoming government. The team's engagement with the new government helped bring forth the increase in school feeding from 2 billion to 5 billion in 2023, a step in the right direction towards meeting the needs of Kenya's young learners.

Electric pressure cookers in Lesotho

In 2022, WFP's Country Office in Lesotho introduced energy-efficient Electric pressure cookers (EPCs) in 5 peri-urban primary schools as part of the school feeding program. The study was carried out to understand the technical and business feasibility, effectiveness of EPCs, and willingness to adopt as an alternative to firewood and LPG.

Testing the use of EPCs in schools with different capacities was important to assess the impact and performance of EPCs at various scales; the highest number of students in schools was around 1300 and the lowest was 80 students. Multiple methods of data collection (such as baseline and evaluation surveys, cooking diaries, interviews, and focus group discussions) were used to assess and monitor the impacts of using EPCs in schools. Before the introduction of EPCs, all schools used LPG as the main cooking fuel except one school which used firewood.

The results of the study align with Batchelor's (2021) findings as the cost of cooking fuel per student per day using an EPC was considerably less than cooking with LPG or firewood due to the high efficiency of EPCs. Schools were able to serve the same types of food (such as porridge, papa, samp, rice, vegetables, beans, fish, eggs, etc.) before and after the introduction of EPCs. Cooks reported that washing EPCs after cooking requires less time and water compared to other cooking appliances because they have a non-stick inner surface. Cooks noticed reductions in food consumption and waste due to changes in cooking practices such as measuring food ingredients before cooking. Additionally, cooking with EPCs was safer than other fuels as cooking with firewood in open spaces in schools can increase the risk of serious injuries for students, staff members or families. EPCs offered another level of reliability as running out of LPG while cooking prevented schools from serving meals on time or at all, leaving students without meals or having to purchase them externally, which is an economic burden. Although few power cuts were reported during the study, LPG could be used as backup for those situations.

Figure 10: Traditional cooking systems used for school meals in a primary school at Lesotho

Figure 11: Electric pressure cookers (EPCs) in Lesotho primary schools (Photo: WFP Lesotho)

Large Electric pressure cookers in Kenya

The SNV (Netherlands Development Organization) supported by EnDEV (Energising Development) and MECS program (Modern Energy Cooking Services) tested the use of large electric pressure cookers (EPCs) in three primary schools that are either connected to a solar mini-grid system or have their own solar system in Kakuma refugee camp and Kalobeyei Integrated Settlement, Kenya. Before the introduction of EPCs, the schools mainly relied on firewood for cooking supplied in bulk by UNHCR. Alongside the scarcity and difficulty of obtaining firewood in the region, cooks suffer the most due to the exposure to large volumes of air pollutants and particulate matter affecting their health and well-being.

To address these challenges and reduce the burden of firewood collection, each school received 2 EPCs (21L and 40L) to cook and prepare school meals.

The findings of the pilot project show that:

- All staff members (cooks and teachers) involved in cooking appreciated the time-savings of EPCs,
- EPCs enabled multitasking, specifically for teachers as they used EPCs to cook their own meals which requires less supervision compared to firewood,
- Cooks reported that cooking using an EPC was cleaner than using firewood as there was no smoke produced while cooking and no soot was left on the pot,
- Cooks also noted that there was less irritation to the eyes from cooking using EPCs and 5) EPCs produced less heat while cooking.

Despite the benefits of using EPCs in the selected schools, a few challenges were reported. Firstly, not enough EPCs had been introduced to meet the cooking needs, preventing a complete shift from firewood to EPCs during the study. Also, the intermittent power supply was a challenge, which meant that cooks had to complement electric cooking with biomass cooking, and, due to the lack of awareness and long-standing perceptions of electricity being unsafe, there were fears about cooking with electricity.

Figure 13: Open Firewood Stove in a School in Kaolbeyei Integrated Settlement (Photo Credit: SNV EnDEV)

Figure 12: Improved Institutional Firewood Cookstoves in a School in Kalobeyei Integrated Settlement (Photo Credit: SNV EnDEV)

Accelerating a Clean Cooking Transition in Schools In Tanzania

The World Food Program (WFP) and Sustainable Energy for All's (SEforALL) joint initiative to support the Government of Tanzania's goal to deliver clean cooking solutions to 80% of the population by 2033, focuses specifically on changing cooking practices in schools. This follows President Samia Suluhu Hassan's announcement in 2022 of Tanzania's commitment to deliver clean cooking solutions to over 80% of the population by 2033.

Tanzania has a total of 17,686 government primary schools, with over 11 million students combined. Biomass (mainly firewood and charcoal) energy constitutes 82% of the primary energy consumption. A significant opportunity exists to introduce electric cooking with more than 60% of the 9,274 government primary schools with school feeding programs that are connected to the electricity grid.

The project is being delivered in two phases:

Phase 1 objectives are to:

- deploy electric cooking solutions to 200 primary schools in Tanzania, reaching over 100,000 students;
- deliver an estimated reduction in emissions of 108,928 tCO2e from 48,312 tons of firewood saved; and
- design an innovative project model to deliver clean cooking solutions in schools for replication across countries in Africa.

On completion of Phase 1, Phase 2 plans to scale up this initiative to:

- Implement a carbon market scheme to generate revenues to co-finance the transition to clean cooking for schools in Tanzania.
- Deploy energy efficient and wherever possible modern, cooking solutions to primary schools across Tanzania with an existing school feeding program. WFP Country Office in Tanzania estimates 9,274 of government primary schools have an existing school feeding program, reaching over 11 million students across Tanzania.
- Deliver an estimated reduction in emission of up to 27 million tCO2e from 11.8 million tons of biomass saved through transitioning primary schools with existing school feeding programs to cleaner, energy efficient cooking solutions.
- Explore how to replicate this initiative across sub-Saharan Africa.

This project opportunity not only directly benefits the children, teachers and (predominantly female) cooks, but also helps schoolchildren act as 'agents of change' as part of the clean cooking transition in their wider communities, contributing to social, health, education and economic development benefits across schools and communities.

Promoting native and underutilized food: the Biodiversity for Food and Nutrition project in Brazil

The Biodiversity for Food and Nutrition Project (BFN) has been implemented in four countries, Brazil, Kenya, Turkey and Sri Lanka, aiming to improve nutrition and livelihoods with a focus on native biodiversity and its conservation. It utilizes the Food Purchase Program (PAA) and the National School Feeding Program (PNAE) of Brazil, institutional food procurement programs that provide equitable support to family farmers, by acquiring products at a fair price and directing them to public schools and social organizations. At least 30% of the food purchased through PNAE with federal funds must be bought directly from family farmers, while both the PNAE and the PAA pays a premium of up to 30% in the price of organic or agroecological produce and prioritizes purchase from settlers of the agrarian reform, quilombolas and indigenous communities.

The program adopts a collaborative approach, highlights the collection of good quality food composition and consumption and making that data available to those responsible for the implementation of PNAE and PAA, providing training for local communities, municipal and school managers, nutritionists and cooks and capacity building of PNAE staff to integrate more socio-biodiversity into institutional procurement.

Key successes for the program have included:

- The publication of the official list of native Brazilian socio-biodiversity species of nutritional value, that has greatly increased the marketing potential of native species (Ordinance Nº 284/2018).
- The creation of a food and nutrition security quality index (IQ COSAN) to plan healthy and balanced school meals. The tool allocates point-based ratings to school meals depending on their levels of dietary diversity and the absence of unhealthy foods, with additional points if meals include neglected and underutilized species.
- Collaboration with the Educating with School Gardens and Gastronomy initiative (PEHEG), to create positive behavioral changes for healthy eating, promote these foods in nutrition education activities, and to educate children unaccustomed to the new tastes and textures.
- The publication, in collaboration with partner universities, nutritionists and the gastronomy sector, of a book with 335 recipes using 64 native underutilized species entitled Brazilian Biodiversity: tastes and flavors (Santiago & Coradin, 2019).
- Adding socio-biodiversity as a main theme in the second edition of Best School Feeding Recipes (driven by a school competition).

Although the sums spent to purchase neglected and underutilized species remain low compared to those spent on overall food purchases, there has been an increase in the uptake of socio-biodiversity in public procurement programs, as well as an increase in total expenditures under some of these programs (see **Figure 14**). In 2017 the federal government increased the funds allocated to states and municipalities for PNAE purchases by 15 percent, benefiting 41 million pupils in primary and secondary education. Also, despite a 20 percent cut in PAA's overall annual budget in, the share in total funds spent under PAA on socio-biodiversity products increased around 2.3%, from 2.75 percent in 2016 to 5.02 percent in 2017, to reach a total of almost BRL 33 million in 2017 (see **Figure 14**) (Brazil, Ministry of the Environment, 2019; Oliveira et al., 2018).

In summary, BFN increased awareness on the importance and nutritional value of food species from Brazilian biodiversity through advocacy and capacity building workshops and by engaging in strategic alliances and partnerships with key actors involved in PNAE, PAA and related policies.

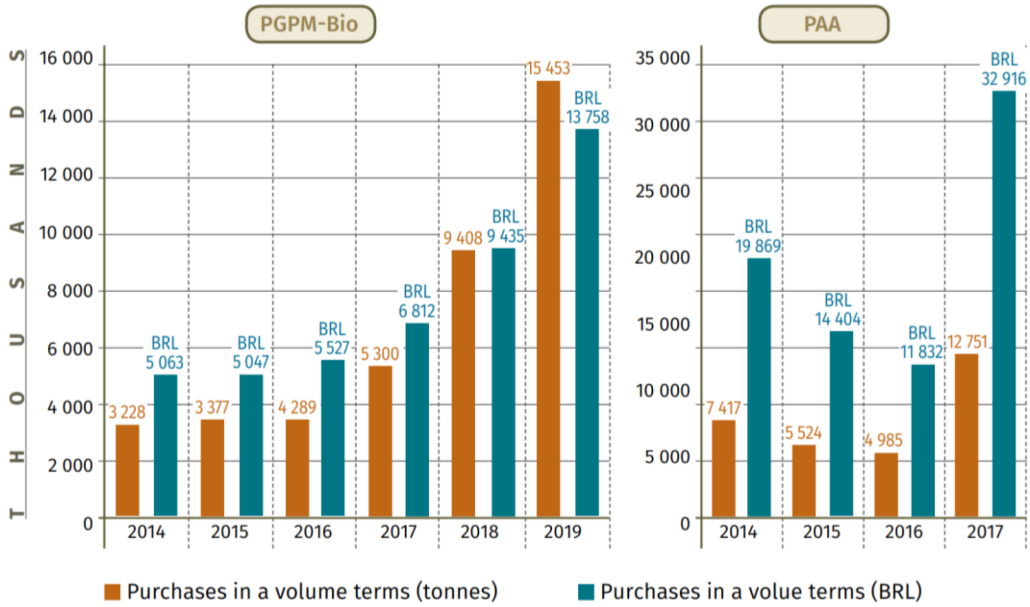

Figure 14: Purchases of socio-biodiversity products under PGPM-Bio (2014–2019) and PAA (2014–2017) Source: Brazil, Ministry of the Environment, 2019. Purchases in a volume terms (tons)

Linking farmers and schools to improve diets and nutrition in Busia county, Kenya

Many children in poverty-stricken areas of Kenya suffer from malnutrition. These same regions harbor locally adapted, indigenous crops that are highly nutritious and grow quickly with minimum inputs, thus offering advantages in terms of both human health and the environment. Despite their potential, these species are neglected in local diets and production systems. School meals are generally monotonous, typically featuring a large portion of a carbohydrate staple e.g., ugali/posho (maize porridge) and complemented by convenient bulk-bought kale or cabbage (UNSCN, 2017). Smallholder farmers also report production uncertainty and poor market infrastructure. In addition to this, success of linking farmers and schools, for example through home grown school feeding programs, can be constrained by lack of trust from farmers that schools will pay consistently, and a lack of information or capacity to properly manage their businesses and contracts. On the demand side, schools lamented the lack of networks, contacts and structures to facilitate school-farmer negotiations (Gelli et al., 2016).

The project's approach (piloted in 2016) simultaneously addresses constraints on the supply and demand side for school feeding, increasing the capacity of smallholder farmers to produce and supply local, underutilized and micronutrient-rich crops, and at the same time create desirability and informed demand for these foods, particularly through school feeding programs. For example, improved seeds and training on sustainable agricultural production, integrated pest management and the use of seasonal calendars to plan and guide production. Also setting up of an adapted farmer business school (FBS). On the demand side, cooking demonstrations, nutrition education and activities to raise awareness of the nutritional value of these foods. Benefits so far have included:

- Economic: As well as increased revenue (yearly profits of USD 540, innovative farmers were also selling manure (USD 10 per bag) and setting up kitchen gardens (USD 15 per household). Schools' savings equated to USD 360 by purchasing these foods, while some schools provided land for farmers to grow vegetables directly on school property, reducing transport costs and waste.
- Dietary diversity and health: By 2019, the farm-to-school network in Busia was providing healthy school meals to approximately 5,500 pupils. Trained cooks ensured that vegetables are prepared with nutrient preservation in mind, including a variety of highly nutritious local crops. Initial reports also reported fewer stomach ulcers.
- Education: Growing vegetables directly on land belonging to schools opened important opportunities for the creation of educational gardens and, as part of their syllabus, students gained hands-on experience regarding the sustainable growing of local crops, while also learning about nutrition and economics.
- Environment: The sustainable agricultural practices promoted in Busia have helped preserve soils, whilst the traditional crop varieties are more resilient to biotic and abiotic stresses, and many are also drought tolerant. This helps improve climate resilience. The use of no chemicals and pesticides has also reduced water pollution.
- Social: Interest in sustainable agriculture as a profitable business venture, and raised awareness of environmental issues among younger generations, as well as employment opportunities for farmers.

The policy is currently being implemented through Busia's County Integrated Development Plan (and budget) for 2018–2022. The plan acknowledges the use of school meals as a social protection mechanism and recognizes the need to promote the sustainable use of indigenous biodiversity for conservation purposes.

Native and underutilized foods in Nepal

A pilot home grown school feeding (HGSF) intervention between 2018 and 2020, as part of the of national school feeding program was undertaken by Partnership for Child Development (PCD), Imperial College London and the World Food Program in Nepal from 2018 to 2021 in specific municipalities in six districts of Nepal: Bardiya, Sindhupalchok, Mahottari, Dhanusha, Nuwakot and Jumla. The districts were purposively selected to be representative of Nepal's agroecological and socio-economic diversity. School meals were designed at the district level in community level workshops, using the Meal Planning Tool (MPT)[20]. For each district, 6 separate meals were finalized for each day of the school week. To improve focus on local foods, a community mapping of local Native and underutilized species (NUS) foods was undertaken for inclusion in HGSF supply chain. A forward-contract based commodity supply system was designed for supply of agricultural commodities to the schools.

Data from 36 school meals (6 meals x 6 districts) was analyzed. A review of the HGSF supply chains in each of the intervention districts found that a total of 18 NUS commodities were included in the HGSF supply chains. By agroecological zones, seven commodities were found in terai (three districts), eight were found in hills (two districts) and ten were found in mountains (one district). Of the 18 NUS foods, nine foods are specifically identified as Future Smart Foods (FSF) in Nepal (Joshi et al., 2020b).

Jumla district in the mountain AEZ has the highest number of NUS and FSF foods, followed by midhills and terai. This is a function of higher agrobiodiversity in Jumla and dietary practices which include a larger variety of foods as compared to mid-hills or terai. The analysis finds over 60 tons of naked barley in the HGSF supply chain in Jumla. Naked barley is one of the oldest cultivated grains and a source of complex carbohydrates (Gabrovská et al., 2002). It is a NUS mountain crop, and it is one of the eight mandate crops of a UNEP project on mountain crop genetic diversity3. Other cereals and pseudo cereals were also found in significant volumes in Jumla, such as buckwheat which contains over twice as much protein as standard varieties of rice or corn. Buckwheat is also well suited to higher altitude in terms of adaptation to different climatic variables and easily fits to different cropping patterns due to short duration (Gauchan et al., 2020). NUS foods also consist of specific cultivars, for example, Jumla supplies consisted of over 20 tons of Marshi rice. Marshi rice is a local rice cultivar uniquely adapted to the extreme cold climate and geography of the region and grow at altitudes of up to 3050masl (Bajracharya et al., 2006). This rice variety is also known to have higher amount of protein, micronutrients and antioxidants as compared to popular native rice varieties grown in other hill and mountain regions of Nepal (Joshi et al., 2020a).

Other NUS cereals and legumes in included finger millet and horsegram. Horse gram red (Macrotyloma uniflorum). It is rich in iron and other macro and micronutrients and is known to have high stress tolerance (Aditya et al., 2019). It is primarily cultivated by poor and marginal farmers in India and Nepal and is considered poor man's food (Aditya et al., 2019). Green amaranth, also known as pigweed, is a source of essential amino acids, dietary fiber and minerals and is identified as FSF in Nepal (Joshi et al., 2020b). It was found in significant quantities in the supply chains of both terai and mountain districts. Another underutilized plant which grows as a weed in farms, Lamb's quarter (Chenopodium album), was found in terai and mountain districts. The leaves of this plant are rich in essential amino acids and contain calcium and vitamin-A in significant amounts (Poonia & Upadhayay, 2015). Many of the crops included in the supply chain such as amaranth and finger millet are also known as 'Himalayan Superfoods' owing to their ecological and nutritive properties (Gauchan et al., 2020).

20 New tool called SMP PLUS was launched in 2021 – see earlier section

Fostering Nutritional Diversity in Zambian School Meals through Traditional Foods

In Zambia, as in many other African nations, the integration of traditional and indigenous diets into school meals holds great promise for promoting cultural diversity, enhancing nutritional value, and fostering a sense of connection to heritage. Incorporating these diets into school meals provides a unique opportunity for students to connect with their cultural heritage, instilling a sense of belonging and pride in their traditional culinary practices. African traditional foods can be seamlessly incorporated into school meals nutrition guidelines, with traditional diets often emphasizing locally sourced, seasonal ingredients, with sustainable and planet-friendly food practices.

One way to further promote traditional foods is by encouraging their cultivation in school gardens (Ministry of Education, Republic of Zambia, 2020). However, Zambia faces a challenge in this regard. The existing Seeds Act and its Regulations essentially render seeds of local vegetables practically illegal for sale, unlike hybrid or imported seeds (Republic of Zambia the plant variety and seeds act, 1995). Without revisions to this legislation, schools may continue to opt for "foreign" or exotic vegetable seeds, which are more readily available but often reliant on additional inputs like pesticides which many local farmers cannot afford. In the context of school feeding programs, there is a growing interest in "orphan foods," which are highly nutritious but often overlooked or underutilized (Council, 1996, 2006, 2008). These foods can play a vital role in enhancing the nutritional quality of school meals while also promoting local agriculture and food security. Notable African "Orphan Foods" that can be an ideal addition, supplement, or base for various dishes to increase the nutritional value of school meals include.

- Moringa: Moringa leaves are packed with vitamins, minerals, and protein.
- Fonio: This gluten-free grain is rich in essential amino acids and micronutrients.
- Amaranth: Amaranth leaves and grains provide calcium, iron, and protein to enhance meal nutritional content.
- Bambara Groundnut: High in protein, fiber, and essential nutrients, these legumes can be incorporated into soups, stews, or roasted snacks.
- Okra: A versatile and nutritious vegetable, rich in vitamins, minerals, and antioxidants.
- Baobab Fruit: high in vitamin C content, fiber, and antioxidants.
- Millet: A drought-resistant grain rich in protein and fiber.
- Pumpkin Leaves: Nutrient-rich pumpkin leaves can be incorporated into soups, stews, or salads to enhance the nutritional content.
- Cowpeas: (black-eyed peas) are rich in protein, fiber, and various vitamins and minerals.
- Sorghum: A drought-resistant grain, and good source of energy, protein, and micronutrients.

In Zambia, the government's initiative to expand the school food basket to include sorghum, millet, cassava flour, cowpeas, sweet potatoes, and wild fruits is commendable (Ministry of Education, Republic of Zambia, 2020). However, addressing the challenges related to the availability of local vegetable seeds is crucial to fully realize the potential of traditional foods in school feeding programs.

By embracing traditional diets, promoting local foods, and incorporating highly nutritious "orphan foods," Zambia and other African nations can provide school children with culturally relevant, diverse, and nutritionally rich meals. These efforts not only contribute to better nutrition but also strengthen ties to cultural heritage and support local agriculture and food security.

The Agrobiodiversity Index - A tool to monitor agrobiodiversity in school feeding programs

Agricultural biodiversity – agrobiodiversity includes all plants, animals, micro-organisms, and ecosystems that directly or indirectly contribute to food and agriculture (FAO, 1999). Agrobiodiversity is a result of strong human-nature interactions and offers invaluable opportunities and resources to humans to adapt to a planet facing changing climate, degraded soils, scarce water, and biodiversity loss (Hunter & Fanzo, 2013).

Agrobiodiversity includes, therefore, many of the food crops mentioned across chapters and case studies (e.g., orphan, lost, native, neglected, underutilized, traditional, indigenous, forgotten, nutrient-rich, climate-smart, and climate-resilient foods or crops). Hence, school feeding programs fostering the adoption of agrobiodiversity in school meals and gardens for healthy diets and land can trigger a virtuous cycle to transform food systems led by younger generations. Healthy diets grounded in a wide range of agrobiodiverse food items (e.g., livestock, fisheries, mushrooms, plants, etc.) can generate demand for and support more diverse production systems with locally adapted crops cultivated with biodiversity and climate-friendly practices. These agrobiodiverse production systems host and maintain a wide range of species and landraces or varieties critical to adapting and recovering from shocks, crises, and catastrophes.

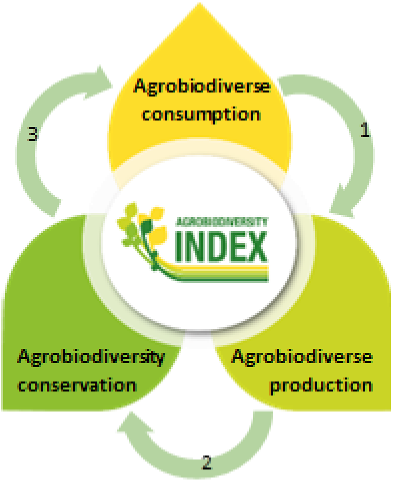

Figure 15: A virtuous cycle triggered by higher consumption of agrobiodiversity in school meals results in more diverse, resilient, and locally adapted production systems that conserve and maintain the agrobiodiversity that will be key to recovering and adapting.

