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**Ensuring Access to Safe and Nutritious Food for all
Through Transformation of Food Systems**
- a paper on Action Track 1 -

Draft for discussion

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Sheryl Hendriks, Jean-François Soussana,
Martin Cole, Andrew Kambugu,
David Zilberman

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Elizabeth Hodson de Jaramillo (Colombia) Professor Em. School of Sciences of the Pontificia Universidad Javeriana, and member of Inter American Network of Academies of Sciences (IANAS).

Andrew Kambugu (Uganda) Executive Director Infectious Diseases Institute (IDI), College of Health Sciences, Makerere University. Co-founder of the Researchers for Global Health (R4GH) initiative.

Kaoru Kitajima (Japan) Professor at Kyoto University Graduate School of Agriculture; a forest ecologist, especially in tropical America and Asia.

Rattan Lal (India) Professor of Soil Science, Director of the Carbon Management and Sequestration Center at Ohio State University. World Food Prize Laureate 2020.

Hoesung Lee (South Korea) Chair, Intergovernmental Panel on Climate Change (IPCC), Professor at Korea University Graduate School of Energy and Environment, Seoul.

Uma Lele (India) is President of the International Association of Agricultural Economists (IAAE).

Lynnette M. Neufeld (Canada) incoming President of the International Union of Nutrition Scientists (IUNS), Director Knowledge Leadership, Global Alliance for Improved Nutrition (GAIN).

Urs Niggli (Switzerland) Scientist focusing on sustainable farming systems, from 1990 to 2020 he led the Research Institute of Organic Agriculture (FiBL)

Claudia Sadoff (USA) Executive Management Team Convener and Managing Director, Research Delivery and Impact, of the Consultative Group on International Agricultural Research

Lisa Sennerby Forsse (Sweden) past President, Royal Swedish Academy of Agriculture and Forestry (KSLA) and was the vice-chancellor of the Swedish University of Agricultural Sciences 2006-2015.

Jean-François Soussana (France) is Vice-President of International Policy at the Institute national de la recherche agronomique (INRAE).

Morakot Tanticharoen (Thailand) Professor and Senior Advisor to the President of the National Science and Technology Development Agency (NSTDA), research in microbiology and biotechnology.

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Aman Wirakartakusumah (Indonesia) Professor Em. at Department of Food Science and Technology and Senior Scientist at SEAFast Center, Bogor Agricultural University (IPB), President-Elect of the International Union of Food Science and Technology.

David Zilbermann (Israel, USA) Professor in the Department of Agricultural and Resource Economics, University of California at Berkeley. One of the Founders of the International Consortium of Applied Bio-economy Research (ICABR).

ENSURING ACCESS TO SAFE AND NUTRITIOUS FOOD FOR ALL THROUGH TRANSFORMATION OF FOOD SYSTEMS

Sheryl Hendriks¹, Jean-François Soussana², Martin Cole³, Andrew Kambugu⁴ and David Ziberman⁵

1. University of Pretoria; 2. INRAE, Paris (National Research Institute for Agriculture, Food and Environment); 3. University of Adelaide; 4. Makerere University; 5. University of California at Berkeley.

1. Introduction

Action Track 1 of the World Food Summit offers an opportunity to bring together the crucial elements of food safety, nutrition and inequalities in the framework of food systems that underlie the achievement of the other Action Tracks (See Box 1). The three elements are embedded in the fundamental human rights, including the right to food, the rights to safe water and sanitation (essential for safe food) as well as the right to be free from discrimination (enjoy equality), since inequalities in society and the food system make affordable and healthy diets inaccessible to the most vulnerable populations. Malnutrition includes undernourishment, micronutrient deficiencies, as well as overweight and obesity. Malnutrition increases susceptibility to foodborne diseases, creating a vicious cycle for health, reducing productivity and compromising development. The current COVID-19 pandemic has exposed long-standing inequalities in our food and health systems that affect the access to safe and nutritious food as well as income to enable this (Laborde et al., 2020).

Food systems provide a framework to advance access to safe and nutritious food¹ for all. A food system encompasses all the elements and activities that relate to the production, processing, distribution, preparation and consumption of food, as well as the output of these activities, including socioeconomic and environmental outcomes (HLPE, 2020).

Box 1: How Action Track 1 (AT1) relates to the other Tracks

Ensuring safe and nutritious food for all (AT1) will require a shift to sustainable production (AT3) and consumption patterns (AT2). If carefully planned and implemented, these changes should lead to co-benefits for climate and the environment (AT3), inclusive development and the development of equitable livelihoods (AT4). Increased coordination, transparency and accountability will help build resilience to vulnerabilities (AT5) across the food system and for the most vulnerable people.

2. What is a safe and nutritious diet?

Established guidelines for dietary intakes for energy, macronutrients, micronutrients and trace elements at different stages of the life cycle, sex and level of activity exist (WHO, 2020). Meeting these requirements demands a diversified diet and small, frequent meals for children. Safe food promotes health and is free of foodborne diseases caused by microorganisms including bacteria, virus, prionics, parasites and chemicals as well as foodborne zoonoses transferred from animals to humans and other associated risks in the food chain (WHO, 2013).

¹ Including all crops, fish, forest foods and livestock

Diet quality comprises four key aspects: variety/diversity, adequacy, moderation and overall balance (FAO, IFAD, UNICEF, WFP and WHO, 2020).

