Food Systems: Seven Priorities to End Hunger and Protect the Planet

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The world's food system is in disarray. One in ten people is undernourished. One in four is overweight. Almost half the world's population cannot afford a healthy diet. Food supplies are disrupted by heatwaves, floods, droughts and wars. The number of people going hungry in 2020 was 13% higher than in 2019 owing to the COVID-19 pandemic and armed conflicts. (FAO, IFAD, UNICEF, WFP and WHO 2021).

The planet suffers too. The food sector emits about 30% of the world's greenhouse gases. Expanding cropland, pastures and tree plantations drive two thirds (5.5 Million ha per year) of the loss in forests, mostly in the tropics (Pendrill et al. 2019). Poor farming practices degrade soils, pollute and deplete water supplies, and lower biodiversity.

As these interlinkages become clear, approaches to food are shifting – away from production, consumption and value chains toward safety, networks and complexity. Recent crises around global warming and COVID-19 have compounded concerns. Policymakers have taken note.

In September, the UN Secretary General will convene a Food Systems Summit. This is only the 6th UN summit on food since 1943 and the first with heads of states in the UN General Assembly. A group of leading scientists has been tasked with ensuring the science underpinning the 2021 Summit is robust, broad and independent – we write as its chair and co-chairs. While such approaches are familiar

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in other areas like climate change and biodiversity, this marks the first time scientists have been explicitly brought in to multilateral discussions around food (Nature Editorial Board 2021).

The global food system needs a revamp – in policies and institutions as well as on social, business and technology fronts (OECD 2021). Science is one lens for making sure that changes are integrated and add collectively to deliver better outcomes. But it is challenging. Food spans many disciplines – not least agriculture, health, climate science, AI and digital science, political science and economics. The indirect effects of policies on climate change, biodiversity loss and adverse health effects need to be factored in to the true costs of food; these could triple **<yes?]** the current global value attributed to food markets (Hendriks et al. 2021). A range of voices is vital. The Scientific Group is engaging with hundreds of experts, across civil society, indigenous peoples, producer organizations, youth organizations and the private sectors.

Here we highlight key roles scientists should play to accelerate the transformation to healthier, more sustainable, equitable and resilient food systems. These seven priorities reflect the Scientific Group's evidence base, comprising more than 40 reports and briefs (see https://sc-fss2021.org/materials/fss-briefs-by-partners-of-scientific-group/).

1 Seven Priorities

Science-driven advances are needed in the following areas.

1.1 End Hunger and Improve Diets

Scientists need to identify optimal conditions and investment opportunities to make healthy and nutritious foods more available, affordable and accessible. Measures that do all three are most effective in cutting hunger and improving diets. For example, improving irrigation on small farms in Tanzania and Ethiopia has enhanced productivity, lowered prices for consumers and increased farmers' income (Passarelli et al. 2018).

Three big game changers are: enhancing research and development (R&D) in agriculture and food to increase productivity sustainably, adding income and nutrition components to social protection programs, and slashing food waste and losses. Research priorities include powering fridges and preserving plants with solar energy. Developing new forms of packaging using recycled materials, coatings of nanomaterials and even edible films, would keep foods fresh for longer and reduce losses. School feeding programs offering nutritious meals for students, plus incentives like take home rations for parents to keep children in education, have increased school participation in Mali by 10% (Aurino et al. 2019). Under Covid-19 lockdowns these programs become even more relevant, as in Addis Ababa schools.

Researchers also need to study behavioral barriers to healthy eating, such as snacking under stress. They should develop policy guidelines for educational food labels and taxes and regulations on unhealthy foods (such as sugar, trans-fats and high-fructose corn syrup). The health properties of fortified foods and cultivated meats need establishing.

1.2 De-risk Food Systems

The more global, dynamic and complex food systems become, the more they are open to novel risks. Scientists need to better understand, monitor, analyze and communicate such vulnerabilities. For example, droughts, biofuels expansion and financial speculation after the sudden imposition of trade barriers led to food price hikes in 2008 (Kalkuhl et al. 2016). The COVID-19 pandemic and armed conflicts have shaken food value chains across Africa this year, driving up food prices. Successful initiatives combining on the ground observations of food systems and nutrition with forecasting include FEWS NET (https://fews.net/) and the joint FAO-World Food Program Early Warning System (https://www.wfp.org/publications/fao-wfp-early-warning-analysis-acute-food-insecurity-hotspots).

Policies and economic solutions are needed. For example, novel insurance products facilitated by remote sensing and weather forecasts would provide cover for lost crops and livestock. Solar powered irrigation systems would reduce risk from drought. Smart-phone apps would provide farmers with information on local crop pests, weather risks and market opportunities; these are already used in Kenya, Senegal, India and Bangladesh (Baumüller 2017). Payment schemes are needed to encourage farmers to manage and capture carbon in soils and trees and trade it.

1.3 Protect Equality and Rights

Poverty and inequalities associated with gender, ethnicity and age restrict many people's access to healthy foods. Socio-economic researchers need to suggest inclusive ways to transform more than 400 million smallholder farms. They must identify pathways out of inequitable and unfair arrangements over land, credit and labor and empower the rights of women and youth. For example, if female-headed households in Southern Ethiopia had same resources as male-headed ones, their productivity in maize would increase by 40%, to match that of the latter (Gebre et al. 2021).