The Agrobiodiversity Index is a framework that puts the spotlight on agrobiodiversity as an accelerator towards more diverse, adapted, and just food systems. The Agrobiodiversity Index is also a tool that includes several indicators to monitor agrobiodiversity in the consumption, production, and conservation pillars of the food system, where this contributes to healthy diets, sustainable agriculture, and resilient futures. The Index can be used to track trends in agrobiodiversity, as well as to identify actions and commitments made by decision-makers to enhance agrobiodiversity's contribution to sustainability outcomes across the three pillars (Jones et al., 2021). The Agrobiodiversity Index tool has been successfully adapted to monitor agrobiodiversity at the national level (Jones et al., 2021) and can be further developed to assess how well agrobiodiversity is used and conserved in school meals worldwide, across regions, or at sub-national levels, to support health, livelihood, biodiversity, and climate goals. The collective power of the School Meals Coalition to transform food systems by enabling agrobiodiverse and healthy diets to 418 million children every day worldwide is unique. In this transformation, agrobiodiversity will play a critical role. Now is the time to take stock of where there is a lack of high-value, locally-adapted, and multifunctional agricultural diversity to ensure actions to boost agrobiodiversity in school diets move beyond delivering nutritious meals to actively help tackle the multiple major crises of our time.

Scaling nutrition-sensitive fisheries technologies and integrated approaches in Odisha, India

A USAID-IPP funded Project led by the Kalinga Institute of Social Science (KISS) that ran between 2017 and 2021 examined the Inclusion of fresh marine small fish (anchovies) in the diets for 27000 tribal children, aged 5 to 14 years. Children consumed the anchovies two times per week over a 6-month period.

Before the trial, the children were actively engaged in providing feedback on their preference for either small fish powder, fresh fish or dried fish.

Both institutional trials and the KISS pilot program results were shared with different government forums and the Women and child development department, which led the Government to pilot the inclusion of small fish-based products in the Supplementary Nutrition Program of Odisha.

In another parallel USAID-IPP funded study, dried small fish was included as part of the Integrated Child Development Services (ICDS) Supplementary Nutrition Program (SNP) in a collaboration between the Fisheries and Animal Resources Development (FARD), the Indian Council of Agricultural Research and Central Institute of Fisheries Technology (ICAR-CIFT), Women and Child Development Department (WCD) and Mission Shakti of the government of Odisha. 1208 children aged 3-6 years were given small fish powder, in a regular meal, 3 times a week for 6 months, together with 186 Pregnant, 284 Lactating Women and 329 adolescent girls who consumed whole dried fish, twice a week for 6 months.

During the initial two weeks, there was lots of plate waste found due to the strong fish odor and use of less vegetables in curry. Through continuous community-level interaction in the early phase of the project, awareness raising work with mothers and caretakers was conducted, including support for method of cooking etc.

The results of the work suggested that the use of sufficient vegetables and drops of lemon to cover the fishy odor and enhance taste improved the uptake. Also, use of good Information, Education and Communication (IEC) materials and sharing them with the community had a positive impact on behavior change.

The WCD agreed to include the dried fish in the SNP program for pregnant and lactating women. The Department only wants to use hygienic dried fish produced (using solar driers) by women's self-help groups of the Odisha coastal region, to help ensure that this vulnerable group benefits from enhanced nutrition and income generation.

WorldFish now has a 5-year Memorandum of Association with the Department of Mission Shakti to support over 30,000 women in the coastal area to produce hygienic, certified dried fish, so that they may be able to supply WCD under SNP for consumption by children, adolescent girls and Women, to improve nutrition and the livelihoods of rural poor women.

Figure 16: Small fish powder inclusion in Anganwadi centers Odisha, India

Home grown school feeding in Armenia

In 2020, the World Food Program (WFP) worked to address food insecurity in the Arpi community, Armenia, with an intervention that included access to solar energy. In the country, a high percentage of food is imported, causing exposure to foreign food markets price fluctuations. High production costs and post-harvest losses are also an issue. Solar PV systems were installed in five schools (109 students) to warm classrooms and greenhouses to produce fresh vegetables all year round, to heat up water to wash hands and dishes, to cook school meals and bake bread and to refrigerate fresh foods, decreasing food losses.

In addition, together with the Social and Industrial Food Services Institute, WFP has supported four livestock and one poultry/egg farms with new equipment to mechanize their production processes and three dairy farms to power processing equipment for milk pasteurization and cheese making.

Lower production costs for energy through solar power increased small-scale farmers' market competitiveness compared to larger producers.

While the investment in technology has improved food production from greenhouses and school orchards and reduced its cost, allowing the introduction of adequate and nutritionally balanced food, school meals' purchasing power has provided stable demand for the produce, at a discounted but stable price. The surplus electricity, sold back to the grid, was reinvested in school feeding and other social services. This green energy not only decreases electricity bills but is also contributing to limit Armenia's carbon emissions (WFP 2021b, WFP 2021c)

The role of diversity and locally available fruit trees in school gardens

Fruit trees play a crucial role in addressing some of the nutritional needs of growing children and communities, providing essential micronutrients. The unique resilience of farm diversification with fruit trees lies in their perennial nature, allowing them to contribute to nutrition beyond typical growing seasons for annual crops. When appropriately integrated into agroforestry systems, fruit trees become a simple yet effective component of a long-term solution, ensuring a year-round supply of nutritious foods locally.

To support farmers in adopting this approach, CIFOR-ICRAF has developed, tested, and implemented the Fruit Tree Portfolios. This strategy offers site-specific recommendations to promote a sustainable, year-round source of nutrition on smallholder farms. By guiding farmers in selecting and cultivating up to 10 fruit tree species, both indigenous and exotic, families can enjoy a continuous supply of micronutrient-rich foods. The key idea is to have at least one tree fruiting at any given time (**Figure 17**).

These portfolios are co-designed with local communities and prioritize fruits, vegetables, and other annual crops based on their ability to provide vital micronutrients such as vitamins A and C, iron, and folate. These nutrients are crucial markers for overall micronutrient intake and play a significant role in dietary diversification strategies, addressing gaps often present in staple-based production systems. By prioritizing agricultural biodiversity, the portfolio approach establishes a foundation for supporting diverse and nutritious diets.

School gardens serve as important hubs for introducing and promoting these portfolios, functioning as active learning sites that emphasize the significance of growing a variety of tree and crop species. They also contribute fresh produce, especially fruits and vegetables, to school meals. This is particularly valuable in regions where school meals heavily rely on staple foods like maize or rice. Schools additionally provide a platform for broader community engagement by fostering practical learning through school clubs and involving the community and parents in initiatives like school management committees and champion farmer programs. To communicate the importance of producing and consuming a diverse range of food species for healthier diets and well-being, tailored materials are used during community engagement and sensitization events, and 'Talking Walls" are used in schools. The portfolio approach has been adapted to over 30 sites in seven countries across East, Southern, and West Africa, showcasing its relevance and scalability across diverse agricultural landscapes.

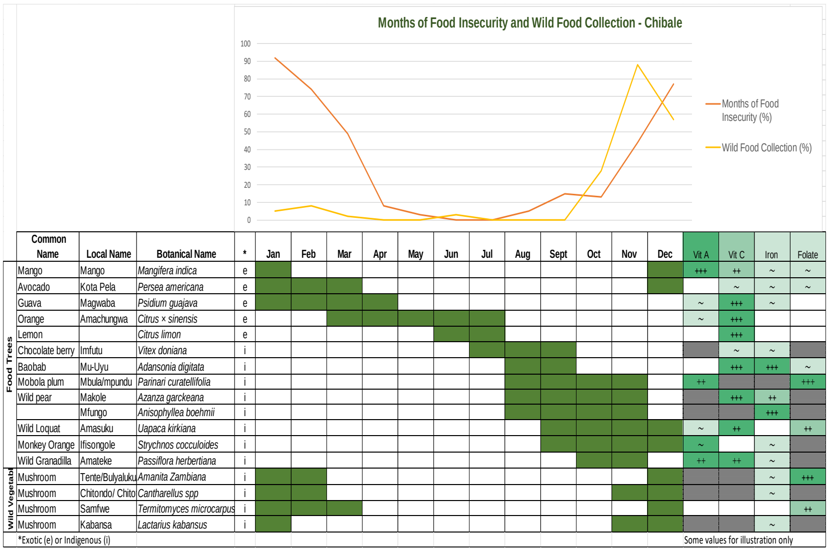

Figure 17: Example of a customized fruit tree portfolio with wild vegetables for Chibale, Zambia. The combination of trees providing food, along with wild vegetables addresses year-round harvest and highlights the important provisioning of priority micronutrients

Transforming Ghana's Food Processors into Catalysts for Change

As part of the Canada-funded Enhanced Nutrition and Value Chains project (2016-2021), the World Food Program (WFP) invested USD 3.3 million and provided technical support to two local manufacturers of nutritious processed foods in Ghana: Premium Foods and Yedent. This strategic partnership aimed to promote the growth of nutrient-sensitive food value chains and strengthen the resilience of food systems in the country.

WFP's catalytic grant investment enabled Premium Foods to secure a USD 25 million capital expenditure (CAPEX) business loan from financial institutions to invest in state-of-the-art food processing technology, including a 3 GW solar PV system to power the equipment. This reduces operating costs for the facility but also the amount of CO2 that would have been otherwise emitted if the power had to come from diesel generators.

WFP's technical assistance has ensured adherence to food safety and quality standards, supported packaging development, facilitated compliance with international export and distribution regulations, and helped Premium Foods and Yedent develop fortified products for local and regional markets.

The flagship Super Cereal is a nutritious product used in the treatment and prevention of malnutrition, especially among women and children. It is made of maize or wheat blended with soybeans, fortified with vitamins and minerals, and processed into flour. Mixed with water, Super Cereal makes a delicious and easy-to-prepare porridge that provides the recommended daily intake of essential nutrients. It is available commercially and at institutional markets such as the Ghana Health Service and Ghana School Feeding Program. The packaged food enables school children to have a nourishing breakfast before the day of learning starts. As it only requires hot water to be prepared, much less fuel is needed compared to cooking a meal from scratch with all the original ingredients.

WFP's support to Premium and Yedent has resulted in increased productivity, employment, and access to markets. The two companies now have a combined production capacity of 38,000 MT of nutritious food per year, and they provide access to markets for 15,000 smallholder farmers who sell their produce to the companies through aggregators. They also directly employ 350 people and have over 50 people undergoing training and internship programs.

This catalytic initiative promotes sustainable agriculture, that is powered by cheap, reliable and green energy, contributing to the building of a resilient and climate friendly food system. Building inclusive and sustainable agri-value chain model WFP helps to transform economies, and ultimately changing lives[21].

21https://www.myjoyonline.com/wfp-supports-ghanaian-agro-processors-to-be-globally-competitive/

Promotion of minor millets in schools and public procurement in India

Keeping in view the crop failures, farmer indebtedness and poor nutrition profiles, the District Administration of Vikarabad, Government of Telangana, initiated a pilot project to include sorghum in Integrated Child Development Services (ICDS) with the support of Watershed Support Services and Activities Network (WASSAN).

A series of three millet food festivals were organized to build consensus around the inclusion of millets in ICDS. Children and mothers were given millet-based foods at the festivals.

To understand the public perception of including millets in diets, feedback was taken from the community, mothers, people's representatives, anganwadi teachers, helpers and children. Resolutions passed in the mothers' committees were also taken to understand the view on these millet-based efforts. Through such participatory approaches, diverse menu options were selected, which also included inputs from the community and from scientists at the National Institute of Nutrition.

Such innovative, nutritious and appealing preparations included a preliminary menu of foxtail millet kitchidi and sorghum upma, which were given to the children in 45 Anganwadi Centers (AWCs). The initiative was launched on April 14, 2017. The cost of one normal rice-based meal per child per day is US$0.08.

As millets were not subsidized under PDS, the cost of the korra (foxtail millet) kitchdi and jonna (sorghum) upma is about US$0.11 and US$0.14 respectively. Additional funds were provided from the District Collector through the Flexi-Funds Scheme.

For the pilot of three months, covering 45 AWCs and 1,000 children, an additional expenditure of Rs. 1.73 lakhs was incurred. The Civil Supplies (CS) Department procured millets through farmer cooperatives as per approved specifications. Based on the success of the Vikarabad initiative, the Women Development & Child Welfare Department, Government of Telangana, is now planning to champion the inclusion of millets in ICDS on a large scale.

A proposal for decentralized pilots for three aspirational districts was also submitted to Niti Aayog. The proposal was approved in the 13th Empowered Committee meeting of Niti Aayog on July 10, 2020. In addition, the state of Telangana has also received an outlay of 355 Metric Tonnes of jowar and 607 MT of bajra under ICDS for piloting millets in ICDS (Deverajan, 2020).

Critical to success was that a multi-stakeholder approach involving different departments, civil society and farmers'/women's collectives was used, that focused on the value chain, within and outside government programs.

Tackling aflatoxin for safer school meals and to reduce food loss

Aflatoxins are poisonous substances produced by certain kinds of fungi that contaminate food crops in many low- and middle-income countries (LMIC), particularly maize and peanuts. Aflatoxins pose a severe threat to human health as carcinogens, affecting the liver and kidneys (Dhakal et al., 2023; Kumar et al., 2017). More than 25% of the world's food crops are destroyed annually (Schincaglia et al., 2023), leading to food shortages and inflated food prices resulting in massive economic losses. Moreover, they interfere with the absorption of nutrients crucial for optimal growth and development, notably zinc (Gong et al., 2002; Rasheed et al., 2021; Smith et al., 2012; Visser et al., 2020), with associations also observed for iron (Shuaib et al., 2010). Recent analyses reveal that 3–36% of stunting-related disability-adjusted life years (DALYs) in children >5 years in African LMICs are attributable to aflatoxin exposure, and 14-49% are attributable to exposure in children experiencing concurrent stunting and underweight (Rasheed et al., 2021). Further, climate change can enhance aflatoxin contamination (Kumar et al., 2017; Magan et al., 2011; Valencia-Quintana et al., 2020).

Aflatoxin exposure is a serious health concern in Rwanda, as a study of women of reproductive age detected AFB1-Ly (aflatoxin exposure biomarker) in 81% of women (Collins et al., 2021). An analysis of food products in the Rwandan market showed Aflatoxin levels 6x the Rwanda Standards Board tolerable limit (Grosshagauer et al., 2020). With fortified maize flour being a central meal ingredient in the Rwanda School Feeding Operational Guidelines (Ministry of Education, Republic of Rwanda, 2021), This poses the unsettling question of whether this contaminated maize might be reaching a student's plate.

Interventions have been piloted across Africa, including the aflatoxin biocontrol product Aflasafe (Senghor et al., 2020, 2021) and AflaSight, (Innovation Accelerator, 2023). But these measures have high costs and identify aflatoxin at the end of the maize value chain. The Africa Improved Foods (AIF) social enterprise has introduced the COB model that uses a centralized facility for immediate shelling and drying (AGRA, 2021). This has significantly reduced aflatoxin levels, but the drying process still takes 30-60 days, potentially exposing post-harvest contamination. Rather than *ad hoc* interventions at certain points along the maize value chain, holistic solutions involving farmer training and testing tools, are needed.

Sight and Life, together with Rwanda Food and Drugs Authority are pioneering the Product Innovations in Nutrition (PIN) project that uses an end-to-end solution for aflatoxin mitigation in Rwanda. This work aims to achieve a 40% reduction in food loss and a 70% income increase among select farmers (IDH - The Sustainable Trade Initiative, 2021). This work is bringing innovative interventions across the entire maize value chain at three critical points: (1) Post-harvest, farmer cooperatives are testing for moisture content with an inexpensive (200 USD) moisture meter (current practice is no moisture testing) compared to the oven method of testing in the lab (costs 15,000 USD; (2) planet-friendly solar dryers that successfully dry 500 kilograms in 4 hours are being trialed at the farm level in two districts to replace sun- drying practices which takes >1 month and are affected by unpredictable weather, where farmers pay a fixed annual rent; (3) At the transport, processing, and retail stages, field-friendly, accurate, rapid test kits check for aflatoxins (Wolf & Schweigert, 2018) in place of expensive and slow liquid chromatography-mass spectrometry (Unnevehr & Grace, 2013). These innovations are accompanied by farmer training and awareness. To date, 1.5 years into the 4-year project, 5,100 farmers have been trained in best practice workshops, empowering farmers with knowledge on how to dry and store their crops (Sight and Life, 2023). Six aflatoxin rapid test kit devices have been distributed to two Regulatory Authorities and two processors, while 20 moisture meters have also been distributed to farmer cooperatives.

In 2021 Rwanda committed to scale up its national school meals program from 360,000 youth to universal coverage (3.6 million), and this game-changing series of innovations has the potential to deliver safe and nutritious maize to schools as part of these school feeding programs.

Phytase-rich school meals for enhanced micronutrient bioavailability

School meals have great potential to reach school children and adolescents with essential nutrients, especially in LMIC, where total consumption of protein and micronutrients is low. Dietary patterns in LMIC, including school meals delivered in these settings, tend to include high amounts of staple foods such as cereals and legumes (Schlemmer et al., 2009), and low amounts of fruits and animal-source protein (Miller et al., 2022); thus, diets generally lack certain essential micronutrients, such as iron, zinc, and calcium. School meals programs can significantly contribute to sustainable food transitions by emphasizing balanced plant-based meals (Roque et al., 2022). Yet, concerns have been raised regarding micronutrient deficiencies in diets high in phytate and limited animal-source foods (Beal et al., 2023).

Phytic acid is an antinutrient found in whole grains, pulses, and nuts which binds to protein and micronutrients (iron, zinc, magnesium, and calcium) (Feizollahi et al., 2021; Thavarajah et al., 2009), forming a chelate called phytate, thereby inhibiting micronutrient and protein absorption and utilization. As a result of phytate-complex activity, micronutrient deficiencies in LMIC populations are widespread (Beal & Ortenzi, 2022; Kumar et al., 2010; Welch, 2002), with children especially at risk (Zimmermann & Hurrell, 2007). Nutrition interventions have focused on supplementing children and adolescents with iron and zinc rather than improving the absorption of these elements already present in the diet (Odle et al., 2017). There is an urgent need to enhance the nutritional value of staple foods in school meals by developing solutions that improve the bioavailability of micronutrients.

Incorporating phytase-rich foods in school meals can make it easier for the body to absorb and utilize iron. Sufficient iron levels are imperative for school-aged children's cognitive, motor, and social development (Lozoff, 2007). Phytase is the phytate-degrading enzyme found naturally in plants and microorganisms (Gupta et al., 2015). In cereal and legume-based foods, in particular, phytase has been used to increase the quality and digestibility of proteins as well as the bioavailability of iron, zinc, and calcium (Kumar et al., 2010; Vashishth et al., 2017). In a review of ten studies conducted in humans, phytase was shown to increase iron absorption by 1.0- to 11.6-fold and zinc absorption by 1.4- to 2.0-fold across five studies (Troesch et al., 2013). Adding phytase to bread and defatted soymilk has been shown to increase soluble protein by 41% and 28%, respectively (Saito et al., 2001; Singh & Satyanarayana, 2008).

Despite strong evidence of the nutritional significance of phytase, its use in human nutrition is nascent (Odle et al., 2017). Adding phytase to human foods is a novel intervention, with a few food products and supplements in high-income countries. Sight and Life is developing and testing two-phytase-based market-driven food products in India and Nigeria in collaboration with local food manufacturers. Target food products include soy-based spiced meat and multigrain bread in India and multigrain bread and bean flour in Nigeria. While all are perceived to be healthy products, phytic acid analysis revealed that all exceeded the ideal phytate to mineral molar ratio (indicating inhibited micronutrient absorption). Sight and Life have seen promising decreases in phytate levels when adding phytase at the processing stage before heating.

Collaborations between school meals fortification initiatives, such as the ongoing work by the WFP and Rockefeller Foundation in Benin, Ghana, Honduras and India (Rockefeller Foundation & WFP, 2023) plus phytase-enriched food manufacturers and researchers, can act jointly to ensure children garner the optimal nutritional benefits from school meals (Hall & King, 2022). The inclusion of phytase-enriched culturally appropriate foods in school meals is a safe and nutritious food innovation that has strong potential to improve the nutritional value of the daily school meal, especially for children in LMIC whose diet primarily consists of plant-based foods with high levels of phytic acid coupled with low quantities of animal protein (Gupta et al., 2015).

High-quality and safe fermented staple foods for nutrient-rich school meals

Fermented foods and beverages have played a significant role in traditional human diets across every continent for millennia (Emkani et al., 2022; Tamang et al., 2020). Widely applied in LMIC, fermentation of staple foods (such as cereals and legumes) with lactic acid bacteria enhances the nutritional content, making minerals more bioavailable (iron, zinc, calcium) (Adebo et al., 2022; Samtiya et al., 2021; Zhang et al., 2022), proteins more digestible (Singh et al., 2015; Zhang et al., 2022), and, in some cases, removing allergens, reducing anti-nutritional compounds (like trypsin inhibitors, lectins and phytate) as well as toxins (like mycotoxins) (Damayanti et al., 2017; Nkhata et al., 2018; Obafemi et al., 2022; ; Priyodip et al., 2017; Rämö et al., 2022). Fermented foods often contain probiotic microorganisms, which can promote a healthy gut microbiome, strengthen the immune system, and potentially reduce the risk of infections and illnesses (Marco et al., 2017; Tsafrakidou et al., 2020; Zhang et al., 2022). Further, fermented foods have a longer shelf-life than the original food (Sharma et al., 2020).

In many African LMIC, dairy- and cereal-based fermented foods are widely consumed as beverages, snack, and porridge (Soro-Yao et al., 2014). Products made from millet, maize or/and sorghum are particularly important as complementary foods for children and as dietary staples for adults, as they contribute to the protein requirements (Soro-Yao et al., 2014). Fermentation in these countries still primarily rely on the indigenous microorganisms present in the raw material and are generally induced spontaneously under relatively poor hygienic conditions, resulting in lower yields, variable product quality and shorter shelf-life (Tamang et al., 2020; Tsafrakidou et al., 2020). In recent years, there has been growing interest in interventions designed to control fermentation processes through the application of starter cultures (FAO, 2011). These improvements help achieve improved consistency, safety, and overall product quality while providing opportunities for small-scale local processors and contribute to local economic development (FAO, 2011; Tamang et al., 2020; Tsafrakidou et al., 2020).