Recent analyses draw attention to the affordability of a healthy diet (FAO, IFAD, UNICEF, WFP and WHO, 2020); Masters et al., 2018). Shocks, including the COVID-19 pandemic, make healthy diets less accessible and affordable, while at the same time increasing the need for a nutritious diet. While the definitions of an adequate diet and safe food are established and widely accepted, there is debate in the literature about what constitutes a sustainable diet. Each proposed diet has trade-offs in terms of affordability, climate and environmental impacts. These trade-offs are discussed in the sections that follow.

3. We are not on track to meet international targets for ensuring safe and nutritious food for all by 2030

With only ten years to go to 2030, the world is not on track to meet nutrition-related targets and no updated data is available to determine the progress on reducing the incidence of foodborne diseases. Table 1 presents a summary of the international targets related to ensuring safe and nutritious food for all. While the proportion of population undernourished, stunting, low birthweight and anaemia among women of reproductive age have declined, the reductions are not sufficient to meet the global targets. The experience of food insecurity (FIES) has increased slightly as have the numbers of overweight children and adults.

No country is exempt from the surge of malnutrition. Undernutrition coexists with overweight, obesity and other diet-related non-communicable diseases (NCDs), even in poor countries. UNICEF et al. (2020) report that 37% of overweight children reside in low and middle-income countries, highlighting the important role that food systems play in nutrition outcomes. Likewise, fragile and extremely fragile countries are disproportionately burdened by high levels of all three forms of malnutrition compared to non-fragile countries (GNR, 2020).

While some progress has been made in certain countries and in some regions, the 2020 Global Nutrition report shows that no country is 'on course' to meet all eight WHO global nutrition targets being tracked, and just eight countries are on course to meet four WHO 2025 targets for malnutrition (GNR, 2020). Although the actions required for reducing all forms of malnutrition are well documented (Lancet report, various WHO guidelines) and the benefits also (Hoddinott, etc.), progress is far too slow. Unless nutrition-specific (direct) and nutrition-sensitive (indirect) interventions are implemented at scale and in a sustainable way with complementary services (such as regular deworming of children), the impact will be suboptimal (Ruel et al. 2018). In addition, urgent action is necessary to minimise the impact of the Covid-19 pandemic on children's nutrition (Ruel et al. 2020)

Table 1 demonstrates the fragmented nature of data on nutrition and food safety. National nutrition assessments are costly and infrequently conducted, constraining the monitoring of progress and the impact of interventions at scale. Even where the indicators have been included in the SGD indicator set, current data on foodborne diseases, some malnutrition indicators (such as wasting), poverty and inequality data are not updated or are missing comparative baselines. One recent innovation is the assessment of the adequacy, affordability and access to health diets included in the 2020 SOFI report. If continually updated, this indicator could become a comprehensive proxy for monitoring progress on ensuring safe, nutritious food for all.

Table 1: Taking stock

Component	Element	International target/s	Latest global estimates	Progress to date (global)
Nutrition	Hunger (Proportion of the population that is undernourished - PoU)	SGD2: By 2030, end hunger and ensure access by all people, in particular, the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round	PoU 8.8% (690M) (SOFI, 2020)	Down from 12.5% in 2004
	Food insecurity (Food Insecurity experience Scale or FIES) moderate or severe food insecurity in the population		FIES - severe = 9% and moderate = 25% (SOFI, 2020)	Severe - up from 8.1% in 2014 Moderate – up from 22.7% in 2014
	Stunting (being short for age)	40% reduction in the number of children under five years of age who are stunted by 2025 and 50% by 2030 (WHO & UNICEF, 2017)	21.3% (moderate and severe) = 149.0 million children under 5 years of age (UNICEF, WHO and the World Bank, 2020)	Down from 24.6% in 2012
	Wasting (being underweight for height)	WHO target: Reduce and maintain childhood wasting at less than 5% by 2025 and less than 3% by 2030 (WHO & UNICEF, 2017)	6.9% (moderate and severe) = 49.5 million children (UNICEF, WHO and the World Bank, 2020)	No available historical estimates, baseline is 2019
	Overweight ² (children <5 years)	WHO 2025 target: No increase in child overweight	5.6% (SOFI 2020) = 40.1 million under 5 years of age are overweight (UNICEF, WHO and the World Bank, 2020).	Up from 4.9% in 2000
	Obesity ² (Adults)	WHO 2025 target: halt the rise in levels	13.1% in 2016, there were 677.6 million obese adults (GNR, 2020).	Up from 11.8% in 2012
	Low birthweight	WHO 2025/2030 target: A 30 percent reduction in low birth weight	In 2015 = 14.6% (SOFI, 2020)	Slightly down from 15% in 2012
	Anaemia (iron deficiency)	WHO 2025/2030 target: A 50 percent reduction of anaemia (iron deficiency) in women of reproductive age	In 2016, 32.8% (SOFI, 2020)	Slightly up from 30.3% in 2012