Protecting the land rights of smallholders, women and indigenous peoples is paramount. Technology can ensure transparency and efficiency. For example, Ghana uses Blockchain ledgers of land use and ownership rights for allocating land (Mintah et al. 2021). At the trans-national scale the Land Matrix Initiative (https://landmatrix.org/) collects and shares data on big land acquisitions and investments, covering almost 100 countries. Similar solutions are needed to protect the land rights of

Indigenous Peoples (see http://www.fao.org/publications/card/fr/c/CB4932EN/). Efforts to build local research capacity, educational programs around food and farming, as well as training and financing opportunities in rural areas are needed.

1.4 Boost Bioscience

Researchers need to find ways to restore soil health and improve the efficiency of cropping, breeding of crops, and re-carbonizing the biosphere. Linkages among all Earth systems must be considered together – a One Health approach.

Alternative sources of healthy protein need to be advanced, including more plant-based and insect-derived proteins, including for animal feed. Plant breeding techniques that capture nitrogen from the air, to reduce the need for fertilizers and increase nutrients, should be investigated. Genetic engineering and biotechnology should be applied to increase productivity, quality and pest and drought resistance of crops; recent examples include varieties of bananas resistant to Fusarium Wilt diseases, and pest-resistant BT eggplants. Property rights, skills and data-sharing should be addressed, to widen access to bioscience technologies.

1.5 Protect Resources

Tools are needed to help people manage soils, land and water sustainably. For example, hand-held digital devices and remote sensing can track concentrations of soil carbon and other nutrients. AI and drones allow farmers to spot areas that need irrigation, fertilization and pest control. Soil microbes can be harnessed to improve soil structure, ability to store carbon and yields. Researchers need to adapt and scale such technologies.

Biodiversity and genetic bases need to be protected. Seed varieties need to be preserved and their phenotype and genotype characteristics explored in the contexts of climate change and nutrition. Traditional food and forest systems, including those of Indigenous Peoples, need to be better understood and supported in national agricultural research systems. Cooperation for mutual benefit should be explored, as the Tribal Adaptation Menu in Indigenous Peoples' areas in the US has for climate adaptation https://forestadaptation.org/sites/default/files/Tribal%20Climate%20Adaptation%20Menu%2011-2020%20v2.pdf.

1.6 Sustain Aquatic Foods

Most of the focus on food to date has been on land-based agriculture. Seafood and seaweed have much to offer nutritionally and environmentally. Aquatic foods need to be better integrated into understanding of food systems (see https://www.nature.com/

articles/d41586-020-03303-3). Researchers should look for ways to increase nutritional diversity in aquatic foods and sequester carbon in the marine environment.

Ecological science perspectives and global cooperation and institutions are needed to bring the harvesting of oceans to sustainable levels and protect biodiversity. Science-based approaches must address the sustainability of fish feeding systems; for example, explore using insect rearing, oil-rich modified legumes and micro-algae as fish feed.

1.7 Harness Technology

Robots, sensors and artificial intelligence are increasingly used on farms and in food processing. For example, robots harvest crops and milk cows. Sensors can monitor the origin and quality of ingredients and products along the food processing chain to reduce losses and guarantee food safety. But most farmers and producers still don't have access. To spread the benefits, devices need to become cheaper and easier to purchase and use. Rental services should be developed, such as an Uber-like app for tractors in India. Rural electricity will be needed, and training and education programs. Again, managing property rights and sharing data are key.

2 First Steps

The 2021 Food Systems Summit is a great opportunity to end hunger by 2030 and set in train a sustainable food system. Previous UN food summits have delivered change. The 1943 conference led to FAO; the 1974 meeting strengthened the CGIAR and led to the founding of IFPR; the 2002 session accelerated the human right to food; and the 2009 meeting established monitoring systems to prevent food price crises.

The breadth of the 2021 agenda could be a hindrance, though, in achieving its goals. To avoid failure, delegates should focus. They should prioritize establishing a guiding framework – for transforming diverse national and local food systems, as well as global networks, with the challenges of trade, finance, climate, innovation and governance.

Debates will be fierce. Food is a contentious topic. Disagreements abound, over goals, pathways and speed of change, and the roles of science and technology, the private sector and the UN. For example, some see agroecology as the only acceptable way of farming, with minimal technology. Biotechnology and gene editing are viewed as both an opportunity and a danger. Livestock exacerbate the climate crisis. (The Scientific Group has aimed to offer a balanced view by noting the diversity of perspectives.)

3 Actions and Targets

Once plans are agreed, the UN Food Systems Summit will need to move to implementation. Here are our suggestions.

First, boost finance. On the research front, we propose that governments allocate at least 1% of the fraction of their nations' GDP that relates to food systems to food-related research. Many countries spend only half of that. Least-developed countries should be given aid to reach a similar level. To end hunger for the poorest, we propose a special fund be set up. This would be supported by development aid donors and bonds backed by the IMF and World Bank. Research and modeling would be required into implementation and impacts.

Second, increase scientific capacity. Use the funding above to strengthen research capacity in low and middle income countries. Expand research collaborations between the public and private sectors, among farmers, start-ups in food value chains and science communities. Sharing research infrastructure and data between the global south and north would be a good start.

Third, strengthen science-policy interfaces. In stark contrast to many other fields, agriculture, food security and nutrition do not have an international agreement or convention to consolidate actions. We call on the UNFSS and UN Member States to explore an intergovernmental treaty or framework convention on food systems, by analogy to the conventions on climate, biodiversity and desertification agreed upon in Rio in YEAR. We recommend that all science organizations and academies with food-relevant research be included in a preparatory process.

Bringing the tools of science to the table will help transform the global food system to end hunger and achieve the Sustainable Development Goals by 2030.

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