Incorporating high-quality fermented foods in school meals can contribute to making nutritious diets accessible in resource-constrained settings. The non-profit organization Yoba for Life, founded in 2012, is a successful illustration of this opportunity. Yoba for Life provides access to probiotic starter cultures for the local production of yoghurt and other fermented foods in resource-poor countries (Westerik, 2020). The Yoba yoghurt school program reaches approximately 45,000 children across Uganda, Ethiopia and Tanzania (Sybesma et al., 2023). A randomized clinical trial demonstrated that the probiotic yoghurt containing L. rhamnosus GG strain helps in the maintenance of a healthy microbiome, boosts immunological function, helps prevent respiratory tract infections, and lessens symptoms of skin rashes among 195 children aged 3-6 years in Southwest Uganda (Westerik, 2020). Furthermore, the Yoba strain was shown to delay diarrhea onset brought on by antibiotics (Westerik, 2020). Another study used the Yoba starter culture in Uapaca kirkiana jam, an underutilized fruit indigenous to Southern Africa. The use of L. rhamnosus GG increased iron and zinc bio-accessibility in the jam from 2.5% to 6.5% and 14.1% to 16.1%, respectively (Chawafambira et al., 2020).

In addition to providing the starter culture to local small-scale processors, Yoba for Life develops course material, training on the application of the technology and how to run a business (Westerik, 2020). In Uganda, the Yoghurt project 1) created income for the business owners and possibly hired workers, 2) created a market for the milk of the farmers in the neighborhoods, 3) reduced milk spoilage, and 4) created access to a healthy and affordable product for the consumers (Westerik, 2020).

OPTIMAT ™ - school meals optimized for climate, nutrition, cost and taste

One of few real life school-based interventions that has proved successful in increasing plant-based food consumption at lunch is the OPTIMAT™-project (Eustachio Colombo et al., 2020).

It was developed with the overall aim to increase plant-based food consumption among pupils in Swedish primary schools. In this project, linear optimization was used to develop a school lunch menu that was planet-friendly while at the same time nutritionally adequate, similar or lower in price to the original menu, and culturally acceptable.

The mathematical method of linear optimization was used to develop this more sustainable menu as it is able to make sure that several (sometimes conflicting) requirements such as climate friendliness, nutritional adequacy, affordability and acceptability are met at the same time.

The new optimized menu, that was 40% lower in greenhouse gas emission compared to the usual one, was tested in Swedish primary schools during a 4-week period. The new menu was omnivorous and not fully vegetarian. It contained nearly 10% more vegetables (including pulses) and about 30% less red meat.

The post intervention assessment showed that the new optimized menu did not lead to an increase in food waste, or decreased consumption among pupils. Meal satisfaction among pupils also remained the same.

In 2020, OPTIMAT was distinguished by the Royal Swedish Academy of Engineering Sciences as an "innovative project with the potential to create benefits through business and method development or societal impact", and work is under way to develop an optimization tool that can be used by all school meals organizations in Sweden to design sustainable lunch menus.

The Global Diet Quality Score-Meal Metric: An Innovative Metric for Measuring Meal Quality

The *Intake* - Center for Dietary Assessment at FHI 360 and the Rockefeller Foundation, in consultation with the World Food Program and other partners, are developing the Global Diet Quality Score-Meal (GDQS-Meal) and Menu metrics. The GDQS-Meal and Menu metrics are designed to be low-cost, robust, and appropriate for use across different countries and contexts. The metric provides comprehensive information on the quality of the meal served in institutional settings with the initial primary application in school feeding programs. Despite the wide reach of school feeding programs globally, until recently, there has not been a standardized, easy-to-use, rigorous metric available by which to measure the quality of meals and menus served (Bell et al., 2023).

The GDQS-Meal and Menu metrics were adapted from the existing, rigorously validated Global Diet Quality Score (GDQS) (Bromage et al., 2021). Food items served are classified into one of 25 food groups that are considered as healthy, unhealthy, or unhealthy when consumed in excess. Points for each food group are awarded in increments, using a linearized scoring method, based on the amount (in grams) of total food served per food group (using the age appropriate GDQS gram cut-off thresholds as the anchor for calculating the linearized points to award per food group). In addition, the GDQS-Meal and Menu metrics award points for fortification and biofortification of foods served in the meal for 16 micronutrients [22] and for diversity of healthy food groups served with the raw score scaled out of 100 total points. Higher values for the GDQS-Meal and Menu metrics indicate meals of better quality, that is, meals that offer a more diverse, balanced, healthy combination of foods and nutrients.

With the availability of the GDQS-Meal and Menu metrics, there is now, for the first time, the potential for achieving widespread measurement of the quality of meals and menus served in school feeding settings around the world. But in the context of planet friendly school feeding, there is also a need to better understand the environmental impacts of school meals as part of the broader contribution that food systems make to climate change and other environmental issues. While the GDQS-Meal and Menu metrics promise to make visible the otherwise invisible aspect of meal and menu quality, without a way to measure and evaluate the environmental impacts of different meals and menus, leverage to encourage institutions to change food procurement towards more planet friendly practices may be limited and any progress achieved ultimately not trackable.

Intake already has work well underway to develop metrics for global use to assess the environmental impacts of diets (Deitchler et al., 2023). Beginning in 2024, this work will also be adapted for use at the school meal and menu context, to provide a set of new metrics to allow for benchmarking the land use, water use, greenhouse gas emissions, eutrophication potential, and biodiversity loss associated with meals and menus served through school feeding programs. Together, these environmental impact metrics, along with the GDQS-Meal and Menu metrics, will provide new, globally relevant solutions to measure planet friendly school meals, and, in doing so, will also offer data-driven methods to inspire incremental shifts in institutional food procurement practices for improved human and planetary health.

22 Vitamins A, C, D, E, B1, B2, B3, B5, B6, B9, B12, Iron, Zinc, Calcium, Magnesium, and Iodine

Does the US need to do more to achieve planet -friendly school meals?

The Intergovernmental Panel on Climate Change (IPCC) reports that "balanced diets, featuring plant-based foods, such as those based on coarse grains, legumes, fruits and vegetables, nuts and seeds, and animal-sourced food produced in resilient, sustainable and low-GHG emission systems, present major opportunities for [climate change] adaptation and mitigation while generating significant co-benefits in terms of human health" (IPCC, 2020). The provision of approximately 30 million school lunches each school day represents a significant opportunity to promote dietary patterns that enhance health, reduce the risk of non-communicable diseases, and support planetary health.

US schools participating in the National School Lunch Program (NSLP) (USDA, 2022b) are required to follow meal patterns and nutrition standards based on the US Dietary Guidelines for Americans (DGA) (Federal Register, 2012). Despite recommendations from the expert US Dietary Guidelines Advisory Committee and global climate concerns, the 2020-2025 US DGAs do not consider the context of food systems and overall environment within its recommendations (Davies, 2022).

The 2020-2025 DGA defines "protein foods" as a broad group of foods from both animal and plant sources (USDA & USDHHS, 2020). The USDA, however, diverged from the terminology in the standards for school meals, requiring a "meat/meat alternate" group instead. This terminology may suggest the default protein food is meat and that other healthy, whole foods such as cheese, eggs, nuts and beans are suboptimal. Beans, cheese, eggs, legumes, nuts & seeds, peanut butter, tempeh, tofu, and yogurt are considered "meat alternatives" in the NSLP, but rules for using these foods in school meals are cumbersome. For example, while firm tofu cubes in a soup or stir-fry can count as the "meat/meat alternative" group, soft tofu blended into a smoothie or soup does not count because it is not "easily recognizable" (USDA & FNS, 2016). Other high-quality plant-based proteins, such as quinoa and seitan, are not yet creditable to the "meat/meat alternative" component of NSLP. Nuts and seeds are allowed but can only make up half of the meat/meat alternative component USDA (USDA & FNS, 2022).

USDA Foods in Schools is a program designed to support American agricultural producers and child nutrition programs by purchasing American grown food for use by schools (USDA & FNS, 2023). One analysis found that 74% of California's USDA Foods budget was spent on industrially produced animal products with "beans and nut butter" the only plant-based USDA Foods protein sources, make up a meager 2% of statewide USDA Foods' school purchases" (Friends of the Earth, 2021).

The USDA could take steps to better support school districts who seek to integrate the IPCC's recommendations by addressing the following:

- Re-name the "meat/meat alternative group" to "protein group."
- Eliminate the regulation that requires creditable food to be recognizable.
- Increase the proportion of USDA Foods spent on plant-based proteins and animal-sourced food produced in resilient, sustainable and low-GHG emission systems.
- Reform labeling requirements that make it difficult to credit plant-based proteins.
- Help schools identify animal-sourced proteins produced in resilient, sustainable and low-GHG emission systems.
- Heed the expert committee recommendation to consider the context of overall food systems and environment within its recommendations.

These changes, which can be made outside of congress, may accelerate school food programs as agent for change to adapt and mitigate climate change. Additional strategies, also include reducing food and packaging waste, climate-smart education, and local purchases.

Examples of successful procurement models in Europe

Torres Vedras

Torres Vedras, a municipality of 83.000 inhabitants located in northern Lisbon, is responsible for the provision of 4.500 school meals a day. These meals are prepared through two different procurement models: a network of private caterers including not-for-profit organizations provides 3.000 meals, and two kitchens under the direct management of the municipality responsible for 1.500 meals a day. The procurement models of the municipality consist of two synergic strategies. Firstly, the tender is divided into different lots[23], allowing the municipality to diversify the source of locally produced organic food including vegetables, diary and meat[24]. Secondly, market dialogues are organized to integrate small food producers in the tenders and help them to align their production to the municipality's needs. This combination, coupled with delivery in bulk, ensures a higher share of organic and locally sourced products on the menu and increased participation of small-scale food producers from the region. As a result, this approach holds the potential to reduce greenhouse gas (GHG) emissions. By sourcing food locally, transportation-related emissions are minimized. In addition, these models integrate food waste management system allowing the municipality to reach zero waste at the kitchen level and a substantial reduction of food waste at the canteens level[25].

Bergamo

Bergamo is a city with a population of 120.000 located in northern Italy, and, similarly to Torres Vedras, it is responsible for providing 5.500 meals a day spread over 59 schools. To achieve this, Bergamo uses a classic procurement system that engages a food catering service selected through a tendering process. The key to Bergamo´s achievement lies in careful drafting of the tender, a set of awarding criteria that prioritizes sustainable and healthy food, and years of collaboration with the leading catering company SerCar. This collaboration has enabled Bergamo to achieve 95% of organic food served in schools, substantially reducing its climate impact (Cerutti et al., 2018). https://doi.org/10.1007/s11367-017-1306-y. In addition, that some of its organic products come from the collaboration with the "Organic District of Social Agriculture[26]." That ensures sustainability standards of locally produced products (i.e., is there a certification?)[27]. Moreover, the municipality asks the catering company to serve at least one vegetarian meal per week (Blondin et al., 2022). Significantly lowering the carbon footprint associated with meat consumption. Additionally, as part of its climate-focused procurement, Bergamo has also taken concrete steps to redistribute food surplus to charities, lowering energy required for its disposal, and serving the most vulnerable communities[28].

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23 The different lots are organic fruits; organic vegetables; conventional fruits; conventional vegetables; red meat; white meat; fish; conventional groceries; organic groceries; organic olive oil; frozen vegetables; bread; eggs; and 4th-range ready-for-consumption products.

24 Being the quantities below the threshold of 75.000 EUR set by the EU Directive 2014/24.

25 https://sustainablecities.eu/transformative-actions-database/?c=search&action_id=crj9hv47

26 "A geographical area where farmers, the public, tourist operators associations, and public authorities enter into an agreement for the sustainable management of local resources, based on organic principles and practices. The aim is to maximise the economic and social potential of the territory. Each 'Bio district' includes lifestyle, nutrition, human relations, and nature considerations" (European Commission, Brussels, COM, 141 Final, 25.03.2021)

27 All food products coming from the Organic District of Social Agriculture have the certificate of conformity from ICEA (Istituto Certificazione Etica Ambientale).

28 https://bergamo.scuole.sercar.it/recupero-eccedenze-alimentari

Växjö

Växjö, located in Sweden, is responsible for providing food for pre- and primary schools, nursing homes, and accommodation facilities for people with disabilities. The city delivers 24.000 meals per day prepared from scratch by 105 kitchens with 300 employees. Long known for its dedication to food sustainability[29], Växjö has taken an even larger stride toward sustainable and innovative public food procurement. Central to this achievement is the implementation of the Dynamic Purchasing System (DPS) alongside food distribution hubs. The DPS, an electronic procurement method, streamlines the acquisition of goods and services readily accessible in the market, permitting registered producers to efficiently bid for small tenders released by the municipality. By embracing the DPS, Växjö innovates the procurement process, ensuring that sustainable and locally produced food can be easily integrated into tenders. This approach not only supports small-scale farmers but also contributes to reduced transportation emissions, as shorter supply chains with no intermediaries are preferred. Furthermore, Växjö has also set up food distribution hubs. These hubs serve as shared central points for receiving deliveries from various food vendors. As a result, Växjö can effectively reduce air pollution, and alleviate urban traffic (Inno4sd, 2019) improve air quality.

Copenhagen

As many studies demonstrate, purchasing organic for public canteens has several benefits from environmental (Tuck et al., 2014), socio-economic (NEF 2005), and health perspectives (Okunogbe et al., 2021) The Municipality of Copenhagen serves 70,000 meals daily via a network of 900 kitchens, reaching (at the time of writing) 84% organic food towards a target of 90-100% organic by 2025 (Ministry of Food, Agriculture and Fisheries, Denmark, 2020). The procurement model comprises a collaborative approach between different actors (public officials, caterers, food service staff, wholesalers, and growers). It results in a comprehensive market analysis, allowing food systems re-localization and a progressive supply transformation towards more organic, fresh, and sustainability-sourced food. The organic transition, coupled with a more plant-based approach to menus, has also proved to reduce food waste in the kitchen by 88% and 26-50% in serving and plate waste (Thorsen et al., 2014). The communication campaign, the new kitchen organic label (Holmbeck, 2020), and the high demand for organic in public canteens have contributed to a fivefold increase in organic sales (De Franceschi, 2023) in the private sector over the past ten years. Together with food waste reduction, a protein shift combined with more traditional food, shorter food supply chains (through market engagements) and reduced transport emissions, Copenhagen's sustainable food procurement led to a substantial reduction in GHG emissions.

Ghent

Contrary to Copenhagen, the city of Ghent has focused on a more plant-based diet to mitigate climate change (FAO and WHO. 2019). In 2009, the city launched the 'Thursday Veggie Day' campaign during which public canteens serve only vegetarian dishes and encourage citizens to eat vegetarian food at least one day a week. Today, 40% of its citizens have at least one meat-free meal every week and 7% of its population is vegetarian or vegan (Ghent Food Council, 2023). This adds to Ghent's procurement "protein strategy" aiming at better proportions between animal- and plant-based proteins: animal proteins are limited to 50% of the total protein content, with the rest coming from legumes, nuts, and soy[37]. In addition, the city supported the creation of an online market platform (B2B) to overcome the difficulty for small farmers in accessing public authorities

29 https://www.theguardian.com/cities/2015/nov/25/what-can-the-world-learn-from-vaxjo-europes-self-styled-greenest-city

(tenders) and vice-versa. This helped to shorten the supply chain, thus cutting CO_2 emissions by 36 percent in the short term (Soler, 2023). However, Ghent estimates their long-term potential to be up to 79 percent. Ghent also fights food waste via its "cascade of value retention" strategy[30]. In the end, it has been calculated that the menu shift has resulted in 4,399 tons of CO2 saved or the equivalent of 2,932 cars being taken off the road.

Milan

The city of Milan procures a total amount of 80.000 hot meals every day and distributes them to 420 school canteens and 184 nursery schools, with the contribution of 4,000 workers and 24 kitchen centers (Buces, 2023). Using a classic procurement method in collaboration with its "in house" canteen provider Milano Ristorazione, Milan has been successful in reducing its climate impact. Part of the Cool Food Pledge[31] since 2015, the city has worked on replacing animal proteins with plant-based proteins in the menu, increasing the percentage of seasonal and organic products, shortening the value chains of certain ingredients (e.g. public canteens have a rice short supply chain that involves local agriculture supplying 240,000kg of rice for a tender value of € 300,000/year) and entirely replacing disposable plastic dishes with ones made of 100% eco-sustainable materials. All these measures combined allowed Milan to reduce the GHG emission by 42,89% on the total procurement between 2015 and 2021.

30 The strategy consists on levels of food surplus managements: 1) avoiding food waste, 2) food redistribution, 3) animal feed, 4) raw materials for industry/agriculture, 5) energy production.

31 The Coolfood Pledge is set of metric systems developed by the World Resource Institute helping the cities and organizations who committed to reach a GHG emission reduction associated with the food they serve of 25% by 2030 (see https://coolfood.org/pledge/)

Strength2Food Research Project

In the European Union Horizon 2020 research project 'Strength2Food' (www.strength2food.eu), the sustainability of different models of school meals procurement was investigated (Tregear et al., 2022). One pair of cases were studied in each of five countries (Croatia, Greece, Italy, Serbia and the UK), ten cases in total. The cases captured a mixture of local (LOC) procurement (where the contract criteria referred explicitly to local sourcing), organic (ORG) procurement (where there was explicit reference to organically grown food) and low-cost (LOW) procurement (in which neither local nor organic was explicitly referenced in the contract criteria). In each case, the carbon footprints of the services were analyzed, along with the local economic impacts and nutritional qualities of the meals.

The key finding of the research was that the procurement models themselves (LOC vs LOW vs ORG) did not have a strong bearing on the carbon emissions of the services. Instead, the choice of waste disposal method, and extent of meat on the menus, in particular ruminant meat, had the greatest impacts (**Figure 18**).

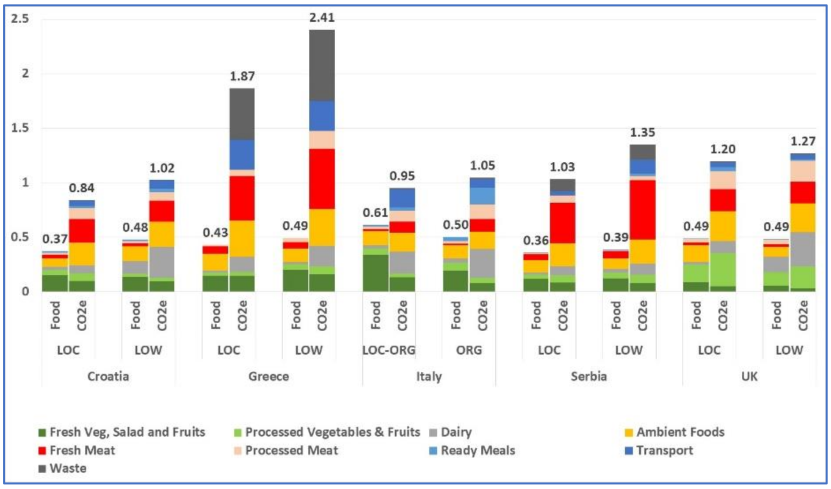


Figure 18: Weights (kgs) of foods procured for the average meal in the case school meal services (left hand bar in each pair), and corresponding carbon emissions (kgs CO2e) (right hand bar in each pair)

As **Figure 18** shows, the emissions from food waste disposal varied the most across the cases, reflecting the different disposal methods used. In the Greek cases, which had the highest carbon intensities per average meal, waste emissions represented as much as one third of total emissions, because the disposal method was 100% landfill. Emissions from waste disposal were much smaller in other cases, due to 100% use of composting or anaerobic digestion. The second greatest variation in emissions was from 'fresh meat', a substantial component of which was beef. In the Greek and Serbian cases, where the proportion of fresh meat on menus was high, those emissions contributed as much as half of total emissions, whereas the contribution was much smaller in the other cases where the proportion of purchased fresh meat was lower.

The research also revealed interesting insights into the local economic impact of school meals services, which is connected to the characteristic of planet -friendly meals as promoting social justice and equality. The results demonstrate the importance of expenditures on staff for local economic impact. They show that valorization of catering service staff is not only worthy from a social justice and equity perspective, but also represents value for local economies, because a well-renumerated local workforce is incentivized to remain in the local area and re-spend a proportion of higher earnings there.

Planet-friendly School Meals provided by the City of Malmö

The post WW2 era led the Swedish Government to subsidize the National School Meal Program. By 1997, it was made mandatory for the local governments to ensure that all children, in both public and private primary schools, were served a free and hot lunch regardless of the pupil's socio-economic background, gender and religion. Since then, the city of Malmö has operated all public school kitchens with trained chefs preparing and serving food to its 75 primary schools, 12 high schools and over 100 after school care facilities. In 2011, the Swedish government required that the school meals were nutritionally adequate. Later that year, Malmö adopted an ambitious policy to improve the quality and reduce the environmental impact of the food served in all public meal settings.

Clear goals were set, and the aim was to serve only organic foods, and reduce the greenhouse gas emissions of the food by 40 % by the end of 2020. The ambitious goals were challenging, and while the city council allocated extra funding for education and training of staff, no extra resources were allocated for food procurement. Malmö changed and adapted its approach to cooking by primarily increasing the number of plant-based meals and adjusting to more seasonal foods. A wide range of stakeholders across all sectors were involved in the transformation, including chefs, kitchen aids, the school meals management and support team, environmental food strategists, procurement officers, wholesalers, and food suppliers. Initially, the menu changes were received with suspicion and negative attitudes amongst staff, pupils, guardians and even politicians. This challenge was, however, overcome by information campaigns and educational activities that explained the reasons for the changes.

Today, the meals have generally reached a greater level of acceptance and less resistance to change. The city's procurement department has, in close collaboration with wholesalers and food suppliers, impacted policy outcomes by contracting favorable deals on organic products. Prior to the policy, the school restaurants had a centralized menu, but flexibility was encouraged so that each school could make use of a wider variety of ingredients, and having days when leftovers were served to reduce food waste and cost. To help staff cook more sustainable meals, training was provided to improve skills and confidence in sustainable food consumption and production.

By the end of 2020, both goals were achieved without increasing the food budget. All foods served in Malmö's public schools were certified organic and the greenhouse gas emissions were reduced by 40% (see **Figure 19**). Whilst this was not measured, it is assumed that this also led to a decrease in the use of pesticides and artificial fertilizers, contributing to an increase in biodiversity and less nutrient run-off. In addition to these positive climate and environmental outcomes, the importance of having clear goals, leadership, and to collaboratively work across all sectors were key findings form the work. As were education, training and communication, as well as an acceptance that change can take time. It should also be highlighted that highly skilled and knowledgeable school restaurant staff are the real change-makers.