² Body Mass Index (BM) over 30 – calculated as weight/height²

Component	Element	International target/s	Latest global estimates	Progress to date (global)
Food safety	Foodborne Disease Burden	WHO Foodborne Disease Burden Epidemiology Reference Group (FERG 2007-2015), foodborne diseases caused 600 million illnesses, 420,000 deaths, and 33 million Disability Adjusted Life Years (DALYs) in 2010	2010: unsafe food caused 600 million cases of foodborne diseases and 420 000 death equivalent to 33 million years of healthy lives are lost (WHO, 2015).	Unknown – only data for 2010 published
Inequality	Inequality	SGD1: By 2030 eradicate extreme poverty for all people everywhere, currently measured as people living on less than \$1.90 a day.	SGD indicator 1.1.1 Proportion of population below the international poverty line, by sex, age, employment status and geographical location (urban/rural) 2015 = 10% (World Bank, 2018)	Down from 11.2 % in 2013. Data on the split between rural and urban poverty is not yet available.
		Access to affordable and healthy diets (FAO et al., 2020) - SOFI 2020 says 3 billion cannot afford healthy diets	% population that cannot afford an energy-sufficient diet in 2019 = 4.6% % population that cannot afford a nutrient adequate diet in 2019 = 23.3% % population that cannot afford a healthy diet in 2019 = 38.3% (FAO et al., 2020)	Unknown – this is a new indicator without historical data

4. Interconnected drivers affect the access to safe and nutritious food for all

Several interconnected socioeconomic and biophysical drivers affect the access to safe and nutritious food. While some of these drivers are global (e.g. trade liberalization, climate change), others are regional (e.g. conflicts) and many are differentiated across geographies (e.g. poverty, demography, technologies, land degradation). Below, we provide a brief overview of the main drivers, which are also depicted in Figure 1.

a) Socio-economic drivers

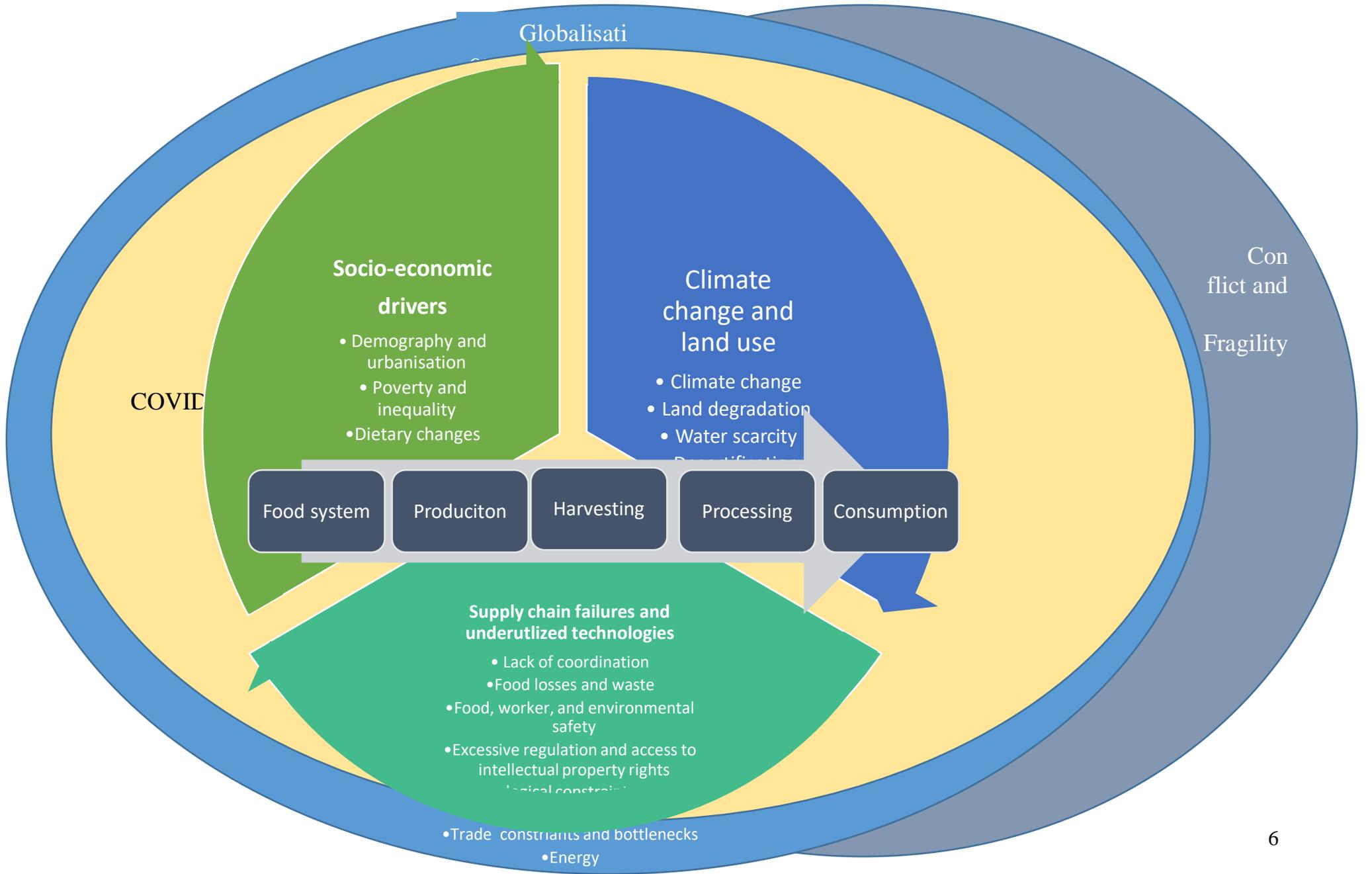
There is a vast array of socio-economic drivers that increase the global food demand, including population growth (Gerten et al., 2020), westernization of diets, increased food wastes and overweight (including obesity) (Hasegawa et al., 2019), increased demand for animal-sourced foods in diets leading to increased demand of feed from arable crops (Mottet et al., 2017), and rapid urbanisation (van Vliet et al., 2017). These trends could cause a doubling of food demand by 2050 and would require a global mean increase of crop yields by over 30% for a range of scenarios without climate change (FAO, 2018), a value lower than in previous projections that were assuming rapid economic growth (Alexandratos and Bruinjsma, 2012).

Globalisation. Lockdowns caused by the COVID-19 pandemic's of zoonotic origin have disrupted the production, transportation, and sale of nutritious, fresh and affordable foods, forcing millions of families to rely on nutrient-poor alternatives (Fore, Dongyu, Beasley, & Ghebreyesus, 2020). Globalized food trade narrows food diversification and biodiversity (Khory et al., 2019), since the diversity of agricultural production diminishes as farm size increases (Herrero et al., 2019), and accelerates land and water degradation (Rosa et al., 2019). The availability of cheap, high-energy, fatty and, sugary foods, the high price of nutritious fresh foods and the demand for more 'westernised' and often obesogenic foods increases the incidence of nutrition-related non-communicable diseases (NCDs) (Chaudhary et al. 2018). Nevertheless, globalized supply chains support the wide distribution of foods, , reducing shortages in import-dependent regions (Janssens et al., 2020), improving seasonal availability and often reducing food loss through technological advances in processing, packaging and storage (Zilberman et al., 2019).

Demography and urbanization. Although population growth has slowed globally, population in the 47 least developed countries (mostly in Africa and Asia) is projected to double between 2019 and 2050 and by 2030 the number of youth in Africa will have increased by 42 per cent. Nevertheless, in 2018, for the first time in history, the proportion of older persons (above 65) outnumbered children under five years – a trend that is predicted to continue (UNDESA, 2019). A growing proportion of older people will put strain on the health system and change nutritional needs and dietary preferences. Moreover, by 2050, 68% of the global population could be urban, shifting the proportion of producers to consumers and of rural to rural poverty, increasing land take (Van Vliet et al, 2019) and pressures on food systems.

Poverty and inequality. Poverty traps millions in poor nutrition, depriving them of their potential (Victoria, 2008). The prevalence of undernutrition and overweight adults are directly linked with relative food prices (Headey and Alderman, 2019). Healthy diets cost between 60 and 400% more than nutrient adequate and energy sufficient diets, respectively (FAO et al., 2020). Currently, more than 1.5 billion people cannot afford a nutrient-adequate diet and over three billion cannot afford even the cheapest healthy diet (FAO, 2020). Food system disruptions caused by COVID measures aggravate this situation (Headly, et al., 2020).

Figure 1: Food system context and drivers



Despite the catastrophic out-of-pocket costs on health care spent by the poorest billion due to non-communicable diseases and injuries, these conditions account for 60–70% of the public health care costs in low-income and lower middle-income countries (Zuccala and Horton, 2020). In total, it has been estimated by the World Bank that under and malnourishment costs 3% of global GDP and overweight and obesity another 2% of GDP (Jaffee et al., 2018). Conflict and fragility

While widespread famine has largely been eradicated, the nature of food crises has changed in recent times. FSIN (2020) reports that 135 million people live in crisis (acute food insecurity) in 2019 – an increase of 11 million people over the previous year (FSIN Food Security Information Network, 2020). While these crises are largely driven by conflict and economic downturns, they have a severe effect on the ability of people to access food. The largest numbers of acutely food-insecure people are in Africa where extreme weather events in the Horn of Africa and Southern Africa have led to widespread hunger. In East Africa, armed conflicts, intercommunal violence and other localised tensions create insecurity (FSIN, 2020). Adverse climate events and stresses compound violence, displacement and disrupted agriculture and trade. Often those affected by crises flee to neighbouring countries, putting additional stress on the international humanitarian response system and on the food systems of the host countries. Populations in crisis are disproportionately vulnerable to the impact of the COVID pandemic and have little capacity to cope with the health and socioeconomic aspects of the shock (FSIN, 2020). WFP predicts that the number of people in LMICs facing acute food insecurity will nearly double to 265 million by the end of 2020 (WFP, 2020). Moreover, fragile and extremely fragile countries are disproportionately burdened by high levels of malnutrition compared to non-fragile countries (GNR, 2020).

b) Supply chain failures and underutilized technologies

While UN Agencies and their partners have converged and coordinated various mechanisms for food security coordination (e.g. FSIN, the Global Network against Food Crises, expanding the SOFI collaborators, the CFS Global Strategic Framework etc.), no global governance system exists for food security and no coordination system exists for coordinated action and accountability with regards to sustainable food systems (see Box 2). If we are to transform food systems to ensure safe and nutritious food for all, a concerted effort is needed to develop a global compact and accountability system to drive agreed-on transformation.