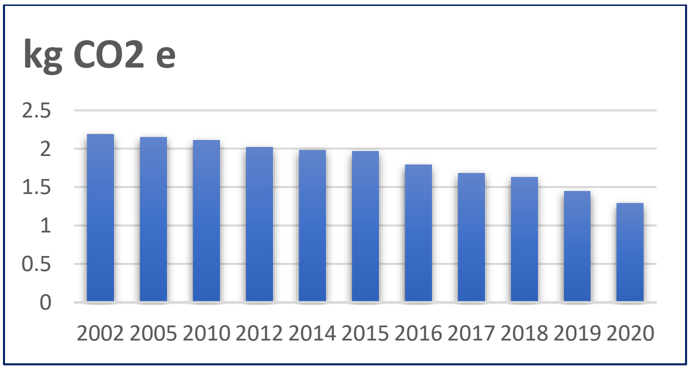


Figure 19: Reduction in greenhouse gas emissions from food procured and served in Malmö's school restaurants from 2002 till 2020

Engaging students to the development of sustainable school meals in Finland

Universal school meals program has been one of the central means to support equal access to good nutrition and education in Finland. The right to daily, wholesome meals for all has been included in the School Act since 1948. Nowadays the national nutritional and school meals recommendations guide the provisioning of the meals (NNR 2023). The sustainability aspects have been integrated into the guidelines more prominently since 2014. The new Nordic Nutrition Recommendation is a major step forward in integrating environmental aspects into wholesome diets (Blomhoff et al., 2023). In Finland the municipalities are responsible of providing food services to schools and resources for them.

In recent years the school meals providers have invested a lot in the development of sustainable school meals by developing menus with meals that are more plant-based, reducing food waste and by investing in procurement of local food. Stronger engagement of pupils in the development of sustainable school meals is important. In Finland, the number of students taking school meals has been in decline, especially in urban areas. Engaging students in meal development, and understanding their needs, is seen as a way to better understand and reverse this trend.

We have engaged pupils in the development of sustainable school meals in several research projects together with the school meals providers and schools (Kaljonen et al., 2019; Kortetmäki et al., 2021; Tykkyläinen et al., 2022). The results underline that climate considerations are important for the Finnish youth. Youth are interested and willing to shift their diets to more plant-based foods, especially in urban areas, although differences exist between gender and in rural areas (Kaljonen et al., 2019). Pupils call for bolder development of tastier and more diversified plant-based meals, with taste and mouthfeel being key ways to get youth interested in the new meals. Pupils have also shared ideas to reduce food waste and save energy in school meals provisioning. Domestic and local food is also an important value for the youth, especially in the more rural areas.

Youth see the sustainability of the school meals in a holistic way. Having time and peace to eat is the first prerequisite for sustainability. Pupils value the social meaning of the mealtime and free time with their peers (see also Baines & MacIntyre, 2022). Mealtime is an opportunity to be within the school community in a less structured manner. This is a central dimension of social and cultural sustainability, which also supports appreciation of food and building of collective values around school meals. Currently these dimensions of sustainability get under-valued in the tight school-day schedule.

Engaging students in the development of sustainable school meals can help to foster the values of school meals, in a more holistic way. The methods of engagement can include permanent student panels, taste panels for new meals, participation in catering, innovating, and preparing new school meals in home economics lessons, feed back surveys etc. In the study we used a PhotoVoice (Wang & Burris, 1997), which is a method developed to empower voices of marginal groups in society.

Using a variety of methods in student engagement is important for supporting both the rational and emotional registers related to food (Peltola et al., 2020).

Dordogne Department, France

The Dordogne Department is using an innovative management model to connect the real "nutritional" needs of school canteens with local food production, re-centering activities to enhance the skills of all stakeholders in the supply chain. Driven by President Germinal Peiro, the program has succeeded in making school canteens an exemplar model in France, engaging small-holders and local producers as partners, not spectators within local food systems.

The Dordogne Department voted for an “Eat Local in Public Foodservice" roadmap in June 2016. This integrated approach ranges from production support through to marketing and distribution. It is also committed to a 100% organic and local food supply for the colleges, as well as having a holistic approach to food; respecting operational limitations, the seasonality of products, the environment, and animal welfare; controlling costs with fair prices for producers; and promoting food education.

As part of its compulsory responsibilities, the Department directly manages the school meals of 35 colleges, representing 13,077 students. In 2019, 1.9 million meals were served in these establishments. All school meals are prepared in-house, with the support of cook trainers and a nutritionist. They use the National Agrilocal ordering platform to facilitate exchanges between colleges and suppliers in compliance with public procurement rules. They also contribute to creating the "Manger Bio Périgord," a logistic platform gathering local organic producers to facilitate market access to small-scale producers.

Kitchen staff have precisely defined roles, and training is provided (particularly for the chefs), and essential new equipment purchased where needed. Menus have been transformed from processed industrial products to cooking with local, fresh and seasonal raw ingredients. This is accompanied by educating students on healthy, and nutritious diets. The Procurement model has moved from rigidly purchasing "products", to flexibly buying seasonal food items, consistently, at a fair price from small-holder producers, with menus that are adapted weekly to match local availability.

The Department also contributes to the upstream organization of local agricultural production and supply chains by identifying production volumes; support for investing in equipment for developing farms; advice and support for farm management and set-up; support for the development of a logistics platform for the marketing and consolidation of organic and local products; and the co-financing of tools for processing local products and vegetable gardens.

The Department has been able to build a model of a healthy and local diet, mainly based on local organic agriculture and building a real food community around the project itself. It has created the conditions for which the individual schools independently develop meals based on their needs and create a food community that supports their implementation.

This model not only offers healthy and local food, strengthening the economy of the region, but it also contributes concretely to the reduction of climate-changing emissions related to food systems, reducing the kilometers travelled by food, significantly reducing the amount of packaging needed for their transport and, thanks to the implementation of a composting system to return raw material to agriculture, creating an entirely circular economy system. What’s more it has all been achieved without an increase in spend, without eliminating meat from the menu while rediscovering legumes and vegetables, in part forgotten, and using herbs and spices instead of salt to enrich the taste of the recipes.

A truly “delicious revolution," as Olivier Roellinger describes it, directly impacts over 13,000 students as well as staff involved, and their families. The outcomes of the project have potential to reach around 15% of the region’s population.

BeanMeals

BeanMeals, funded through the Transforming the UK Food System for Healthy People and a Healthy Environment SPF Program, is based on a 'fork-to-farm' concept, a reversal of the usual production-led 'farm-to-fork' model, which helps identify bottlenecks from the demand side, by starting with the meal and working backwards through the supply chain to the grower. It aims to foster innovations that require collaboration between multiple actors using systems approaches for improving dietary health with lower greenhouse gas emissions, using UK-grown beans.

BeanMeals introduces two new bean varieties (Godiva and Capulet, developed by the University of Warwick for UK growing conditions and ease of cooking), using a stepped approach:

- New bean-based recipes were introduced to lunchtime menus in the six schools between February and July 2023. This involved close collaboration with the two catering companies supplying the schools as well as the school cooks. Children could choice the bean meal or an alternative.
- Food for Life (see below) developed a classroom curriculum and training materials to support the active involvement of teachers, pupils and school cooks.
- Games designer Joanne Craven worked with several groups of primary-school children to co-design "Beantopia", a board game following the Godiva and Capulet beans' journey to the plate. The game includes several specific references to the 'climate benefits' along the journey and was enthusiastically played by the children.
- Families were chosen from two of the schools to participate in family cook and eat sessions in school using the Godiva and Capulet beans. The families benefited from cooking together, trying new recipes, and sharing recipes and food.

This initial research, based in six primary schools in the English county of Leicestershire, is helping to understand the impact of the bean-based meals and educational activities on children and capture the experiences and perspectives of key actors along the supply chain. Interviews and focus groups with school cooks and lunchtime supervisors explored their views of the opportunities and challenges of incorporating the bean-based meals into the school food menu and the educational activities into curriculum. One challenge reported by the cooks was that the dry beans needed soaking for about one hour in hot water and then cooking for 90 minutes to two hours. The use of pressure cookers would greatly reduce the cooking time and would be a very useful addition to school kitchens to facilitate future use of the beans in school meals.

Changing food education in the UK: Taste Education (TastEd)

TastEd is a way to teach children about new foods (especially fruits and vegetables) and their own senses and it is also a way to raise attainment in literacy. It is relatively new to the UK (having been piloted at Washingborough Academy in Lincolnshire as well as St Matthews Primary School in Cambridge since 2017). It has, however, been tried and tested in Scandinavian countries such as Sweden and Finland (where it is called Sapere) for several decades.

The idea of TastEd is to prevent and alleviate childhood obesity in the U.K. by equipping children with the opportunity to develop a taste for a wide variety of vegetables and fruits. These are lessons in eating, not lessons in cooking. Children learn about new foods and healthy eating in a very fun, non-judgmental environment. Rather than lecturing children about food, as some healthy eating schemes have done in the past, TastEd is founded on the idea that children learn best through actually experiencing the joys of fresh food.

The vast majority of the1000+ UK schools that have included sensory food-based education into their curriculum have shown that it is a very effective intervention for changing children's tastes and teachers have observed that children who once said they did not like eating fresh fruits and vegetables are now much more willing to choose vegetables and salad at lunchtime

TastEd lessons encourage children to talk about their likes and dislikes, adding explanations of why they do or don't like a certain food. The lessons help them to fulfil the Communication and Language requirement to answer 'how' and 'why' questions.

The aim of TastEd is to support schools with developing children's vocabulary through a multi-sensory approach to tasting and interacting with food stuffs – fruit and vegetables. Children's well-being would also be developed, understanding where their food comes from and understanding that to keep our bodies healthy we need to eat a wide range of foods. The long-term aim is to help children develop a taste for a range of fruits and vegetables as well as building up their vocabulary and self-expression around food.

TastEd equips children with new sensory tools for trying foods that they do not like. Children who are reluctant to try new foods are told that they can smell or lick them instead.

A further aim is that TastEd supports the national curriculum in PSHE/PSED as children are encouraged to understand that not everyone likes the same foods, but we can all respect each other's different tastes.

Pacific School Food Network

The Pacific School Food Network (PSFN) is a recent but growing regional network that aspires to connect stakeholders from across food systems, including primary producers, educators and nutrition and health experts, to support the advocacy, development and establishment of activities that result in the provision of food and nutrition education activities in Pacific Island Countries (Burkhart et al., 2022).

Against the backdrop of a nutrition transition, under- and over-nutrition and significant non-communicable disease rates, the Pacific Islands are at the forefront of, and disproportionally impacted by climate change (Andrew et al., 2022; Burkhart et al., 2022). The geographical dispersion of countries and territories in this region can make collaboration and communication challenging (Burkhart et al., 2023). There is recognition of the role of healthy dietary patterns in Pacific Island communities, however food environments are changing rapidly, making healthy food choice more challenging.

Large scale, traditional school feeding programs are not commonplace in the Pacific Islands region (Burkhart et al., 2022, 2023) However, there is increasing interest and momentum towards the use of these, especially with models that could support and promote the integration of local, traditional climate-resilient, nutrient rich foods.

School feeding programs present a significant opportunity within the region to ensure food and nutritional security, support local livelihoods, and increase food literacy through education for both students and the wider school community (Burkhart et al., 2022, 2023). In the Pacific Islands there are high school attendance rates and schools are a central part of the community, supporting a 'whole of community approach' (Burkhart et al., 2023).

Members of the PSFN are currently engaged in projects that support healthier school food environments, promote the use of school gardens, support the development, implementation and monitoring of policy, support nutrition education, and investigate what home-grown school feeding in the region might look like.

This work to date has shown an appetite for school feeding programs, and when these are not yet viewed as a feasible option, other school food and nutrition activities. Activities to map school food and nutrition programs are now providing more information on the types of activities currently underway and planned for, and opportunities to share and collaborate. Efforts to understand what homegrown school feeding might look like in the region are in progress, with plans to trial the model(s) that are identified from this work. Although many challenges exist, for example, limited agricultural productivity due to limited land area for farming and differing soil types (some islands are atolls), there are many local, traditional climate-resilient, nutrient rich foods that could be incorporated into school feeding programs and other school-based food and nutrition activities.

The PSFN looks forward to continuing to provide opportunities for collaboration, networking, and capacity building, acting as a forum for technical input and policy guidance, leadership and advocacy for healthier school food environments in the Pacific Islands region using climate resilient, nutrient rich local, traditional foods.

ProVeg UK's School Plates Awards

ProVeg UK, a not-for-profit organization that supports any school caterer in the UK, free of charge, aims to make school food both healthier and more sustainable through the reduction of animal products (including 'blending' plant protein and vegetables in meat-based dishes) and the increase of predominantly whole food plant-based lunch options. In the UK it has supported, is supporting, or in discussions with over 25% of all local authorities in the UK with responsibility for school food.

The School Food Standards in England offer nutritional guidance for planning and providing food in schools in England. They are applicable to all local-authority-maintained schools, pupil referral units, academies and free schools, and non-maintained special schools. The current Standards aim to ensure vegetables, protein, and unrefined starchy foods are key features of menus.

ProVeg's experience is that local authority caterers are very aware of, and typically adhere to, the School Food Standards strictly. However, many don't understand how to interpret the standards accurately and feel they are ambiguous in places. Many school caterers have also expressed the opinion that they would like to serve more vegetarian and fully plant-based dishes than the Standards allow.

ProVeg creates planet-friendly, plant-based, low carbon, low cost, nutritionally balanced recipes for schools that comply with the School Food Standards. These dishes appear on menus in thousands of schools across the UK. Schools are incentivized to positively change menus through ProVeg UK's menu accreditation scheme, the ProVeg School Plates Awards. This recognizes the positive steps taken by school caterers to create healthier and more sustainable menus. School caterers submit their menus to be scored against the checklist of evidence-based actions to progress towards a Bronze, Silver or Gold award.

ProVeg provides plant-based cooking in schools workshops for local authorities and multi academy trusts in the UK, free of charge. These workshops aim to inspire school caterers about plant-based food and build their confidence to create delicious dishes for children. There is also a certificate of completion for all who take part. ProVeg has also created an online version of the workshop in response to demand from individual schools. 100% of respondents recommended the workshops to other school caterers, and confidence to create good quality, plant-based food for children increased among workshop participants.

In addition to this, ProVeg has created recipes with photos, key nutrition facts and carbon labelling in its free resource, The Recipes, the UK's first fully plant-based recipe resource designed specifically for schools.

This program positively impacts the menus in over 6,000 schools across the UK and over 1 million children eat from these menus every day, helping to ensure school caterers are aware of the facts around the health of children and the health of the planet, and the significant role food plays in both.

School Gardens in the Philippines: Addressing the Nutrition, Climate Change and Biodiversity Nexus

The Philippines, like many emerging economies in Southeast Asia, is in a "nutrition transition", which involves a downward trend in the consumption of fruits and vegetables and an increased consumption of meat, fats and oil, milk, and sugars (Popkin, 2001). Nutrition transition, together with intensive agriculture and environmental pressures, is also a result of reduced dietary diversity as well as loss in agrobiodiversity and associated traditional knowledge (Burlingame & Dernini, 2012)

Losses in agrobiodiversity and dietary diversity are leading to increasing rates of malnutrition among Filipino children. Obesity rate among school-aged children (5-10 years old) has increased over the years, from 9% in 2013 to 14% in 2021. The Philippines ranks 5th in the Asia-Pacific Region with a high prevalence of stunting (27% in 2021) (FNRI-DOST, 2022). Connections of children and communities to backyard gardening and family farming where agrobiodiversity has been traditionally practiced is being lost, knowledge of grandparents who relied on a diversity of plants and animals for food and nutrition is not being passed on to the new generation. Children and youth are not anymore familiar with the many nutritious vegetables, fruits, nuts and seeds available in the wild or in traditional systems (Luci-Atienza, 2021).

In the Philippines, the Gulayan sa Paaralan Program (GPP)[32] of the Department of Education issued a memorandum that explicitly stated that garden outputs shall be used for school feeding programs. Based on individual school assessments, GPP effectively provided vegetables for the school feeding programs and one study mentioned that school children's consumption of vegetables improved after the introduction of nutritional garden initiatives. (Umali et al., 2023)

In partnership with the Philippines Department of Education (DepEd) and the Food and Nutrition Research Institute of the Department of Science and Technology (FNRI-DOST), IIRR developed and tested the Integrated School Nutrition Model (ISNM) that links school gardening, supplementary feeding, and nutrition education through a five-year action research project (2012-2018) with support from the International Development Research Centre-Canada (IDRC).

The project strategically delivered nutrition interventions to public school children aged 5-12, and indirectly, to their families and communities (Hunter et al., 2020b). From 27 schools in Cavite Province in 2012, the program was out scaled in 2016 through a network of 58 "lighthouse schools", which served as learning hubs, while providing evidence for integrated nutrition approaches in Region 4A (8).

In 2016, DepEd issued a memorandum endorsing the concepts of lighthouse schools and crop museums in implementing the Gulayan sa Paaralan Program (GPP) to promote school gardens in public schools (Philippines Department of Education, 2016). In 2022, DepEd and IIRR signed a Memorandum of Agreement (MOA) covering five years to scale up implementation of the Integrated School Nutrition Model (ISNM) including the school gardens program. (Philippines Department of Education & IIRR, 2022).

The lighthouse schools[33], in operation for more than 5 years, have effectively promoted biodiverse garden systems, conserved cultivars of traditional and locally adapted vegetables which strengthen dietary diversity and consumption of nutrient-dense fruits and vegetables. This is strengthened by school gardens as learning laboratories to provide students with knowledge on climate resilient approaches such as water-conserving strategies and Bio-intensive gardening practices, introduced by the International Institute or Rural Reconstruction.

32 Gulayan sa Paaralan Program, a school-based gardening program in the Philippines, aimed to boost fruit and vegetable production to supply the needs of the SBFP, other school feeding programs, and promote food security in schools and homes.

33 https://schoolnutritionphils.files.wordpress.com/2018/05/ls-primer-final-draft.pdf

School Gardens in the Philippines: learning and education for nutrition sensitive and climate smart approaches

Recognizing the need for a sustainable food source for school feeding initiatives, the Philippines Department of Education (DepEd) initiated the Gulayan sa Paaralan Program (GPP), a school gardening program, which seeks to enhance food security within both public schools and local communities by encouraging self-sustaining food production efforts and cultivating a deeper understanding of agriculture as a vital support system for life (Umali et al., 2023). GPP is currently being implemented in all DepEd schools nationwide.

The Philippine Government and especially the DepEd has been a pioneer on school garden approaches through the GPP. A wide range of approaches have been used over the years. The International Institute of Rural Reconstruction, over the past ten years, has introduced principles that feature soil regeneration, conservation of local biodiversity known to be climate-resilient, nutrient-dense and of relevance to ongoing school-based feeding efforts. DepEd has set up and supported networks of crop museums which feature locally important vegetable biodiversity (Oro et al., 2018).

School-based gardens and crop museums serve as repositories for diversity and as source of seed diversity kits for students and communities (Anunciado et al., 2023). Crop museums are platforms for learning about nutrition, food systems and food safety, science, environment and good health. A diverse range of nutritionally relevant and climate-hardy vegetable varieties and agroecological methods are demonstrated in a crop museum. Crop museums are located within the network of lighthouse schools within the DepEd infrastructure, serving as action research sites, demonstration and learning hubs (IIRR 2017).

Bio-intensive gardens (BIG) provide opportunities to demonstrate nutrition-sensitive and climate-smart agriculture, SAFE FOOD and RESILIENT GARDEN. Bio-intensive gardens are a biological (organic) form of gardening compatible with other initiatives (container gardens, landscape and edible gardens). Gardens mimic nature: birds, butterflies and natural predators. Both below and above ground biodiversity are featured. Diversity in a garden result in an immediate drop in pest populations, creates micro-climates (evaporation rates differ) and different demands on soil nutrient nutrients (Gonsalves et al., 2017; Hunter et al., 2020b).

Nutrition sensitivity can be achieved via a diverse garden: at least 12 to 15 crops (inter-species and intra-species diversity). BIG features locally adapted crops and varieties that withstand low fertility conditions and adverse environments. To reduce climate and pest risks and ensure nutritional diversity, (at least) 60% should be indigenous crops (Gonsalves et al., 2017).

Nearly every school in the Dept of Education efforts of the Bureau of Learner Support Services in the Philippines uses in schools as centers for discovery, learning and education on biodiversity-friendly and nature-friendly approaches With a national network of 273 Lighthouse schools and 5,000 crop museums (Anunciado et al., 2023), the Philippine Dept of Education has emerged as a pioneer in supporting garden-based informal education for both students and communities, while also serving as source of climate-resilient crop cultivars. Whatever the approach used for school-based feeding, gardens provide supplementary nutrients to those efforts. What school gardens grow are invariably rich in fiber, micronutrients and iron, calcium and magnesium. School gardens source produce is usually totally herbicide and insecticide free (in most cases indigenous and locally adapted crops are resilient or tolerant to pests). That these mentioned approaches are complementary to feeding based on Iron Fortified rice has already been demonstrated in the past in a joint effort of the DOST FNRI and IIRR (Oro et al., 2018). Future efforts to enhance school-based feeding can build on two decades of success demonstrated by the Dept of Education and its partners the Dept of Agriculture and other partners.

The Slow Food Gardens in Africa

Since 2010 Slow Food has been supporting its African network in developing agroecological gardens all over the continent. Slow Food gardens can be community or school gardens, and they follow a decalogue of principles that are more about concepts than concrete boundaries, to allow for adaptation to local circumstances[34].

The Slow Food Gardens in Africa program offers numerous benefits to local communities. It promotes biodiversity by growing a variety of crops, it supports sustainable agriculture practices, and it provides fresh and nutritious food to the community. These gardens also create income opportunities for local farmers and foster community engagement by bringing people together to work on the gardens, share knowledge, and celebrate local food traditions. Overall, Slow Food Gardens in Africa offer a holistic approach to food production that promotes sustainability, biodiversity, and community engagement.

The objectives of the program mirror the core values of Slow Food, focusing on a collective effort to overcome the major challenges food systems are facing, while preserving the environment and the right of people to eat healthy and culturally appropriate food.

The program aims to defend biodiversity and is an essential tool to achieve food sovereignty in African countries. By combining the data on agroecological practices, communities' participation in decision making, and the gardens' food production, more than half (56%) of the gardens monitored have achieved food sovereignty status.

Key achievements of the program in 2022 have included:

- *Biodiversity*: The large majority of crops grown in Slow Food gardens are local varieties; and almost 40% are species or varieties at risk of extinction. As of now, only 19% of the crops grown in the gardens are registered in the Ark of Taste (registered crops at risk of extinction). Slow Food aims at doubling this share in three years.

- *Education*: Virtually all the gardens monitored in 2022 stated that 'training/learning about sustainable gardening', and 'being part of a network', were either important, or very important objectives.