Almost one-third of total food production is discarded as food loss and waste, equating about one-quarter of land, water, and fertilizer used for crop production (Shafiee-Jood and Cai, 2016). Food losses and food waste occur throughout the food chain. They constrain food system sustainability due to their adverse effects on food security, natural resources, environment, climate and human health (e.g., toxic emissions from incineration) (Xue et al., 2017).

Box 2: Sustainable food systems

“Sustainable food systems are: productive and prosperous (to ensure the availability of sufficient food); equitable and inclusive (to ensure access for all people to food and to livelihoods within that system); empowering and respectful (to ensure agency for all people and groups, including those who are most vulnerable and marginalized to make choices and exercise voice in shaping that system); resilient (to ensure stability in the face of shocks and crises); regenerative (to ensure sustainability in all its dimensions); and healthy and nutritious (to ensure nutrient uptake and utilization)” (HLPE, 2020).

Approximately 600 million people fall ill through consumption of contaminated food each year, with considerable differences among sub-regions; with the highest burden observed

in Africa (WHO, 2020). More than 420 000 die every year, equating to the loss of 33 million Disability-Adjusted Life Years (WHO, 2015). Foodborne diseases disproportionately affect children, accounting for 40% of the foodborne disease burden. The consumption of unsafe foods cost low- and middle-income countries at least US\$ 110 billion in lost productivity and medical expenses annually (Jaffee et al., 2019). With a large proportion of emerging human infectious diseases originating from animal sources (zoonotic diseases) there is also an increasing need to consider both animal and human health as a 'one health' issue.

While technology advances (including biotechnology, digitalisation and mechanisation) can have significant benefits for the food system, these advances can also drive negative food system changes. One example is the advance of biofuel production that, when based on food crops, can drive staple food prices up and compete for land, exacerbating inequalities. Biotechnology is mostly used for fibre and animal feed, and less often for food, to a large extent, because of regulatory constraints and intellectual property rights barriers (Barrows et al., 2014). Orphan crops would likely benefit from new technologies as could disease control in animals and plants. Reduced support for public research and extension (as part of budget cuts and privatisation efforts), and reduced foreign aid hamper the dissemination and adoption of new and innovative technologies.

c) Climate change, land use change and natural resources degradation

Climate change, including increases in frequency and intensity of extremes, has adversely impacted food security, with negative impacts observed on the yields of some crops (e.g., maize and wheat) and on pastoral systems in low latitude regions (IPCC, 2019). With increasing warming, the frequency, intensity and duration of heat waves, droughts and extreme rainfall events are projected to increase in most world regions, increasingly threatening the stability of food supply (IPCC, 2019). For instance, an estimated 86% probability of losses across the world's maize breadbaskets was found with warming of 4 °C, compared to 7% probability for 2°C warming (Gaupp et al., 2020). Nutritional quality of crops will also be affected by rising atmospheric CO₂ levels (IPCC, 2019).

The global food system (from farm inputs to consumers) emits about 30% of global anthropogenic greenhouse gases (GHG), contributes to 80% of tropical deforestation and is a main driver of land degradation and desertification, water scarcity and biodiversity decline (IPCC, 2019). About a quarter of the Earth's ice-free land area is subject to human-induced degradation and about 500 million people live within areas undergoing desertification (IPCC, 2019). By 2050 land degradation and climate change could lead to a reduction of global crop yields by about 10% with strong negative impacts in India, China and sub-Saharan Africa resulting in the displacement of up to 700 million people (Cherlet et al., 2018). Around 2 billion people live within watersheds exposed to water scarcity and this number could double by 2050 (Gosling and Arnell, 2016). Future agricultural productivity in the tropics is also at risk from a deforestation-induced increase in mean temperature and the associated heat extremes and from a decline in rainfall (Lawrence and Vandecar, 2015). Over half of the tropical forests worldwide have been destroyed since the 1960s, affecting the lives of 1 billion poor people whose livelihoods depend on forests and equalling a mass extinction event if tropical deforestation continues unabated (Alroy, J., 2017).

5. Transforming food systems is key to safe and nutritious food for all

Apart from urgent action necessary to manage future population growth, changing the path of our future will demand including structural transformation of food systems, leading to changes in allocation of focus, resources and research attention to factors beyond production, accompanied by far more concerted efforts to coordinate activities, monitor progress more closely and greater accountability from all players across the food system. This raises the need for a global compact for managing the demand and consumption drivers and harnessing science,

technology and innovation to improve the sustainable production of enough food to ensure access to affordable, safe and nutritious foods for all (Figure 2). The sections below identify some of the levers for change.

a) Coordination, monitoring and accountability

Food security is a public good. Therefore, improved coordination, monitoring and accountability across the food system and among all stakeholders is necessary, including sharing knowledge, building capacity, better measurement, updated data, better modelling for foresight, scenarios and case studies and access to documented success stories. Advances in information technology and data science play an important role in enabling rapid assessment of situations (such as the IPC Pilot Artificial Swarm Intelligence Project), monitoring and decision making and adaptive learning. An integrative global food system model is still missing, since existing models (see Khanna and Zilberman, 2012) do not have consistent global coverage and are not designed to assess the impacts of a broad range of factors. Strengthening national policy scenarios and foresights is also necessary (Schmidt-Traub et al. 2019). Moreover, improved indicators of food systems (see SOFI, 2020) are required (see Sukhdev et al. 2018, Chaudhary et al. 2018 for examples), that could provide more holistic measures that capture the three elements of safety, nutrition and inequality.

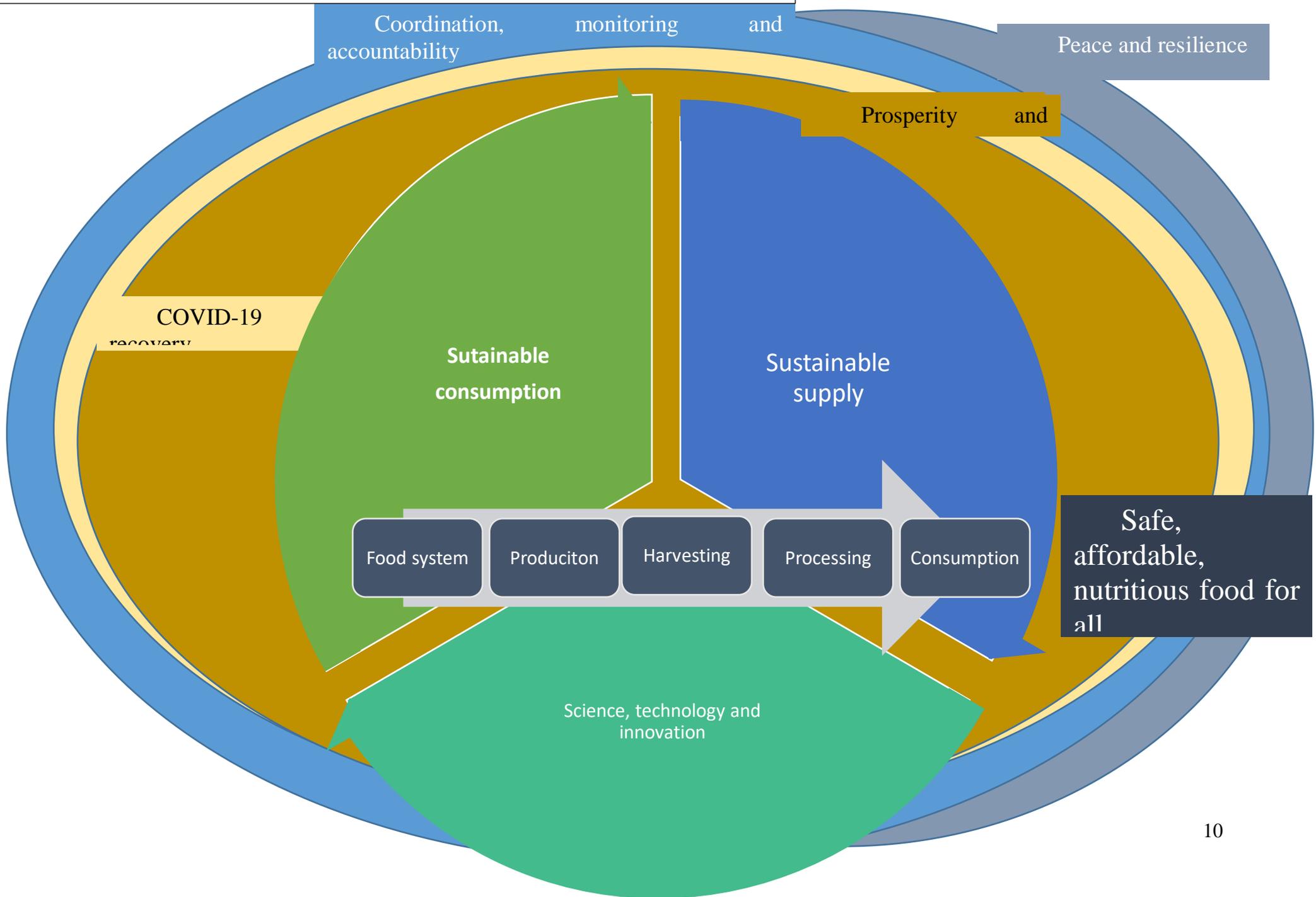
Rigorous global monitoring systems require global collaboration, updated information, and investment with significant returns. A taskforce charged with understanding global monitoring and data collection opportunities about agrifood systems, could provide a clearing house for the multiple (often duplicated) data held by UN agencies as well as public and private organisations. While some effort has been made to coordinate international actions to address crises, access to food requires targeted interventions for the most vulnerable. Two-way real-time digital applications to collect and disseminate information to various stakeholders and beneficiaries are needed in last mile and crisis situations and in regions disproportionately affected by the Covid-19 pandemic food system disruptions. This could include driving supply side demand through food banks, social grants, subsidised meals, vouchers and other food assistance (including through e-commerce systems) (WFP, 2017).

b) Influencing food demand and dietary changes

There are several ways to reduce demands on the global food system, both in the short and long-term, by accelerating demographic transitions, reducing food losses and wastes and changing diets. Because of the strong association between female education, fertility and infant mortality, alternative education scenarios alone (assuming identical education-specific fertility and mortality levels) lead to a difference of more than one billion people in the world population sizes projected for 2050 (Lutz and Samir, 2011; Samir and Lutz, 2017).