- *Advocacy*: Slow Food Gardens contribute to train and empower individuals and communities to become advocates for the necessary transition to fair and sustainable policies. In 2022, 795 people, including 109 students, had a role in the governance of the Gardens. Women were the majority in most roles.

34 https://www.slowfood.org.uk/10000-gardens-in-africa/

LOMA-Local Food in Schools

LOMA is an abbreviation for 'LOkal MAd' in Danish; 'local food' in English. It is the name of a school meals program that applies an integrated perspective on student participation in planning, preparing, serving and learning about food (Jones et al., 2022; Ruge et al., 2016).

The background for this planet-friendly initiative was the situation in Denmark with no national school food program. This means that parents are responsible for children's intake of food during schooldays. However, as parents are not present in schools, this constitutes a difficult task for parents. Studies have shown that many children in Danish schools are often hungry during schooldays. Most families will have to go to the supermarket for food, so the-packed-lunch-from-home is rather food-bought-in-the-supermarket (Ruge & Lennert, 2021). This mechanism facilitates supermarket's use of 'the packed lunch' as a vehicle for marketing of a wide range of sugary, fat and salty commodities, both for school children's food and for the family.

After the establishment of the first LOMA school at Nymarkskolen in Svendborg, 2013, the good results facilitated new funding for scaling-up to six schools in four municipalities. The Danish Evaluation Institute evaluated the project and concluded that the LOMA-school food approach promoted student motivation for trying new food and for collaboration around planning, cooking and serving food for peers (EVA, 2017). Another outcome was improved enthusiasm among children for 'being active' during the educational activities and to obtain improved relations between pupils and their teachers during LOMA activities. During 2017-2020 all LOMA schools implemented the activities, however the covid-pandemic had a negative impact on the LOMA-canteens, because of school closure for longer periods of time.

This dynamic underlined the importance of school food being 'free for all students' and independent of parental payment. From 2020-2023 it has become increasingly difficult to obtain public or private funding to support free school meals, despite the good results regarding student's health and learning. Therefore, we mostly see 'local level solutions' at individual schools in Denmark during these years. An example of this is a new LOMA School, Østerbyskolen in Vejen Municipality, that has adopted the LOMA principles to their local conditions. The National LOMA-Local Food Association is giving advice to new schools and currently, this constitutes a meaningful activity that can inspire other schools via social media and Nordic collaboration in the LEARNFOOD 2 project

Nymarkskolen, recently had their 10 Year LOMA jubilee. UCL University College has been following the development, implementation and maintenance process in order to be able to provide evidence on the degree LOMA could be regarded as a contribution to public health and social innovation. This was evaluated by applying the RE-AIM framework (Ruge & Villebro, 2023). The social innovation part is related to the local sourcing of fresh produce from local suppliers. The contracts with the local suppliers include several criteria that could encourage local suppliers: fresh produce, reduction of food miles, organic products in season and other criteria that are included in EU regulation. Most importantly, the addition of a criteria for suppliers to also participate in educational activities, such as school visits and guest-teachers, provides local farmers and suppliers with good options for a contract during the municipal tender process. According to kitchen manager, Camilla Suna, the following numbers can be shared: "During the last 10 years, we have had approximately 3600 students participated in cooking LOMA meals in the kitchen. The number of produced lunch meals is estimated (250 meals a day; 5 days a week; 39 school weeks; during 10 years): 487,500meals. In addition, the kitchen has produced buns and healthy snacks. The locally produced part of the food is estimated to 50% on average, which indicates that there has been a significant planet-friendly impact from the LOMA-local food kitchen. More research into the 'social return of investment' that is related to the LOMA approach will be initiated.

Food for Life: championing every child's right to healthy and sustainable school food

The Soil Association's Food for Life program has been running since 2003, across England and has been commissioned by the Scottish government. At the center of the program is Served Here, an accreditation scheme verifying that schools and caterers are serving healthy meals, cooked from seasonal and more sustainable ingredients. Using a tiered framework that progresses from bronze to silver to gold, caterers are supported to improve their menus, to demonstrate benefits for animal welfare, nature, and the climate. To achieve a Food for Life Served Here (FFLSH) award, Local Authorities must demonstrate their school meals will always serve food that complies with national nutritional guidelines, with the majority freshly prepared from scratch using unprocessed ingredients, using only: higher welfare meat, sustainable fish and free-range eggs. As well as food that are free from undesirable additives, trans fats, and genetically modified ingredients, and with menus that make the most of seasonal ingredients and locally sourced produce, prepared by skilled and knowledgeable catering staff.

Evidence of impact is primarily delivered through associated assurance schemes. This has the potential to deliver climate, nature and welfare benefits. Organic farms can have on average 50% more abundant wildlife, including almost 50% more pollinator species and 22% more bird species, compared to non-organic (Bengtsson et al., 2005). Organic farmed soils can support climate change mitigation, sequestering on average up to 450kg more carbon per hectare than non-organic farm soils (Gattinger et al., 2012). If 10% of UK land was organic, this could result in a reduction of 2Mt CO_2e and increased carbon sequestration, worth over £40 million annually. (Lampkin, 2020). The Alliance to Save our Antibiotics also report that organic foods better support animal welfare and have lower antibiotic use. (Alliance to Save our Antibiotics, 2022).

Beyond the provision of healthy and sustainable school meals, Food for Life also offers a Schools Award that supports schools to take a 'whole school approach', giving pupils voice, delivering cooking and growing activities plus farm visits, positioning good food at the center of the school day. Independent evaluation has shown that this approach has a marked impact on children's eating behaviors, with children in Food for Life schools twice as likely to eat five portions of fruit and veg per day, and a third more fruit and veg overall, compared to children in other schools. Alongside the provision of 'less and better' meat, Food for Life thereby helps to normalize more sustainable, plant-rich dietary patterns, championing every child's right to a healthy and sustainable school meal.

Healthy and sustainable school meals in Milan

The City of Milan has a strong tradition of public school meals. The history of this service started back in 1900 with the aim of promoting access to school for all and particularly to the most vulnerable. Several changes occurred across the years: the meals that were characterized by meat, sliced bread and ham, became healthier while at the same time sustainable. Furthermore, many educational activities have been introduced to involve kids and parents. The school canteen service is provided by Milano Ristorazione, an 'in-house company' owned by the Municipality of Milan. This gave the chance to keep the service public-oriented and to create a fruitful environment to cooperate to promote a shift toward more sustainable and healthy diets among schoolchildren.

Since 2015, the City of Milan developed a Food Policy[35] that has among its main priorities, to guarantee access to food for all. This goal is strongly promoted through the school canteen service as Milano Ristorazione serves today almost 80,000 meals per day from kindergarten to secondary schools. The cooperation between the City and the company has strengthened and increased the opportunity to work on the sustainability of the service as a whole: from preparation to the delivery of the meals with a strong focus on the menus. Progressively, since 2014 the company has worked toward the reduction of plastic and a major revision of the menus' ingredients and recipes started in 2015, in order to address both health and sustainability.

Thanks to the participation in the international monitoring program Cool Food Pledge promoted by World Resources Institute since 2019, Milan was able to monitor the decrease of the impact of its menus related to the changes implemented, considering the GHG related emissions in the last 7 years. The data related to the period 2015-2021 stated that the City increased its performance, reaching the reduction of almost 42% of GHG related emissions. The City of Milan obtained this important result due to major changes such as: meat reduction; increase of legumes (e.g. lentils and chickpeas), vegetables and eggs products; promotion of public water distributed through jars on the table; promotion of food waste reduction practices such as school doggy bags (Sacchetto Salvamerenda) or food surpluses collection from charities; programs such as "Middle Morning fruit - Frutta a metà mattina", that promotes healthy snacks in the morning break at primary schools while reducing food waste as kids feel hungrier at lunch time.

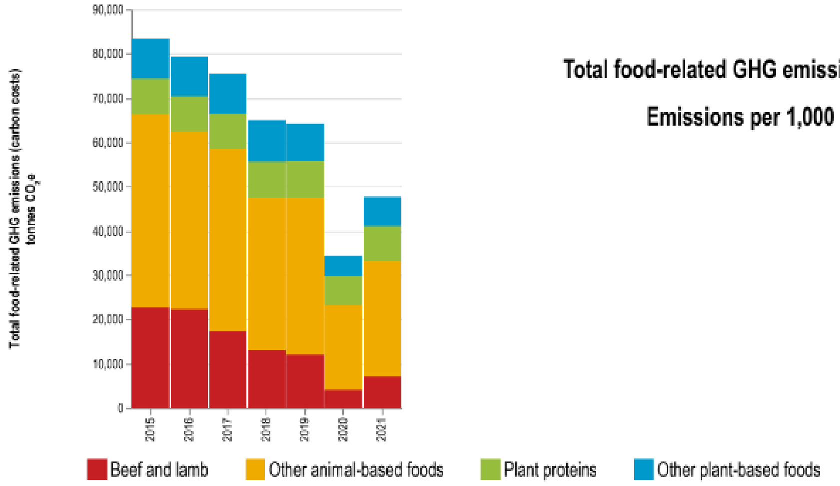
Participation in this international program helped the city to increase its efforts on sustainable procurement through Milano Ristorazione and to focus on the implementation of strategies to promote short supply chain, the purchase of organic food, the continuous research and development on recipes that could be delicious, healthy and sustainable at the same time.

Through the application of the calculation of the total amount of GHG related emissions per food category, the municipality has also started to analyze each single plate and menu to have a better understanding of the possible changes to further promote the upgrade on sustainability.

In this framework, all actions have been accompanied by informative newsletters for parents, social media activities and educational activities for kids and families also in the kitchen centers, to share results and impact among all stakeholders. Particularly effective have been 3 booklets dedicated to children from 3 to 10, on issues of healthy and sustainable diets, fruit and vegetables consumption, food waste reduction and local markets, as well as farms to buy fresh and local products. New actions will be dedicated to chefs and parents to increase the appreciation of the meals and to raise awareness among different stakeholders on the value of healthy and sustainable meals, such as training for chefs and educational activities with farm twinning practices and urban gardening in schools.

35 Milan Food Policy, https://foodpolicymilano.org/

City of Milan: total food-related emissions (2015-2021)



	% change
Total food-related GHG emissions	-42.89%
Emissions per 1,000 kcal	-28.38%

Sources: Purchase data provided by member. Emission factors from Poore and Nemecek (2018) (agricultural supply chain) and Searchinger et al. (2018) (carbon opportunity costs).

COOL FOOD*

Figure 20: City of Milan 2021, Cool Food Pledge

Sustainable Diets & Nutrition in cities: the Milan Urban Food Policy Pact experience

The City of Milan is actively working on the issue of school feeding programs also at an international level. Indeed, in 2015 Milan launched the first and foremost international agreement among cities committed to developing sustainable, inclusive and resilient urban food systems: the Milan Urban Food Policy Pact (MUFPP).

At the time of writing, there are more than 270 signatory cities, and the Pact's mission is to constantly work to promote the knowledge exchange among Mayors through the sharing of best practices.

Undoubtedly, one of the priority areas of the network relates to school feeding programs as they represent a powerful driver of urban food policies through which cities can achieve multiple cascading objectives: promoting sustainable food consumption for children and facilitating the shift to a healthy and sustainable diet; fighting against food poverty; working on health prevention and healthy food habits; focusing on improving school canteen procurement to reduce GHG emissions; strengthening rural-urban linkages; raising awareness among children on food waste.

These objectives are also at the core of the MUFPP Framework for Action: indeed, there is a whole category on "Sustainable Diets & Nutrition" which is primarily linked to school meals. Many cities are also working on this topic under other relevant categories, such as "Food Production" and "Social & Economic Equity". What is more, the MUFPP Monitoring Framework developed with FAO and RUAF, has devoted indicators specifically on the topic of school meals that support cities in assessing and monitoring their policies.

Through the knowledge exchange promoted by the Milan Pact Awards, it is clear that cities in the network are highly engaged on this matter, showcasing their own experience and achievements, demonstrating a wealth of approaches and perspectives to the issue. Thanks to the expertise acquired both at local and at international level, over these 8 years the City of Milan has hosted over 50 delegations interested in learning more about its school canteens' model.

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Appendix

APPENDIX

A1. NUTRIENT BASED REQUIREMENTS FOR SCHOOL AGE CHILDREN.

On food and nutrient based requirements for school age children. Dietary needs can be characterized in terms of food-based and nutrient-based approaches. Food-based approaches typically reference food-based dietary guidelines that describe dietary patterns associated with improved health outcomes or protection against diet-related non-communicable diseases (WHO, 2021). A review of nutrition guidelines and standards for school meals in 33 LIMCs found that most commonly, food-based standards defined portion size, preferences and restrictions for cereals, grains and tubers, followed by provisions and frequency of fruits and animal source foods, and to a lesser degree on the provision of vegetables, legumes and milk and dairy (FAO 2019). Restrictions on processed foods, including sugar sweetened products were less prominent. Fruit- and vegetable-related standards centered on frequency of consumption (ranging from twice a week to daily) and portion size requirements (ranging from 100g to 150g), with restrictions on canned or pickled vegetables. With regards to animal-source foods, frequency and portion sizes requirements varied by type of food, with restrictions typically involving processed, cured, canned and fatty meats.

Nutrient-based approaches involve the use of nutrient reference values (NRV). NRVs are used to assess the adequacy of intake in population groups and design interventions to address gaps in nutrient intake. Various sources exist for NRVs and recent efforts have been made to propose a set of harmonized NRVs for populations (Allen et al., 2020). The average requirement (AR) is defined as the average daily nutrient intake that is estimated to meet the requirements of half of the healthy individuals in a particular life stage and sex (**Figure 21**). Similarly, the recommended intake is the average daily nutrient intake that is sufficient to meet the nutrient requirements of nearly all (97–98%) healthy individuals in a particular life stage and sex. As such, using recommended intakes (e.g RDAs) will yield overestimates when measuring inadequacies at the population level. Though specific targets vary by context, and NRVs vary by child age and sex, school meal programs in LMICS are often designed to meet 30% of the daily nutrient requirements for primary school age children (FAO, 2019a).

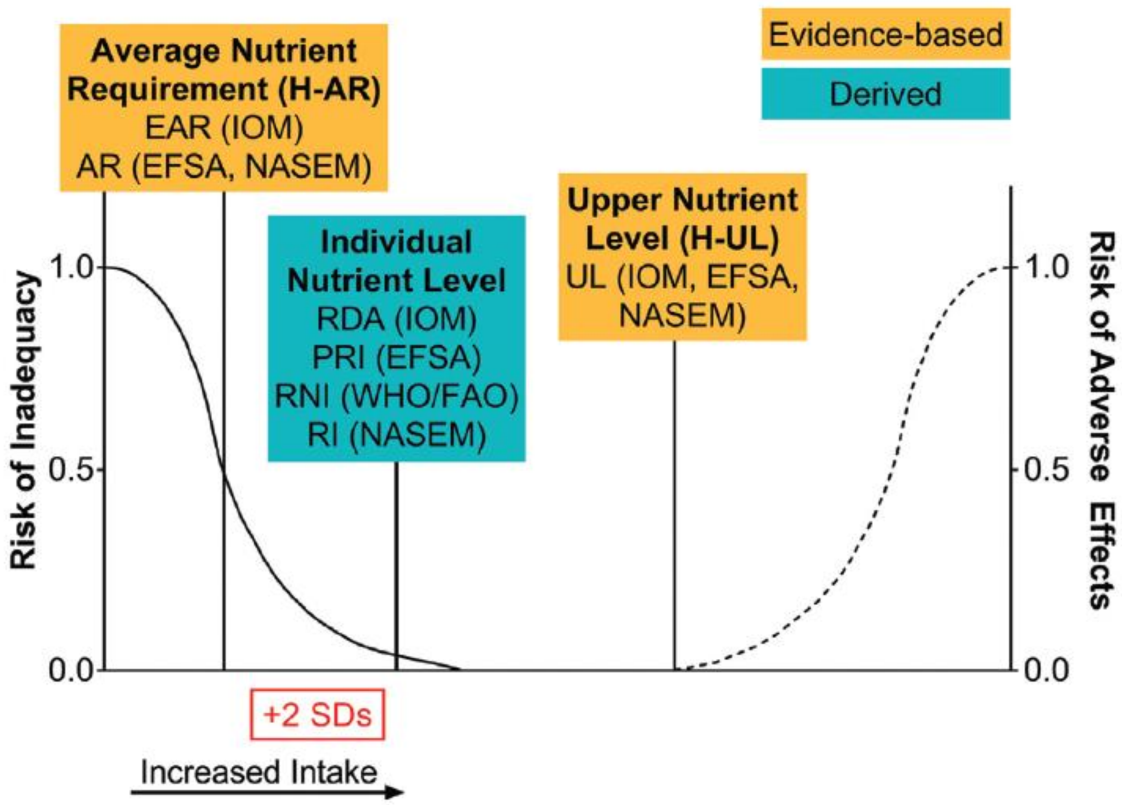


Figure 21: Distribution and terminology for nutrient reference values. IOM (1); EFSA (9); WHO/FAO (11); NASEM (16). AR, average requirement; EAR, estimated average requirement; EFSA, European Food Safety Authority; H-AR, harmonized average requirement; H-UL, harm

Factors to consider when developing menus and meal plans (Source: Adapted from Galloway, 2010):

- Food composition and food groupings
- Seasonal availability of foods.
- Food prices and costs of preparation.
- Food transportation and storage.
- Food processing requirements.
- Food preparation limitations based on available facilities, fuel, cooking utensils, and water.
- Potential food safety and contamination.
- Environmental footprint of food supply chain (e.g., greenhouse gas emissions).
- Potential for smallholder farmers sourcing.
- Acceptability and food preferences of school children.

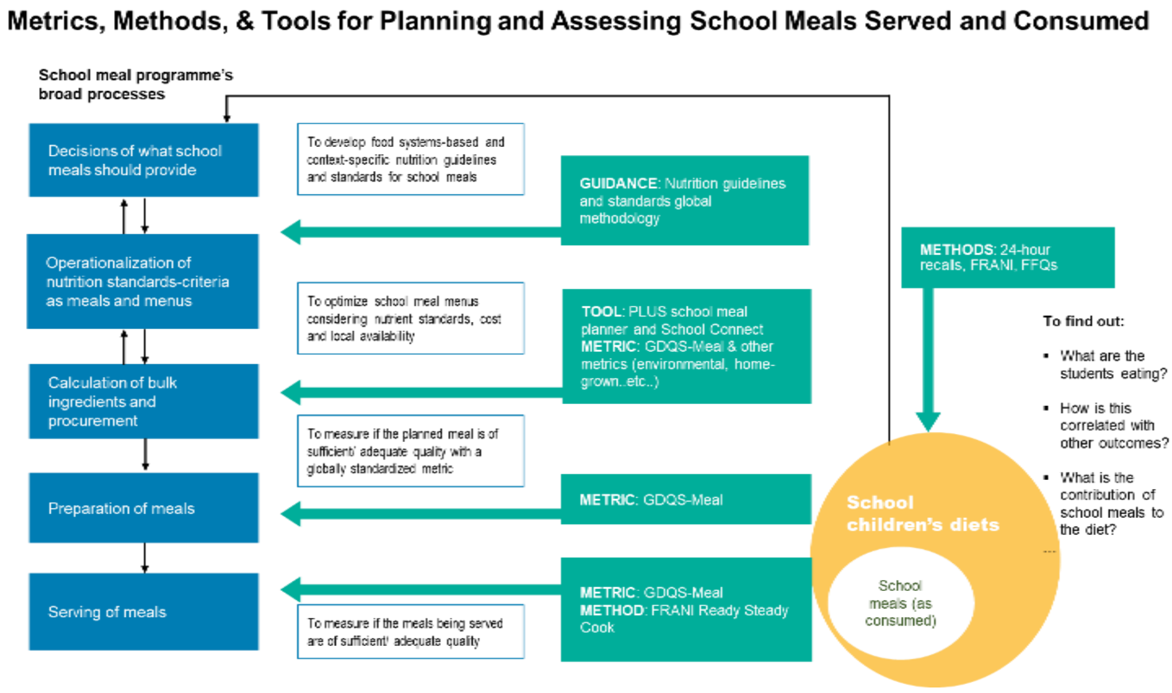


Figure 22: Stylized view of key process for monitoring school meal quality and the school meal data chain. GDQS: Global Diet Quality Score; FFQ, Food frequency; FRANI, Food Recognition and Nudging Insights.

A2. THE PLANETARY HEALTH DIET

The planetary health diet is flexible by providing guidelines to ranges of different food groups that together constitute an optimal diet for human health and environmental sustainability. It emphasizes a plant-forward diet where whole grains, fruits, vegetables, nuts and legumes comprise a greater proportion of foods consumed. Meat and dairy constitute important parts of the diet but in significantly smaller proportions than whole grains, fruits, vegetables, nuts and legumes. In addition to the targets set within each section, the dietary targets also suggest that the average adult requires 2500 kcal per day. While this amount will vary based on age, gender, activity levels and health profiles, overconsumption is a waste of food with both health and environmental costs (Willett et al., 2019).