Household food waste is growing rapidly in emerging economies. Global per capita food waste could double by 2050 (Barrera and Hertel, 2020). Halving food losses and wastes is a target of SDG 12 that could help feed more people, benefit climate and the environment and conserve water (Kummu, et al., 2012, Searchinger et al., 2018; IPCC, 2019). This requires changes along supply chains (agricultural production, food processing, distribution/retail, restaurant foodservice, institutional foodservice, and households) through improved logistics and processing technologies, economic incentives, regulatory approaches and education campaigns (Read et al., 2020; Barrera and Hertel, 2020). A combined scenario targeting under-nourishment while also reducing over-consumption and food waste would reduce food demand by 9% in 2050, compared with a business-as-usual scenario (Hasegawa et al., 2019).

Figure 2: Food system transformations and solutions



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 adaptation and mitigation of climate change while generating significant co-benefits in terms of human health (Springmann et al., 2018; IPCC, 2019). ‘Healthy sustainable diets’ can be defined by optimization procedures (Donati, et al., 2016). However, all diets have trade-offs between nutritional values and the environment and not all may be affordable for all (Headey & Alderman, 2019). Populations with a high prevalence of undernutrition and micronutrient deficiencies (Fanzo, 2019) benefit from increasing the consumption of animal-sourced products due to the bioavailability of key micronutrients (Perignon, Vieux, Soler, Masset, & Darmon, 2017). Moreover, a balance is necessary between meeting the demand for diversified, nutritious and affordable food and minimizing the time and energy to prepare meals.

Urgent public policy action is needed to create incentives for creating healthy, sustainable food systems and delivering safe and nutritious foods for all are crucial instruments to manage food demand, shift consumption patterns and ensure equity through trade, agricultural research, taxes and subsidies across the food system. A wide range of well-established and relatively inexpensive policy options and interventions are available for improving nutrition at the individual level (Buckhman et al., 2020, Hawkes et al., 2020; Bhutta et al., 2008). Policies that enable healthy food environments (such as sugar taxes, educational food labelling, reducing salt, the prohibition of trans-fats and a reduction in the use of high-fructose corn syrup) are core to improving food environments and limiting the burden of non-communicable diseases. Increasing the diversity of food sources in public procurement, health insurance, financial incentives and awareness-raising campaigns, can potentially influence food demand, reduce healthcare costs, contribute to lower GHG emissions and enhance adaptive capacity.

c) Meeting sustainably food and nutrition demand for all

Nutrition outcomes in developing countries are affected by agriculture in several ways: as a source of food for household consumption and of income, through the role of food prices and agricultural policies, through the role of women’s employment in agriculture for nutrition, child care and child feeding and their own nutritional and health status (Gillespie and van den Bold, 2017).

There are more than 570 million farms worldwide, most of which are small and family-operated. Over 1960-2000, average farm size decreased in most lower to middle-income countries, whereas it increased in most in high-income countries (Lowder et al., 2016). As farm sizes increases, the production of diverse nutrients and viable, multifunctional, sustainable landscapes requires efforts to maintain production diversity (Herrero et al., 2019). (Herrero et al., 2019).

Diversification in the food system (e.g., implementation of integrated production systems, broad-based genetic resources, and diets) can reduce risks from climate change (IPCC, 2019). Diversified agroecological systems can play a key role in meeting health and nutrition goals, while also reducing environment-related health risks caused by conventional agriculture through water and air pollution, and more specifically by pesticides, antibiotics and inorganic fertilizers (Frison and Clément, 2020). Compared to conventional agriculture, organic agriculture generally has a positive effect on a range of environmental factors, including above and belowground biodiversity, soil carbon stocks and soil quality and conservation, but it has weaknesses in terms of lower productivity and reduced yield stability (Knapp and van der Heijden, 2019).

Sustainable land management can bridge yield gaps and avoid deforestation, while providing climate change adaptation and mitigation and land degradation co-benefits, in croplands and pastures (Smith et al., 2020) by increasing soil organic carbon (Soussana et al.,

2019), agroforestry, erosion and fire control, improved irrigation water and fertilizers management, heat and drought tolerant plants (Pretty et al., 2018). For livestock, sustainable options include better grazing land management, improved manure management, higher-quality feed, and use of breeds and genetic improvement (Herrero et al., 2016). Under stringent global climate change mitigation policy, risks for food security would be increased (Hasegawa et al., 2018) through competition for land between food production, bioenergy and afforestation. Nevertheless, increasing and valuing soil carbon sequestration on agricultural land would allow reducing these negative impacts by approximately two thirds (Frank et al., 2017). The large-scale deployment of bioenergy options such as afforestation, energy crops, carbon capture and storage has adverse effects for food security, but small scale projects with best practices may deliver co-benefits (Smith et al., 2020).

Increased demand for fish and seafood has threatened fisheries and sustainability of ocean resources. The aquaculture industry has emerged and increasingly fills the seafood supply gap to meet growing demand. Challenges in marine feed supply, in antibiotics use and in waste recycling need to be overcome to further develop aquaculture (Belton et al. 2020).

d) Harnessing science and innovation and managing risks

To transform food systems and reach safe and nutritious for all, science should increasingly inform solutions and generate knowledge that is actionable (Arnott et al., 2020). Since policy agendas are largely set at national and local scales, the translation of global scale scientific assessments into actionable knowledge at national and local scales is needed.