Figure 23: The planetary health diet

A3. NORDIC NUTRITION RECOMMENDATIONS: FOOD GROUPS FOR ADULTS

Taken from The Nordic Nutrition Recommendations 2023 (NNR 2023)

Table 2: Science advice for food groups for adults (p.99-102)

Food group	Health effects of foods on chronic diseases not attributed to specific nutrients	Health effects of foods based on nutritional adequacy and effects of specific nutrients	Environmental impacts of foods consumed	Advice to authorities in Nordic and Baltic countries
Beverages	A moderate intake of coffee may reduce the risk of some cancers. High intake of unfiltered coffee may increase LDL-cholesterol levels. High SSB consumption probably increases risk of obesity, CVD, type 2 diabetes and dental caries.	Negative health effects of caffeine more than 400 mg/d. SSB consumption displaces nutrient-dense foods and may contribute to excess energy and added sugars intake.	The high coffee consumption can contribute to a higher total environmental footprint in the Nordic and Baltic diet and consumption should therefore be limited. High-quality tap water should be the preferred choice before SSB, LNCSB and bottled water.	Moderate consumption of filtered coffee (about 1-4 cups/day) and tea may be part of a healthy diet. The total consumption of caffeine from all sources should be limited to 400 mg caffeine/day. For children, a safe level of caffeine intake is 3 mg per kg body weight per day. Consumption of unfiltered coffee and SSB should be limited.
Cereals	Intake of at least 90 grams/day (dry weight) of whole grains (including whole grains in products), reduces the risk of CVD, CRC, T2D and premature mortality, with likely further benefits of higher intakes.	Contribute with fiber and many essential nutrients, such as thiamin, folate, vitamin E, iron, and zinc.	Due to the low climate impact of cereals and cereal-based foods, rice being an exception, they are key foods in the transition to an environment-friendly diet.	It is recommended to have an intake of at least 90 grams/day of whole grains (including whole grains in products), with likely further benefits of higher intakes. Whole-grain cereals other than rice should preferentially be used.
Vegetables, fruits, berries	High consumption (500-800 grams/day) reduces the risk of several cancers, CVD, premature mortality.	Contribute with fiber and many essential nutrients, such as dietary fiber, vitamin C, vitamin E, vitamin K, folate, and potassium. Cruciferous vegetables provide calcium, and leafy green vegetables	Vegetables fruits and berries have in general low climate and environmental impact/footprints per weight unit. Environmental impacts are mainly related to pesticide use and impacts on biodiversity, locally	It is recommended to consume a variety of vegetables, fruits, and berries, 500-800 grams, or more, per day in total. A variety of different types of both vegetables and fruits (including

		provides, iron, zinc, calcium, magnesium, carotenoids.	and globally. Fruits and vegetables that store well will reduce waste and thereby reduce negative impacts.	berries) should be consumed, with emphasis on dietary fiber contribution (potatoes and pulses are not included). Limit intake of products prepared with added/free sugars. Please refer to separate recommendation on fruit juice.
Potatoes	Not sufficient evidence to inform a quantitative FBDG	Common staple food, contribute with fiber and many essential nutrients. Negative health effects of potato products with added salt and fat.	The environmental impacts are among the lowest among food products, supporting potatoes as part of a plant-based healthy diet.	Potatoes can be part of a healthy and environmentally friendly diet. Potatoes should be included as a significant part in the regular dietary pattern in the Nordic and Baltic countries. Intake of boiled or baked potatoes and potatoes prepared with low content of fat and salt should be preferred. Intake of deep-fried potatoes should be limited.
Fruit juice	Not sufficient evidence to inform a quantitative FBDG.	Contributes with energy and many essential nutrients. May contribute with fiber.	Climate and environmental impact of fruit juice depend on the fruits and berries they contain, and climate impact is generally low.	Low to moderate intake of fruit juice may be part of a healthy diet. Intake of fruit juice should be limited for children.
Pulses	Intake of pulses may protect against cancer and premature mortality. Not sufficient evidence to inform a quantitative FBDG.	Contribute with protein, fiber and many essential nutrients such as folate, potassium, magnesium, iron, zinc, and thiamine, as well as bioactive compounds such as phytochemicals.	Pulses have low climate impact while environmental impacts vary depending on production method and production site.	Pulses should be included as a significant part in the regular dietary pattern in the Nordic and Baltic countries. Pulses are important providers of nutrients such as dietary fiber, protein iron and zinc.

Nuts and seeds	Reduced risk of CVD from intake of 20-30 grams/day.	High nutrient density. Contribute with unsaturated fatty acids, protein, fiber and micronutrients.	Nuts and seeds have a low GHG emissions. However, when increased consumption is achieved, more detailed recommendations are warranted to avoid the potential water stress and biodiversity loss associated with nut and seed consumption.	It is recommended to consume 20-30 grams nuts per day. It is also recommended to include seeds in the diet due to the nutrient content; however, evidence for a certain quantity is not available. Nuts and seeds are important in plant-based diets as they have a low GHG emissions and a high nutrient density.
Fish	Intake of 300-450 grams/week (of which at least 200 grams fatty fish/week) reduces risk of CVD, Alzheimer's disease, cognitive decline, and premature mortality.	Contribute to n-3 fatty acids and essential nutrients such as protein, vitamin D, vitamin B12 and iodine.	Fish and seafood from sustainably managed farms and wild stocks should be prioritized and consumption of species with high environmental impact should be limited.	It is recommended to consume 300–450 grams/week (ready-to-eat or cooked weight), of which at least 200 grams/week should be fatty fish. It is recommended to consume fish from sustainably managed fish stocks.
Red meat	Intake above 350 grams/week increases the risk of CRC. Intake of processed meat increases risk of CRC.	Contributes with many essential nutrients, such as iron and vitamin B12.	High environmental impact. The high consumption of red meat is the most important contributor to GHG emissions from the diet in the Nordic and Baltic countries. Negative environmental impact is related to methane emissions from ruminants, and feed which contribute through fertilizer, pesticide, water and land use and thereby reduced biodiversity. Positive environmental impact may be related to grazing and biodiversity.	For health reasons, it is recommended that consumption of red meat (including red meat in products and processed foods) should be low and not exceed 350 grams/week ready-to-eat (cooked) weight. Processed red meat should be as low as possible. For environmental reasons the consumption of red meat should be considerably lower than 350 grams/week (ready-to-eat weight). The choice of meat should comply with the

			GHG emission from pigs is lower than ruminants but there are environmental issues related to the feed production and manure management.	recommendations for fatty acids. The reduction of red meat consumption should not result in an increase in white meat consumption. To minimize environmental impact, meat consumption should be replaced by increased consumption of plant foods, such as legumes and fish from sustainably managed stocks.
White meat (poultry)	Not sufficient evidence to inform a quantitative FBDG. Intake of processed meat increases risk of CRC.	Contributes with many essential nutrients, such as protein, iron and vitamin B12.	In general, lower environmental impact across many environmental metrics compared to red meat. Negative environmental impact is related to feed production and manure management. Due to negative environmental impacts, it is not desirable to increase white meat consumption from current levels.	It is recommended that consumption of processed white meat should be as low as possible. To minimize environmental impact, consumption of white meat should not be increased from current levels, and may be lower. Instead, total meat consumption should be replaced by increased consumption of plant foods, such as legumes and fish from sustainably managed stocks.
Milk and dairy	Moderate consumption may reduce risk of CRC. High consumption of high-fat milk may increase risk of CVD.	Contributes with many essential nutrients, such as protein, calcium, iodine, riboflavin and vitamin B12.	In general, dairy, especially concentrated products such as hard cheese, is associated with high environmental impact. The high consumption of milk and dairy is an important contributor to GHG emissions from the diet in the Nordic and Baltic countries. Negative	Intake of between 350 ml to 500 ml low fat milk and dairy products per day is sufficient to meet dietary requirements of calcium, iodine and vitamin B12 if combined with adequate intake of legumes, dark green vegetables and fish (varies among different species). The range depends

			environmental impact is related to methane emissions from the enteric fermentation of ruminants. Feed contributes through fertilizer, pesticide, water and land use, and thereby reduced biodiversity. Positive environmental impact is related to grazing and biodiversity.	on national fortifications programs and diets across the Nordic and Baltic countries. If consumption of milk and dairy is lower than 350 gram/day, products may be replaced with fortified plant-based alternatives or other foods.
Eggs	Not sufficient evidence to inform a quantitative FBDG.	Contributes with all essential nutrients except vitamin C.	Egg consumption is associated with lower GHG emissions than meat and dairy, but as feed production demands land and may contribute negatively to biodiversity.	A moderate intake of egg may be part of a healthy and environment-friendly diet.
Fats and oils	Not sufficient evidence to inform a quantitative FBDG.	Vegetable oils contribute with essential fatty acids and some fat-soluble vitamins.	A shift from animal to plant-based fats it is recommended to contribute to lower GHG emissions and it is recommended to avoid oils that contribute to deforestation.	It is recommended to consume at a minimum of 25 g/day vegetable oil (or similar amounts of fatty acids from whole foods) considering a sufficient intake of ALA (minimum of 1.3 g/day per 10 MJ/day) and limiting the consumption of butter and tropical oils.
Sweets	High intake of sweets, including other sugary foods, as well as SSB increases risk of chronic metabolic diseases, reduces diet quality and increases risk of caries.	Sweets, cakes and biscuits contribute to high energy intake of sugar and fat.	Even though the GHG emission from sugar production is low, the high consumption of the food group contributes to the relatively high GHG emissions in the Nordic countries. Sweets also contribute to decreased biodiversity by land use change and	Limiting the consumption of sweets and other sugary foods is recommended.

			intensive large-scale cropping systems with low diversity.	
Alcohol	Intake increases risk of several cancers and total mortality.	High intake reduces diet quality.	The consumption of alcoholic beverages contributes to negative environmental impact.	No safe lower limit for alcohol consumption has been established. For children, adolescents and pregnant women abstinence from alcohol is advised.
Dietary patterns	Healthy dietary patterns are associated with beneficial health outcomes, such as reduced risk of CVD, T2D, obesity, cancer, bone health, and premature death.	Healthy dietary patterns are often micronutrient dense, including high intake of unsaturated fats and fiber, and low intake of saturated fats, added/free sugars and sodium.	Transitioning towards a healthy dietary pattern, i.e., a more plant-based dietary pattern, will reduce several negative environmental effects of the diet. However, the environmental impact of dietary patterns depends on the specific foods included.	A dietary pattern, characterized by high intakes of vegetables, fruits, whole grains, fish, low-fat dairy, and legumes and low in red and processed meats, sugar-sweetened beverages, sugary foods, and refined grains, would benefit health and will lower the climate impacts. Food group-specific considerations are essential to simultaneously reduce the environmental impacts and achieve nutritional adequacy of dietary patterns.

Abbreviations: CVD, cardiovascular disease; CRC, colorectal cancer; GHG, greenhouse gas; LNCSB, low- and no-calorie sweetened beverages; SSB, sugar-sweetened beverages; T2D, type 2 diabetes.

Figure 24: Visual food circle from Norway's dietary guidelines

A4. COOKING SYSTEMS AND STOVES

Table 3: Common definitions of cooking systems (Bisaga & Campbell, 2022)

Polluting/ traditional	Polluting cooking methods, often referred to as traditional cooking systems, are the combination of high emissions fuels such as firewood, charcoal and kerosene, burned inefficiently on open fires or simple stoves. These do not meet the international standards for health or emissions.
Improved	Improved cooking systems act as an intermediary solution between polluting cooking systems and clean and modern alternatives. Improved cookstoves control the combustion of biomass to improve efficiency and reduce the pollution output. These have varying levels of effectiveness in reducing emissions, as well as challenges in the usability and adoption on a wide scale. Although improved cookstoves (ICS) (typically tier 0-3) reduce the amount of biomass fuel consumed to prepare a meal, they do not offer the same social, health, and environmental impacts as higher-tier cooking solutions (Rosenthal et al., 2018).
Clean	The term clean cooking refers to a measurable criterion classified by meeting the standards for particulate and carbon monoxide emissions laid out under the WHO guidelines and following the ISO/TR 19867-3:2018 Voluntary Performance Targets (VPTs) (WHO, 2014), which are of critical importance for health. Solar, electric, biogas, natural gas, liquefied petroleum gas (LPG), and alcohol fuels including ethanol are all classified as clean at the point of use, as well as biomass cooking systems which meet the required criteria in laboratory testing (e.g., mini gasifiers).
Modern	Modern energy for cooking refers to fuels, technologies and approaches which fall under tier 4 or higher on the MTF framework across all six attributes and provide the greatest benefits to users. These are commonly referred to as the BLEENS, consisting of biogas, LPG, electricity, ethanol, natural gas and direct solar cooking. BioLPG, Hydrogen and bioethanol are emerging fuel alternatives for clean cooking. Modern energy for cooking excludes any type of improved cooking system. MECS defines modern energy cooking as using Tier 5 stoves (ESMAP defines modern energy cooking as Tier 4 and 5).

Table 4: Types of cookstoves (Bisaga & Campbell, 2022)

Technology	Description	Opportunities	Limitations
Improved cookstoves	ICSs come in many different varieties and utilize a range of biomass fuels, including firewood, charcoal, agricultural and forestry residues, pellets and briquettes.	ICSs usually have low manufacturing costs and are affordable to users ICSs are widely available in most contexts Fuels for ICSs are, in many rural contexts, widely available and accessible Many commercially made ICSs are more efficient than three-stone fires and some also meet most of the international quality standards	Most ICSs do not meet the standard The for clean cooking, particularly if used improperly ICSs are dependent on biomass fuel sources, many of which are unsustainably collected and cause environmental degradation ICSs can cause burns and give origin to fires Handcrafted ICSs cannot guarantee equality standards, and consequently it is impossible to quantify impacts

			As most biomass is non-renewably collected, ICSs contribute to climate change
Liquid petroleum gas (LPG)	LPG, a by-product of natural gas extraction, can be supplied to kitchens in cylinders, providing a convenient cooking fuel which increasingly features in government policies to transition from biomass fuels.	LPG is a clean fuel, which emits lower GHG emissions than biomass or coal LPG stoves are convenient to use, efficient and fast LPG is easy to store and transport	LPG stoves have associated safety concerns if not stored or used correctly LPG is dependent on a reliable distribution network, which is a challenge in remote and rural areas In many contexts, LPG can be prohibitively expensive LPG is a finite, fossil fuel resource LPG contributes to climate change
Electric cooking appliances	Cooking with electricity, using energy-efficient appliances such as electric pressure cookers and rice cookers, has become increasingly feasible in parts of the Global South, and remains a key potential solution to move to entirely renewable cooking systems. This can be facilitated through both grids connected and off-grid systems.	E-cooking is clean if generated from renewable sources, this method emits very few GHG It is fast, safe, convenient and, very efficient with appliances such as electric pressure cookers (EPCs)	E-cooking often depends upon reliable and accessible grid or off-grid electricity infrastructure While in some contexts it is cheaper than charcoal (ESMAP, 2020), it can be expensive in rural locations, especially compared to collecting free biomass
Ethanol stoves	Ethanol is an alcohol fuel distilled from a variety of biomass feedstock, usually produced in liquid or gel form.	Ethanol stoves are clean and mostly safe Ethanol can be affordable in contexts with appropriate supply ecosystems (SEI, 2015) Ethanol can be produced from a variety of feedstocks – When produced from organic matter (biofuel) it can be a renewable fuel	Large scale cultivation of ethanol feedstock can be environmentally and socially damaging, requiring fossil fuel for its production and occupying land for food and biodiversity Ethanol requires production and dedicated supply chain infrastructures
Biogas systems	Biogas is produced from agricultural, food and/ or human waste through processes of anaerobic digestion. It is particularly viable in rural areas where feedstock is available.	Biogas is clean and if feedstock processes are managed correctly, safe for users Biogas systems can contribute to circular economies and can incorporate sanitation management strategies Biogas produces fertilizer as a by-product which is a sought-after co-benefit	Biogas systems require intensive upkeep and maintenance, which is labor intensive and requires skilled local operators Biogas systems need additional water to work Biogas systems require a continuous supply of suitable feedstock, which is a challenge to procure or produce Such systems have high investment costs

Direct solar systems	Solar cookers are containers whose walls are covered with reflective material that concentrate solar rays on the pot raising the temperature inside. Concentrated Solar Power, using concave reflecting dishes, can reach higher temperatures.	Solar cooking is highly efficient There is no cost for fuel	Can only be used when the sun is high enough, so is a potential option to prepare midday meals in some institutions, but is impractical on a household level The cook needs to be in the sun to operate the appliance, often unpleasantly hot Not all types of foods can be cooked in solar cookers (it boils but cannot fry, roast etc.) It takes a long time to cook Parabolic systems are faster but quite expensive, particularly the most effective ones that rotate with the sun Cannot be used in rainy places or rainy seasons

A5. HANDBOOK FOR REDUCING FOOD WASTE – SWEDEN

The handbook for reducing food waste is based upon the Gothenburg Model, with the addition of an extra section on “plate waste”, ways of measuring food consumption, and the Swedish Food Agency’s national method for measuring food waste.

The handbook has been reviewed by external experts and representatives of municipal meal services

The handbook can be found at:

https://www.livsmedelsverket.se/globalassets/publikationsdatabas/handbocker-verktyg/handbook_for_reducing_food_waste.pdf

Figure 25: The various areas that must be included in efforts to reduce the different types of food waste (Sweden).

A6. SCHOOL SYSTEM ENTRY POINTS FOR SUSTAINABLE FOOD AND NUTRITION EDUCATION

Table 5: School system entry points for sustainable food and nutrition education (Source: adapted from FAO, 2020)

Integration	Description	Potential for impact
Within a core subject	Integrated as a specific thread with own learning objectives, within a core subject, such as science, home economics/consumer sciences, social studies, agriculture, sustainable development/environmental studies/climate education, health education, among others.	The potential for impact is adequate if the food curriculum responds to the actual context and needs, goes beyond a knowledge transmission approach, is developed from year to year and available to all grades, is supported by parents, and is reflected in the schools' own practices and staff outlooks.
Transversally within various subjects	Contents are spread through various subjects, mainly through text books or activities.	The potential is not very high, as there is risk of dilution, usually explicit learning objectives are not formulated, and contact hours are not significant.
Through school projects	Aspects are integrated into thematic lessons, or as topics for specific and time-bound school projects, such as food waste reduction campaigns, climate-friendly meal days or food system research projects.	The potential depends on the linkages with the school curriculum, the regularity of exposure, the overall project objectives and the learning approach.
As part of extracurricular programs or activities	Usually contents and activities are implemented through dedicated clubs, teams, groups or other initiatives outside of the formal curriculum and usually outside of school hours. These can be managed by education authorities or by other groups.	The potential for impact highly depends on how widespread and institutionalized the extracurricular programs are, as well as the aims, approach used, connections with the official curriculum and regularity. Commonly, the programs are not available for all, can have resource limitations and can receive low support from the school authorities.
As a component of non-education programs or services	Can be a component of institutionalized school meals programs or other relevant school food services. It can, for example involve dedicated lessons centered on climate-friendly school menus, school/parent briefings on more sustainable meal options or reducing home food waste, and can also target food service and other school staff.	The potential is high for reinforcing curriculum learning, but generally underexploited: the actual meals and foods, procurement, preparation and disposal processes are not often seen to have a pedagogical use.
As part of the hidden curriculum	The hidden curriculum refers to the implicit, unofficial, unwritten and often unintended messages and material aspects that may reflect the values and culture about food sustainability in schools. In other words, these are the "lessons" that are taught unintentionally in schools. For example what teachers model with their food choices, how school food is packaged, or even the academic status of some subjects.	The hidden curriculum is a powerful force. It can be exploited for a higher potential if schools recognize its importance and state and implement a school food culture.

A7. GLOBAL MODELLING STUDY WITH COUNTRY-LEVEL DETAIL

The health, environmental, and cost implications of providing healthy and sustainable school meals for every child by 2030: a global modelling study with country-level detail

Version: 12 August 2023

Please provide comments to Marco Springmann, marco.springmann@lshtm.ac.uk

Notes:

- This paper is in draft
- Please take the write up below only as a reflection where I am with this at the moment. There are still a couple of things to sort out before this would be ready for publication, especially when it comes to the cost estimates.
- Some back on the envelop: the WFP quotes school-meal costs of US$ 64 per child; multiplying this by the 1.6 billion school kids in 2030 gives you about US$ 102 billion in costs; and subtracting the costs already covered by current programmes (US$ 64 x 300 million kids in primary and secondary education in 2020 = US$ 19 billion) gives you US$ 83 billion in additional financing needs, also much higher than reported. In short, it would be good to chat about the costing data with the people who processed/analysed them. If there had some more detailed data, then maybe those could be used as baseline. The estimates below amount to about US$ 600 billion just to cover average diets.
- Part of the large difference in cost estimates might be that the ones below are in PPP terms, whereas the ones estimated for the WFP report are probably nominal ones; there is about a factor 4 differences between nominal and real GDP.
- With the cost estimates so much higher than existing ones, it might make sense to focus only on the health and environmental aspects, including costing those, and comparing them to existing estimates of funding needs, discussing in qualitative terms the cost differential between average diets and sustainable ones.
- If the focus is shifted like that, then it would be good to also get the undernourishment estimates costed; from what I saw, there have been some estimates of how stunting has affected economic indicators, but not much in terms of cost penalty per stunted child or per percent of undernourishment (something like that would be needed though).

Introduction

Here we assess the impacts that extending school meal programmes could have for health, the environment at global, regional, and national levels. Our analyses integrate and advance previously disparate strands of enquiry. The health assessment integrates analyses of changes in the prevalence of undernourishment that could result from having an additional meal per day, especially in low-income countries, as well as changes in diet and weight-related risk factors that become important determinants of health in adulthood in all regions.

The environmental assessment quantifies the environmental resource use and pollution associated with the provision of school meals, including food-related greenhouse gas emissions, freshwater use, and land use, and it analyses options to reduce their impacts such as changes in the composition of meals and reductions in food waste in school canteens.

The relevance and capacity to extend school meal programmes differs by geographic location and economic circumstances. We therefore provide a supplementary dataset that accompanies our analysis and include the results of the full set of scenarios we considered, including scenarios on school meal coverage, the number of school meals provided per school day, the dietary composition of the meals provided, and the amount of waste associated with their preparation. We hope this dataset will facilitate detailed and context-specific planning of school meal programmes.

Methods

Overview

We structured our analysis into several steps (Fig. 1). They included preparing the data on school meals and scenarios of extending their coverage and changes in their composition; health assessments of the potential short-term and long-term impacts of school meal programmes; and an environmental assessment of the resource use and pollution of school meal programmes.

Data on school meal coverage

Our analysis focused on analysing the impacts of school meals for pupils in primary and secondary education. Whilst exact ages and durations differ, primary education is typically designed for children aged 6-11, and secondary education for children aged 12-17, with a subdivision into 2-4 years of lower secondary education and 2-3 years of upper secondary education. We used data collected and disseminated by the United Nations Educational, Scientific and Cultural Organization (UNESCO) on school enrollment, age of entrance, and duration,1 and population data from the United Nations Population Division (UNPD),2 to identify the size and age of the population currently attending school in each country, and to project the school aged population for the School Meal Coalition's target year of 2030.

We used data collected by the Global Child Nutrition Foundation (GCNF) for its Global Survey of School Meal Programs to identify the current ratios of the school population currently receiving school meals, the number of school days per year, and what type of school meal was provided (e.g., breakfast and/or lunch).3 The GCNF's latest survey which we used for our analysis was conducted between July 2021 and March 2022. It covered 139 countries, of which 125 had school meal programs. In line with existing meal and nutrition standards for school meals, we assumed that the calorie content of breakfast, lunch, and dinner constitute a third each of the daily requirement respectively, and snacks constitute a tenth.4

Scenarios on school meal composition and provisioning

For constructing baseline dietary exposures for 2020, we triangulated several data sources to construct a complete and regionally comparable proxy for food intake of the school-aged population. Age and sex trends in the intake of food groups of health relevance were adopted from the Global Dietary Database (GDD),5 and overall levels and food groups missing in the GDD were adopted from the Food and Agriculture Organization's food balance sheets (FAOFBS) after adjusting for food waste at the household level.6,7 To correct for misreporting of intake in the GDD and of waste fractions in the FBS, we adjusted overall intake to those energy levels that are required to sustain measured levels of weight, height, and physical activity for each population subgroup, making use of equations for energy requirements based on doubly labelled water studies,8 and using data of the WHO and NCD-RisC collaboration.9,10 We then used food and country-specific trend projections from 2020 to 2030 from the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) to estimate food intake for 2030.11,12

In absence of detailed information on the composition of school meals, we constructed several scenarios of school meal composition. These included scenarios in which school children are provided with the same average diet at school as indicated by dietary data and surveys for their sex and age group; a diet in line with national dietary guidelines where they exist and a diet in line with recommendations by the World Health Organization (WHO) where they do not; and a diet in line with recommendations for healthy and sustainable diets, including nutritionally balanced flexitarian (with low to moderate amounts of animal source foods), vegetarian (with dairy but without meat), and vegan (completely plant-based) dietary patterns.

In addition, we specified a set of scenarios on feeding and waste ratios, and the number of meals served during school days. They include scenarios in which the current coverage of school children fed is extended to all enrolled children or to all children of school age; scenarios in which the current number of meals served per school day is set to one, two, or all daily meals; and scenarios in which food waste is halved or completely eliminated, the latter of which intended to serve as a quantification of the role of food waste in a school setting. For analysing the pledge of providing healthy and sustainable school meals to every child by 2030, we focussed specifically on providing at least one school meal per day (without penalising current school meal programmes that provide more than one meal per day) to all children of school age. The Supplementary Datafile provides results for all other scenario combinations.

Health analysis

We assessed the health implications of meeting the SMC's pledge of providing every child of school age with a healthy meal in school by 2030 in two ways. As an immediate impact of extending the coverage of school meal programmes, we considered the potential changes in the prevalence of undernourishment in affected households. For that, we assumed that school meals are provided to school-aged children in affected households in addition to their current food intake, something that could increase the nutritional status of both the school-aged children and other members of the household who could use food previously allocated to school aged children. We estimated the associated change in energy supply at the population level and then used FAO's methodology and baseline data to estimate the changes in the prevalence of undernourishment as changes the percentage of the population whose food intake falls below minimum dietary energy requirements (MDER).6,13,14

As an additional and longer-term impact of providing healthy school meals, we considered the potential impact on dietary and weight-related risk factors in adulthood. For that, we assumed that the changes in dietary composition and intake are proportionally maintained as adults, for which we paired the dietary composition of school-meal scenarios with the dietary composition of a country's average diet on non-school days and for meals eaten outside of school. We considered several degrees of sustaining this composition into adulthood, including 100%, 50%, 35% and 15%, in each case relative to a country's average diet. We then used a comparative risk assessment (CRA) framework to estimate changes in dietary and weight-related risks, including for low intake of fruits, vegetables, legumes, nuts, and whole grains, high intake of red meat and processed meat, as well as being underweight, overweight, or obese.15 To parameterise the CRA, we used relative-risk estimates from meta-analyses of epidemiological cohort studies,16–19 mortality and population data for current and future years from the Global Burden of Disease project,20 baseline weight distributions from the NCD-RisC project,21 and future projections from previous studies.22

Environmental analysis

We assessed the environmental impacts of extending school meal programmes by using a set of region-specific environmental footprints, specifying the GHG emissions, land use, freshwater use, and eutrophication potential of foods that that accrue throughout their lifecycle, including production, inputs, and transport to the point of consumption.23 The footprints were adapted from a meta-analysis of 570 life-cycle assessments covering results from over 38,000 farms in 119 countries. For the assessment, we paired the environmental footprints with our scenario estimates of food consumed at school, taking into account the proportion of daily food intake obtained at school, the number of school days, the proportion of food waste associated with food intake.

Providing every child with at least one meal at school by 2030 would substantially increase the current coverage of school meal programmes (Fig 1, SI Table 1). In the school year starting in 2020, 19% of the school-aged population, i.e., 304 million children and young adults aged 5 to 19, were fed school meals in their primary and secondary education, ranging from 8% in low-income countries, to 20% in middle-income countries, and 30% in high-income countries. Extending the coverage of school meal programmes to all school-aged children by 2030 would increase the number of recipients by a factor of five to 1.6 billion (+1.3 billion; +430%). The relative increases would be particularly large in low-income countries that currently have low coverage (+243 million; +1,500%), large in absolute terms in middle-income countries (+940 million; +400%), and still substantial in high-income countries (+110 million; +220%).

Health impacts

Increasing the coverage of school meal programmes can have immediate impacts on the nutritional status of school children and, where undernourishment is a persistent problem, also on the associated households, e.g., by allowing foods distributed to other family members. We estimated that if school meals were provided in addition to current diets in at-risk regions, then energy intake at the population level could increase by 9% in low-income countries and 3% in middle-income countries (SI Table 2). This, in turn, would reduce the prevalence of undernourishment in low and middle-income countries by 25% on average (with range of 23-28% across specific income groups), and the number of undernourished people by about 120 million (Fig 3). At a country level, the relative reductions were largest for Senegal (-69%), Malaysia (-68%), Niger (-64%), Uganda (-61%), and Cambodia (-54%).

Providing school meals can have additional health impacts later in life. By forming preferences for healthy meals, school meal programmes can contribute to reducing diet and weight-related risk factors and the associated non-communicable diseases (NCDs) in adulthood. Assuming dietary preferences are maintained, we estimated that 2.2-3.0 million annual deaths could be avoided in the original cohort of children, representing reductions in the total number of deaths in the school cohort of 12-16% (Fig 4, SI Table 3). The reductions were greater for adherence to the relatively more comprehensive recommendations for healthy and sustainable diets (flexitarian, vegetarian, or vegan diets). Across regions, the reductions ranged from 8-12% in low-income countries to 16-20% in high-income countries where baseline diets are relatively more imbalanced and levels of overweight and obesity are higher. At a country level, the reductions were largest for Slovakia (54%), Lithuania (42%), Bulgaria (38%), Estonia (38%), and Poland (36%) for the example of meal compositions in line with healthy and sustainable flexitarian dietary patterns.

Environmental impacts

Expanding school meal programmes would increase the ratio of environmental resource use and pollution that can be addressed through changes in the composition and provision of school meals. According to our estimates (SI Table 4), universal coverage with school meals would triple the coverage of food-related environmental impacts, if a country's average diet was provided at school, from 1% in 2020 to 3-4% in 2030. This includes changes in GHG emissions (from 170 to 630 MtCO2eq), land use (from 550,000 to 2,600,000 km2), freshwater use (from 25 to 110 km3), and eutrophication potential (from 710 to 2,800 ktPO43eq). The increases in environmental impacts across the different environmental indicators ranged from factors of 3-4 in high-income and middle-income countries to factors of 16-27 in low-income countries.

Changes in meal composition and reductions of food waste can reduce the environmental resource use and pollution of school meals programmes, either by reducing the demand for foods with high environmental impacts such as meat and dairy, or by reducing the overall demand for foods. We estimated (SI Table 5) that providing meals in line with recommendations for healthy and sustainable dietary patterns could reduce environmental impacts on average by 26% (12-42% across the environmental indicators) for flexitarian meals, 43% (18-62%) for vegetarian meals, and 52% (23-81%) for vegan meals, in each case with greatest reductions for land use, followed by GHG emissions, eutrophication potential, and freshwater use. The reduction potentials were substantial in all income regions, including 33-55% across the dietary patterns in high-income countries and 19-47% in low-income countries. In contrast, providing meals in line with national or WHO guidelines – which often include less ambitious recommendations on limiting the consumption of foods with high environmental impacts such as meat and dairy – had little mitigation potential (-1% on average) and similar impacts as providing meals in line with a country's average diet.

Reducing the amount of food wasted in school meal programmes can reduce the overall demand for foods and the associated environmental resource use and pollution. We estimated (SI Table 5) that halving food waste could reduce environmental impacts on average by 13% (10-14% across environmental indicators), with similar reductions across income regions. Combining reductions in food waste with changes in meal composition resulted in combined reductions of 13% on average for meals in line with national or WHO guidelines, and of 35-57% for meals in line with recommendations for healthy and sustainable dietary patterns, with greatest reductions for vegan meals, followed by vegetarian and flexitarian meals. At a country level (Fig 5), the overall reductions in environmental impacts for the combination of halving food waste and providing the lowest-impact plant-based (vegan) meals were largest for Mongolia (-83% on average across environmental domains), followed by Chad (-77%), Bolivia (-77%), Turkmenistan (-76%), and Zimbabwe (-76%).

Discussion [the discussion in context of the current literature still needs to be expanded]

At present, only a minority of children benefit from school meal programmes. Our analysis suggests that extending school meal coverage from currently one in five children of school age to all children by 2030, as envisaged by the School Meal Coalition's pledge, could be associated with substantial health and environmental benefits. For food-insecure populations, we estimated that the additional meals provided at school could reduce the prevalence of undernourishment by quarter. By shaping dietary habits in the early years, healthy school meals could also help reduce dietary and weight-related risks in adulthood, which we estimated could prevent up to 3 million cases of non-communicable diseases per year in all countries. Finally, we estimated that the environmental impacts of school meals can be more than halved relative to meals following a country's average diet if they adhered to recommendations for diets that are both healthy and sustainable diets and food waste was reduced, thereby making important contributions to making food systems more sustainable.

Our analysis also identified several challenges associated with extending school meal programmes, especially concerning enrollment and affordability in low and middle-income countries (LMCs). In low-income countries, for example, less than a third of children are enrolled at school, and of those, less than a quarter receive school meals. Extending school meal coverage therefore depends on first increasing enrollment and providing schooling.

Our analysis also showed that meal composition is the primary driver of school meal programmes' environmental footprint. Providing nutritionally balanced and predominantly plant-based meals that are in line with recommendations for healthy and sustainable diets generated reductions in environmental resource use and pollution of more than 50%, whilst halving food waste led to reductions of 10-14%, and meals in line with national or WHO guidelines led to a reduction of 1%. Currently, about 100 countries have reported their food-based dietary guidelines to the FAO, including most European but only about a fifth of Africa countries.15,29 The poor environmental performance of existing dietary guidelines highlights the need to reform and update the relevant guidelines where they exist, especially for children and school meals which are often omitted, and to establish them where they do not.

Our analysis provides a comprehensive set of school-meal scenarios that we hope can help in national planning of school meal programmes. They include scenarios on the ratio of school children covered by meal programmes, the number of meals served per day in a programme, the composition of the meals, and the amount of waste generated. The global coverage of our analysis substantially extends the current public-health literature on school meals that has tended to focus on national analyses of specific aspects, e.g., dietary interventions and composition, often in high-income countries.30,31 Our what-if analysis also complements the economic development literature on school meals that has focused on the returns to schooling in LMCs from an empirical perspective [REFs needed]. Lastly, it complements the literature on sustainable diets by focussing on an important subgroup of the population (children) in a specific food environment (schools) which, compared to the food environment of the general population,22,32 offers greater points of intervention through changes in procurement.

Our analysis also has important caveats we want to highlight. Those regard especially the assumptions we made in each component of the analysis. In the assessment of undernourishment, we assumed that school meals are consumed in addition to the current food available to hunger-affected households. The assumption is supported by the economic development literature that… [REF]. However, we cannot rule out other budget decisions that would, for example, reduce a households food budget in proportion. In the assessment of dietary and weight-related risks in adulthood, we assumed that dietary preferences are maintained in proportion as calorie needs increase, something that can be assumed to be contingent on supportive policies and food environments. A systematic review of cohort studies identified correlations of about 35% for dietary behaviours between childhood and adulthood.30,33

Assuming a maintenance rate of 35% would reduce the health benefits we estimated in proportion.

In the environmental assessment, we focused on the environmental resource use and pollution associated with food demand. The implicit assumption is that food supply would adjust in the medium term for the identified effects to be realised, but such adjustment also depends on favourable policies on the supply side, e.g., reform of agricultural subsidies and dedicated procurement policies.34 In the cost assessment, we used market prices collected for the World Bank's International Comparison Programme and matched foods at a calorie basis to the food groups used in the scenarios of meal composition. The calorie cost of each food group has therefore a high uncertainty range, which offers additional opportunities to save costs, but also generates high overall uncertainty as we do not possess detailed enough data on food intake to establish a credible baseline of diet costs.25,35

These uncertainties notwithstanding, our analysis suggests that the health and environmental benefits of providing healthy and sustainable school meals to every child by 2030 are substantial.

Display items

Fig 1. Schematic of our analysis of school meal programmes. The analysis was structured into data and scenario preparation (yellow), health assessments (blue), environmental assessments (green), and cost assessments (orange).

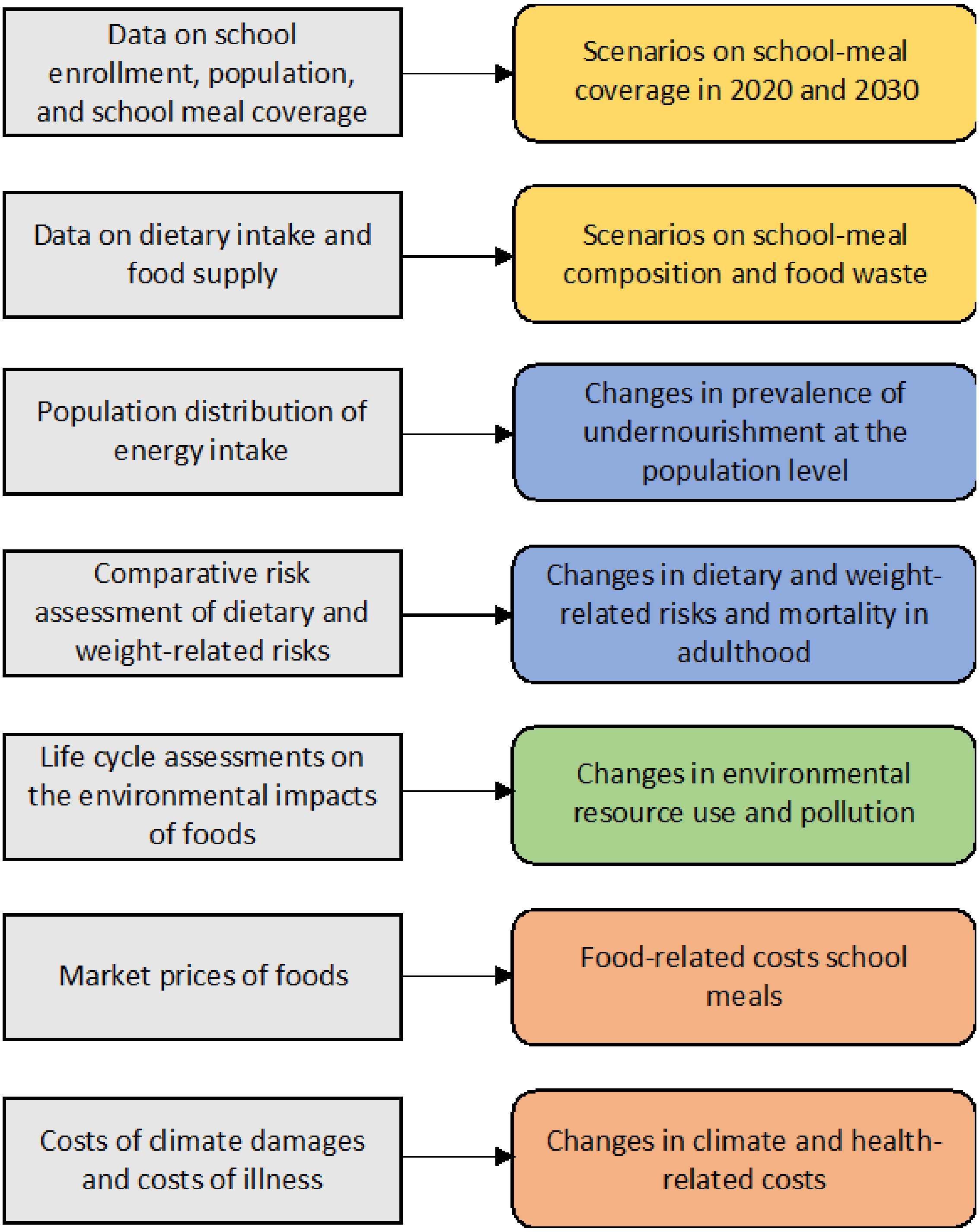
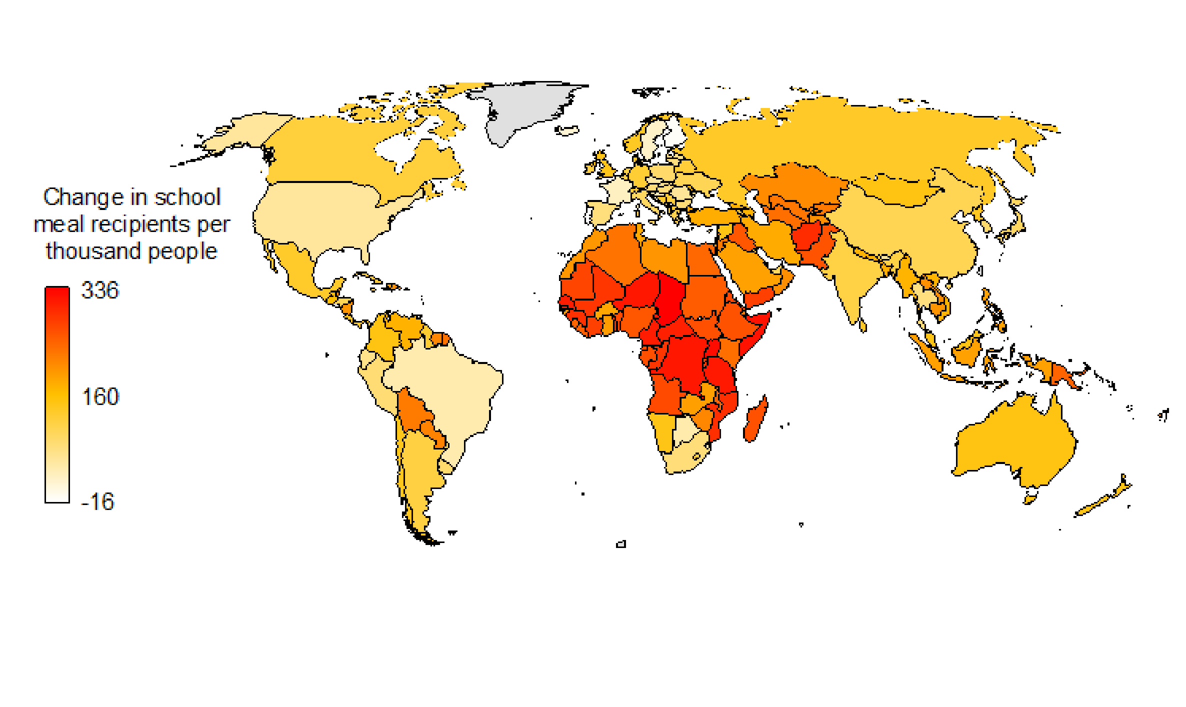


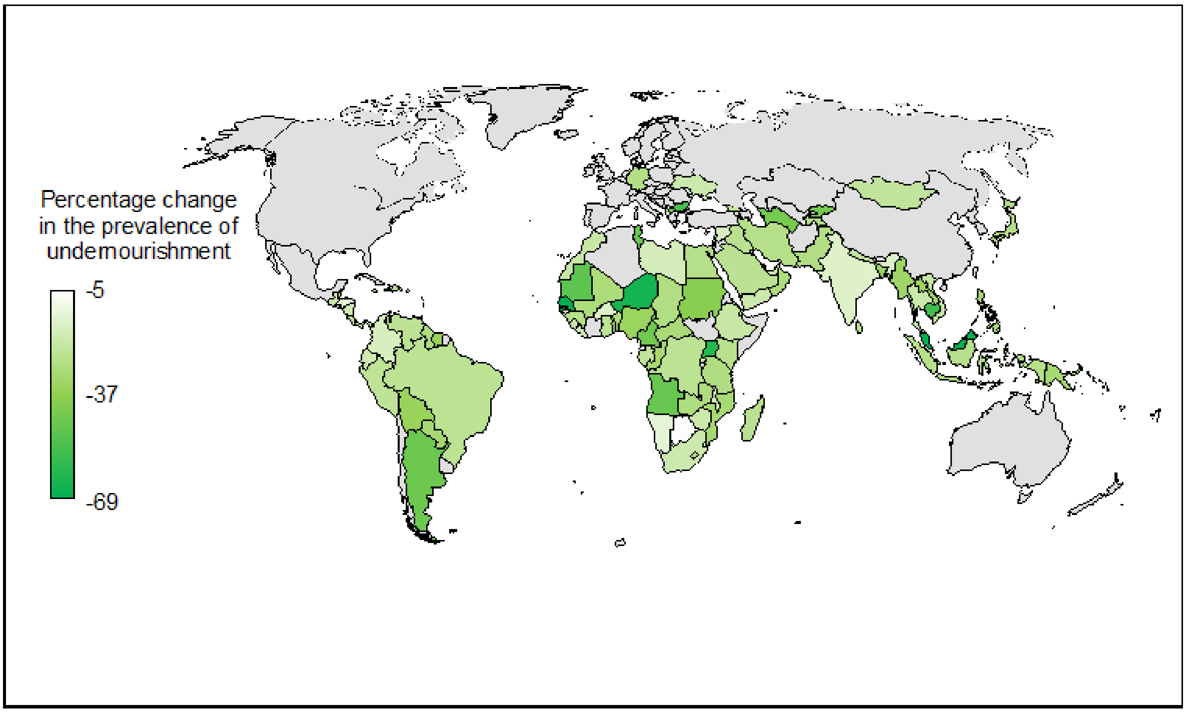
Fig 2. Change in the number of children receiving school meals under the School Meal Coalition pledge of providing every child with a meal at school by 2030 compared to the school meal coverage in 2020. Changes are normalised by a country's population and are provided as changes of school meal recipients per million people.



SI Table 1. Population estimates for the School Meal Coalition (SMC) pledge. They include population estimates (in million) of school-aged populations in 2020 and 2030, of the population enrolled in school in 2020, and of the population receiving school meals in 2020, including changes for meeting the SMC pledge of increasing school-meal coverage from its 2020 levels to all school-aged children in 2030.

Region	School-aged population		Enrolled in school	Receiving school meals	Change in school meal coverage for meeting pledge			
	2020	2030	2020	2020	(million)	(per thousand)	Δ(factor)	Δ(%)
World	1,563	1,598	1,008	304	1,295	153	5.3	426%
High-income countries	167	157	161	49	107	87	3.2	217%
Upper middle-income countries	477	453	382	94	358	120	4.8	381%
Lower middle-income countries	708	730	397	144	586	174	5.1	406%
Low-income countries	210	259	68	16	243	271	16.1	1513%
Asia	883	846	641	163	684	139	5.2	421%
Africa	394	482	127	48	434	257	10.1	910%
Europe	96	92	75	19	72	98	4.7	374%
Latin America and the Caribbean	125	118	104	45	73	104	2.6	162%
Northern America	57	52	56	29	23	59	1.8	79%
Oceania	8	9	5	<0.05	9	177	178.4	17739%

Fig 3. Changes in the prevalence of undernourishment (%) for meeting the School Meal Coalition pledge of providing every child with a meal at school by 2030. The analysis is independent of school meal composition.

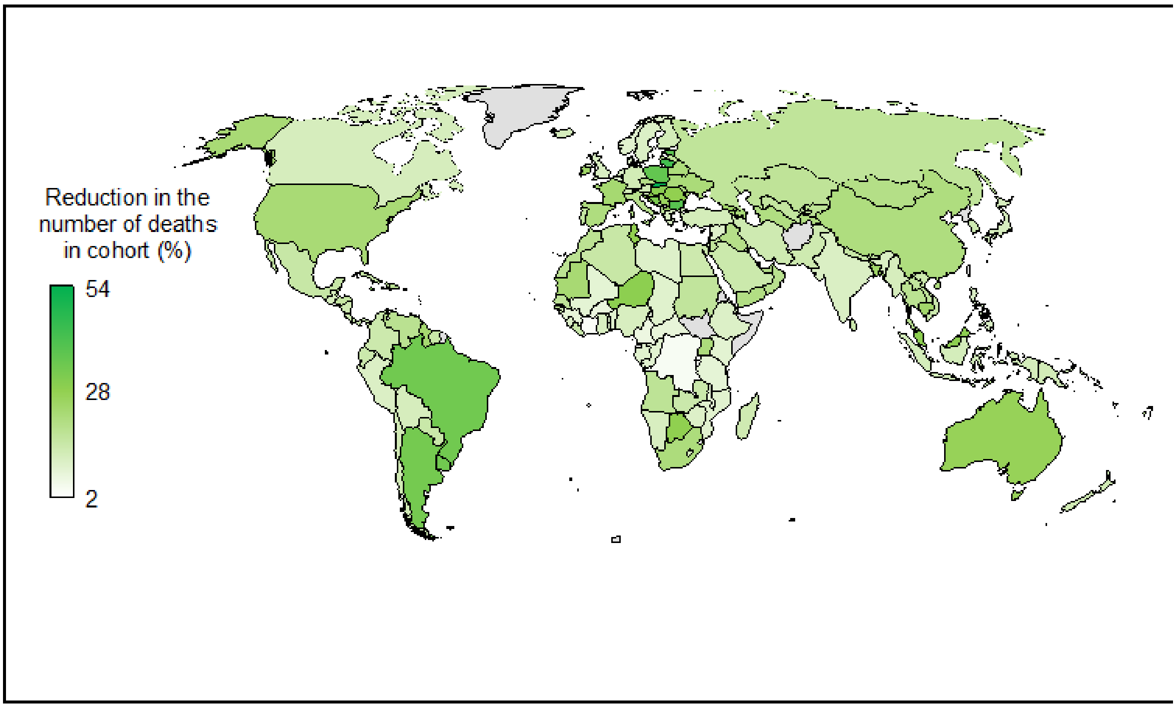


SI Table 2. Estimates of changes in the Prevalence of Undernourishment (PoU) for the School Meal Coalition (SMC) pledge. The estimates include the total energy supply (in kilocalories per person per day, kcal/d) and the associated PoU (in million) for projected population-level energy intake in 2030 (Baseline), for a scenario in which the SMC pledge of providing at least one meal for every school-age child on school days is met and the associated energy intake is added to the total population-level intake (Pledge).

Region	Energy supply				Prevalence of undernourishment			
	Baseline	Pledge			Baseline	Pledge		
	(kcal/d)	(kcal/d)	Δ(kcal/d)	Δ(%)	(million)	(million)	Δ(million)	Δ(%)
World	3,070	3,183	113	3.7	498	374	-124	-24.9
High-income countries	3,529	3,617	88	2.5	4	3	-1	-25.6
Upper middle-income countries	3,496	3,598	102	2.9	45	34	-11	-24.0
Lower middle-income countries	2,785	2,900	115	4.1	284	219	-66	-23.1
Low-income countries	2,104	2,283	179	8.5	165	118	-47	-28.2
Asia	3,079	3,173	94	3.1	236	188	-47	-20.1
Africa	2,621	2,806	186	7.1	230	160	-69	-30.2
Europe	3,527	3,616	89	2.5	1	1	0	-24.7
Latin America and the Caribbean	3,136	3,242	106	3.4	30	24	-7	-21.6
Northern America	3,927	4,016	89	2.3	0	0	0	0.0
Oceania	3,041	3,218	177	5.8	2	1	-1	-31.3

Fig 4. Reductions in the number of dietary and weight-related disease deaths as a proportion of all deaths within the cohort of former school children. The analysis assumed that dietary habits at school are proportionally maintained into adulthood. The analysis was conducted for the year

2050 when the school children of 2030 are in adulthood. The map shows the impacts for the example of providing flexitarian school meals to every child of school age in 2030.



SI Table 3. Estimates of changes in mortality from diet and weight-related diseases for changes in meal composition and extending the overage of school meal programmes in line with the School Meal Coalition (SMC) pledge. The meal compositions include meals in line with national or WHO dietary guidelines (DGL), and meals in line with recommendations for healthy and sustainable diets, including flexitarian (FLX), vegetarian (VEG), and vegan (VGN) dietary patterns. The impacts are estimated for the year 2050 when the school cohort of 2030 are adults.

Region	Number of avoidable deaths				Reduction of all deaths in cohort (%)			
	DGL	FLX	VEG	VGN	DGL	FLX	VEG	VGN
World	2,195,410	2,828,000	2,877,240	2,962,860	12.1	15.6	15.9	16.4
High-income countries	390,042	468,299	476,836	494,443	15.6	18.8	19.1	19.8
Upper middle-income countries	914,705	1,219,830	1,239,670	1,268,530	14.9	19.8	20.1	20.6
Lower middle-income countries	760,043	947,391	964,576	997,639	9.8	12.2	12.4	12.9
Low-income countries	130,620	192,478	196,154	202,253	7.7	11.4	11.6	11.9
Asia	1,224,280	1,550,490	1,576,920	1,619,590	11.8	14.9	15.2	15.6
Africa	310,967	444,561	454,263	467,666	8.4	12.0	12.2	12.6
Europe	225,945	293,937	299,477	312,782	14.4	18.7	19.1	19.9
Latin America and the Caribbean	251,501	323,565	327,608	335,834	17.7	22.7	23.0	23.6
Northern America	163,182	193,184	196,309	203,627	18.2	21.5	21.8	22.7
Oceania	19,538	22,265	22,662	23,360	17.5	20.0	20.3	21.0

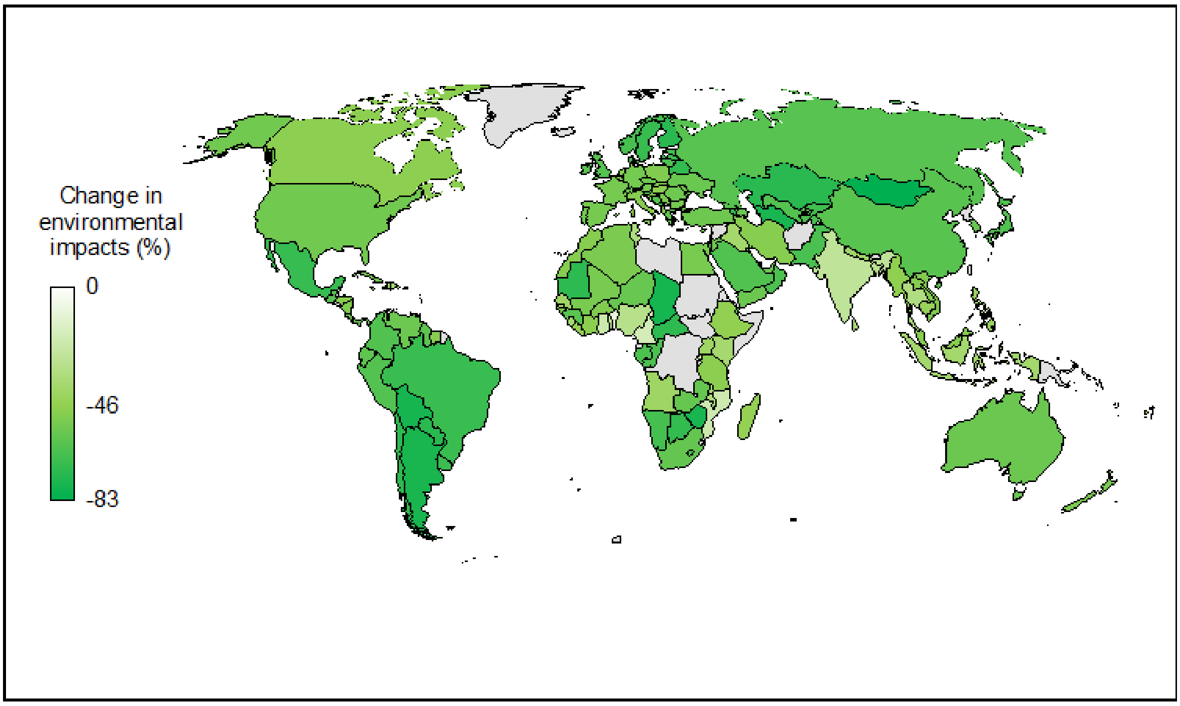
SI Table 4. Environmental resource use and pollution of extending school-meal coverage without changes in school-meal composition or provision. The environmental impacts include food-related greenhouse gas (GHG) emissions, agricultural land use, freshwater use, and eutrophication potential.

Region	Baseline in 2020				Universal school-meal coverage with baseline diets and waste in 2030			
	GHG emissions (MtCO2eq)	Land use (1000 km2)	Freshwater use (km3)	Eutrophi-cation (ktPO43eq)	GHG emissions (MtCO2eq)	Land use (1000 km2)	Freshwater use (km3)	Eutrophi-cation (ktPO43eq)
World	173	555	25	705	633	2,636	112	2,842
High-income countries	32	97	4	137	85	364	10	349
Upper middle-income countries	104	324	11	380	294	1,038	43	1,258
Lower middle-income countries	33	115	9	174	198	757	48	997
Low-income countries	3	18	1	14	57	478	10	238
Asia	46	125	14	264	264	875	68	1,447
Africa	21	177	3	77	148	1,112	24	621
Europe	12	19	2	45	38	85	6	153
Latin America and the Caribbean	74	156	5	229	139	337	10	439
Northern America	21	78	2	90	35	129	3	153
Oceania	0	0	0	0	10	97	0	29

SI Table 5. Changes in the environmental resource use and pollution of school meal programmes for reductions in food waste and changes in meal composition. The changes were calculated with respect to school meals that are in line with a country's average diet in 2030.

Region	Diet scenarios	Current levels of food waste					Halving of food waste				
		GHG emissions (Δ%)	Land use (Δ%)	Freshwater use (Δ%)	Eutrophi-cation (Δ%)	Average (Δ%)	GHG emissions (Δ%)	Land use (Δ%)	Freshwater use (Δ%)	Eutrophi-cation (Δ%)	Average (Δ%)
World	BMK						-13.2	-13.5	-10.2	-13.3	-12.6
	DGL	-2.5	-2.6	1.6	-0.6	-1.0	-15.4	-14.7	-9.2	-14.1	-13.3
	FLX	-28.2	-42.4	-12.0	-19.6	-25.6	-37.7	-48.4	-22.0	-31.0	-34.8
	VEG	-46.3	-61.5	-17.6	-44.8	-42.5	-51.8	-64.0	-26.0	-50.1	-48.0
	VGN	-53.9	-81.3	-23.0	-49.5	-51.9	-59.5	-82.9	-31.8	-54.9	-57.3
High-income countries	BMK						-14.0	-15.4	-11.7	-15.3	-14.1
	DGL	2.0	-14.1	12.0	1.5	0.3	-12.9	-26.9	-2.5	-14.5	-14.2
	FLX	-38.2	-55.6	-1.3	-35.1	-32.5	-47.8	-61.6	-15.1	-45.4	-42.5
	VEG	-53.4	-71.8	-8.4	-54.3	-47.0	-59.6	-74.6	-20.4	-60.2	-53.7
	VGN	-62.2	-81.5	-14.4	-59.7	-54.5	-68.4	-83.9	-27.1	-65.7	-61.2
Upper middle-income countries	BMK						-14.6	-12.3	-12.1	-14.9	-13.5
	DGL	-2.6	3.9	4.0	0.7	1.5	-16.5	-6.9	-8.7	-14.5	-11.7
	FLX	-37.2	-44.7	-10.6	-26.1	-29.6	-46.1	-49.4	-22.0	-37.6	-38.8
	VEG	-57.1	-57.1	-17.7	-53.2	-46.3	-61.6	-59.4	-27.0	-57.9	-51.5
	VGN	-63.4	-84.7	-23.2	-58.3	-57.4	-68.0	-86.1	-32.8	-63.0	-62.5
Lower middle-income countries	BMK						-10.9	-13.6	-8.2	-10.7	-10.8
	DGL	-4.5	-6.1	-1.9	-2.2	-3.7	-15.0	-18.4	-10.2	-13.0	-14.2
	FLX	-14.9	-34.2	-15.5	-8.3	-18.2	-24.7	-41.4	-23.6	-19.8	-27.4
	VEG	-31.6	-58.8	-19.8	-33.2	-35.9	-37.9	-61.4	-26.7	-38.6	-41.2
	VGN	-40.4	-73.2	-25.1	-37.3	-44.0	-46.6	-75.1	-32.1	-42.9	-49.2
Low-income countries	BMK						-13.3	-14.8	-10.4	-13.1	-12.9
	DGL	-1.9	-2.2	-2.4	-3.3	-2.4	-14.7	-16.5	-12.5	-15.9	-14.9
	FLX	-13.5	-40.3	-12.0	-9.6	-18.9	-24.4	-47.2	-21.6	-21.9	-28.8
	VEG	-30.8	-67.8	-15.3	-35.1	-37.2	-38.3	-69.8	-24.0	-41.7	-43.4
	VGN	-39.8	-86.4	-21.4	-39.5	-46.8	-47.3	-87.5	-30.3	-46.3	-52.9

Fig 5. Percentage change in the average environmental impacts of halving food waste and providing healthy and sustainable school meals to every child of school age in 2030 compared to current waste levels and providing meals following a country's average diet. The map shows the example of providing vegan diets (which had the greatest environmental benefits) combined with halving of food waste.



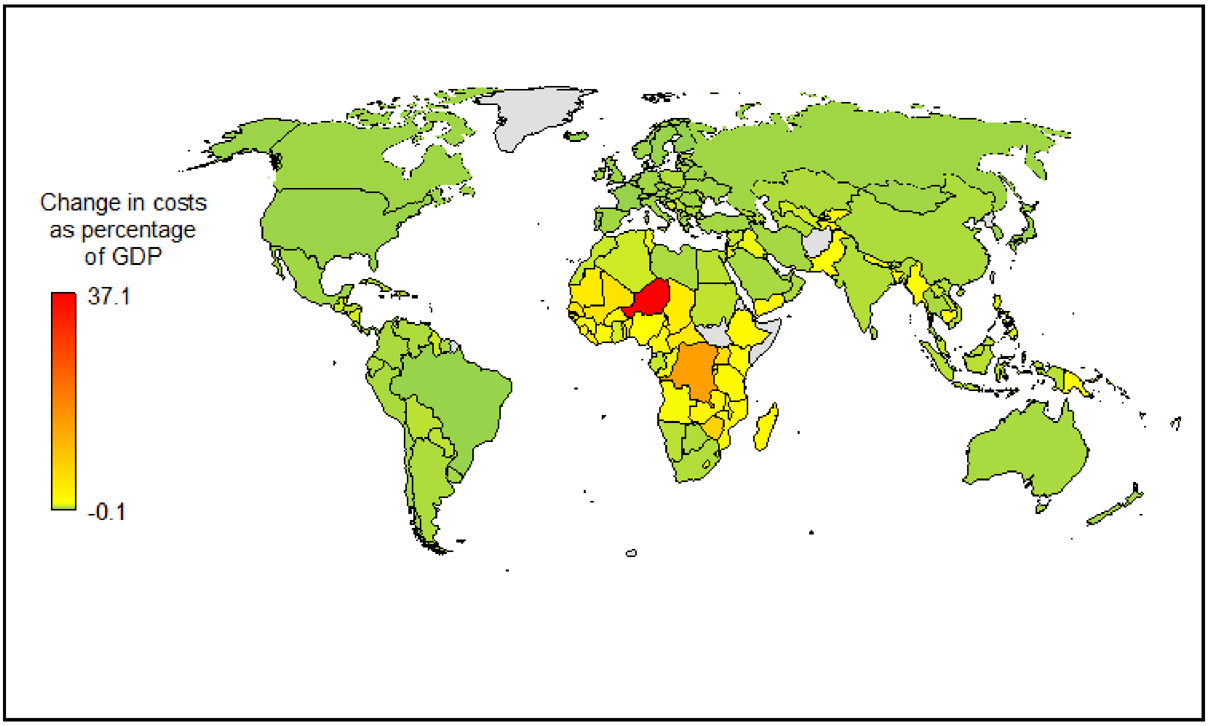
SI Table 6. Costs per school meal in 2030 with and without waste by income region for different meal compositions. The meal compositions include meals in line with a country's average diet (BMK), meals in line with national or WHO dietary guidelines (DGL), and meals in line with recommendations for healthy and sustainable diets, including flexitarian (FLX), vegetarian (VEG), and vegan (VGN) dietary patterns, as well as for cost-optimised vegetarian and vegan diets with greater proportions of whole grains (_wg). Costs are provided in absolute terms (US$-2020) for meals of average-diet composition and current levels of food waste and as percentage changes otherwise.

Waste scenario	Region	BMK (US$/d)	Percentage change for diet scenarios					
			DGL	FLX	VEG	VGN	VEGwg	VGNwg
Current levels of food waste	World	1.95	12%	22%	14%	27%	8%	9%
	High-income countries	1.89	35%	15%	-1%	8%	-7%	-11%
	Upper middle-income countries	2.15	16%	9%	1%	12%	-6%	-5%
	Lower middle-income countries	1.78	9%	26%	19%	34%	13%	14%
	Low-income countries	2.16	1%	38%	34%	50%	29%	36%
Halving of food waste	World	-14%	-3%	5%	0%	11%	-4%	-3%
	High-income countries	-16%	12%	-6%	-17%	-10%	-21%	-26%
	Upper middle-income countries	-16%	-1%	-7%	-12%	-3%	-17%	-17%
	Lower middle-income countries	-13%	-5%	10%	6%	18%	1%	2%
	Low-income countries	-12%	-11%	21%	19%	34%	15%	22%

SI Table 7. Total cost of school meal programmes (US$ billion) for 2020 with current coverage (first set of rows), and for 2030 covering all children of school age with at least one meal (other rows). Monetary values are expressed in US$-2020.

Parameter	Region	Costs for meal compositions in 2030 (US$ billion)						
		BMK	DGL	FLX	VEG	VGN	VEGwg	VGNwg
Costs of meal ingredients for current coverage	World	162.2	197.1	185.2	170.0	189.7	161.4	159.4
	High-income countries	36.0	50.3	39.5	34.1	37.0	32.1	30.3
	Upper middle-income countries	67.9	78.2	67.8	61.5	67.6	57.6	56.5
	Lower middle-income countries	50.0	59.8	67.4	64.2	73.2	62.0	62.0
	Low-income countries	8.3	8.8	10.5	10.2	11.9	9.8	10.6
Costs in meal ingredients for meeting SMC pledge	World	776.1	884.1	929.9	866.3	966.2	822.1	827.8
	High-income countries	94.1	129.3	106.1	91.7	100.1	86.4	82.2
	Upper middle-income countries	282.5	322.7	299.0	275.9	306.0	257.4	257.7
	Lower middle-income countries	281.9	311.7	361.2	340.3	381.1	325.3	327.0
	Low-income countries	117.6	120.5	163.7	158.3	179.0	153.0	160.9
Change in costs for halving of waste	World		-123.2	-128.1	-104.2	-120.6	-96.2	-95.6
	High-income countries		-22.3	-18.8	-14.7	-17.1	-13.6	-13.6
	Upper middle-income countries		-48.5	-44.2	-35.2	-40.6	-31.9	-31.9
	Lower middle-income countries		-38.5	-45.3	-37.2	-43.6	-34.5	-34.0
	Low-income countries		-13.8	-19.8	-17.1	-19.4	-16.1	-16.1
Reductions in costs of illness in adulthood	World		-333.7	-445.3	-453.1	-468.3	-450.2	-460.2
	High-income countries		-121.1	-147.7	-150.3	-155.5	-148.7	-151.1
	Upper middle-income countries		-135.2	-190.1	-193.3	-198.5	-192.7	-197.2
	Lower middle-income countries		-57.2	-76.8	-78.5	-81.6	-77.8	-79.9
	Low-income countries		-20.2	-30.7	-31.1	-32.7	-30.9	-32.0
Reductions in climate damage costs	World		-18.0	-44.2	-60.7	-69.7	-61.7	-72.9
	High-income countries		-2.0	-7.5	-9.3	-10.7	-9.5	-11.2
	Upper middle-income countries		-9.0	-25.0	-33.5	-36.9	-33.9	-38.3
	Lower middle-income countries		-5.5	-9.1	-13.9	-17.1	-14.2	-18.2
	Low-income countries		-1.6	-2.6	-4.0	-5.0	-4.1	-5.2
Changes in total costs for providing healthy and sustainable meals	World		-366.9	-463.8	-527.8	-468.6	-562.1	-577.1
	High-income countries		-110.2	-162.0	-176.6	-177.3	-179.6	-187.8
	Upper middle-income countries		-152.5	-242.8	-268.6	-252.5	-283.7	-292.2
	Lower middle-income countries		-71.5	-51.9	-71.2	-43.1	-83.2	-87.1
	Low-income countries		-32.7	-7.0	-11.5	4.4	-15.7	-10.0

Fig 6. Changes in the food-related costs of school meals as a percentage of a country's GDP for providing school meals to every child by 2030 compared to the 2020 coverage of school meal programmes. The map shows the changes for the example of meals in line with healthy and sustainable vegetarian dietary patterns with high whole-grain content. Costs are expressed in US$-2020.



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