New and emerging technologies could be game changers for overcoming challenges, but their development should be guided by assessing their socio-economic, ethical and environmental impacts. Research is also needed to understand the diffusion modes of traditional knowledge and social innovations that could support the conservation of common goods in more participatory, collaborative, inclusive and equitable ways.

Advances in science and technology such as genome editing (Khatodia et al., 2016), precision agriculture and digital agriculture (Basso and Antle, 2020), active packaging and block chain technologies (Kamilaris et al., 2019), artificial intelligence and big data analysis (Wolfert et al., 2017) and whole-genome sequencing in food safety (Deng, Bakker, & Hendriksen, 2016) have the potential to meet these challenges. However, adapting these technologies to local conditions, making them accessible to farmers and retain much of the gain among consumers and the rural communities is challenging, especially for developing economies, smallholder farmers and small businesses. Therefore, investments in science-based, participatory processes to map out realistic and equitable options are needed (Basso and Antle, 2020).

The importance of agriculture in producing non-food products (biofuels, chemicals, biomaterials) and in supporting ecosystem services is increasingly recognized in the context of the bioeconomy, which targets an increased reliance on renewable sources to address climate change (Zilberman 2014). A circular bioeconomy envisions developments in industrial biotechnologies to generate co-products, by-products and waste recycling, thereby generating an overall increased input efficiency of agricultural systems producing bio-based products in diversified agroecological landscapes (Therond et al., 2017; Maina et al., 2017).

Global and regional data sharing systems based on the FAIR principles (findable, accessible, interoperable and reusable data) (Mons et al., 2017) for food security, nutrition and health, food safety and waste management, as well as agricultural, climatic and environmental impacts of food systems would greatly enhance the accountability of all stakeholders of the food systems.

Increasingly, risk assessment tools will be needed to drive food safety policy and standards and to optimize surveillance, detection and early warning systems of zoonotic

diseases (Di Marco et al., 2020) and crop diseases (Mohanty et al., 2016). Modernizing our food safety and biosecurity risk management systems is an integral part of the food system transformation required to meet food and nutrition security needs. This will require a science- and risk-based approach for production of safe food within a food systems approach.

6. Concluding messages

Action to address safety, malnutrition and inequality, as well as climate and environmental issues, through food systems transformation will undoubtedly bring large health, social, economic, ecological and development co-benefits and savings on public expenditure, while supporting a number of interrelated SDGs. A range of priority actions to speed up progress towards international targets and scale up the solutions proposed in section 5 can be taken in the short-term, based on existing knowledge, while supporting longer, more sustainable responses with significant co-benefits. Future actions will have to be iterative, coherent, adaptive and flexible to maximise co-benefits and minimise trade-offs. Many recommended policy changes and interventions have win-win potential for food security, health and the environment. However, other choices will have adverse or unintended impacts on the interconnected drivers affecting food systems and their outcomes.

Adopting a whole-system approach in policy, research and monitoring and evaluation is crucial to manage trade-off and externalities from farm-level to national scales and across multiple sectors and agencies. Ultimately, context matters and comprehensive national action plans are crucial for setting out actions suited to the particular economic, agricultural, social and dietary preferences of the particular nation.

Adaptive learning and new knowledge must be shared globally to accelerate our capacities to meet existing and future challenges. Substantial public, private and international investment is necessary to faster progress towards the targets and recover from the set-backs of the Covid-19 pandemic. International cooperation and coordination of the food system is necessary, including the establishment of a comprehensive monitoring, evaluation and early warning system with comprehensive indicators, transparency and commitments of all stakeholders. For example, bringing all the indicators in Table 1 into one annual food system monitoring report would facilitate cooperation among UN agencies. Creating a food system compass could be based on bottom-up pathways developed at national scale to reach food systems targets supporting an ensemble of global scale and integrative food systems models. Establishing such a system will require capacity development for comprehensive foresight, scenario and predictive modelling to better understand uncertainties, trade-offs and impacts of various change pathways. More research is necessary to identify the most adequate, affordable, healthy and sustainable diets across different contexts. More frequently collected nutrition and poverty data are necessary to provide more data points for monitoring change and progress. Innovative indicators such as the affordability of adequate, nutritious and healthy diets are vital to bring the three elements of safety, nutrition and inequality together.

The costs of acting and not acting on the key drivers of diet and food system change and the impact of these changes and shifts are required for effective decision making. For example, the cost of nutrition interventions is relatively low per unit compared to the long-term losses in human potential and incomes for poorer people. The cost of NCDs to the health system is significantly higher per unit than the cost of scalable interventions. Rapid reductions in anthropogenic GHG emissions across all sectors can reduce negative impacts of climate change on food systems in the long term (similar for land and for water restoration).

Research and technology advances are essential to solve critical constraints and offer many opportunities to improve productivity, food safety and reduce food losses and waste, as well as GHG emissions. Capacity-building, property rights, technology development, transfer and deployment and enabling financial mechanisms across the food system can support

livelihoods and increase incomes. Greater cooperation with regard to trade could overcome constraints and barriers.

Enabling a common future with safe and nutritious food for all requires a transformation of food systems, changing both supply and demand of food in differentiated ways across world regions: increasing crop yields and livestock feed conversion efficiencies, largely through agro-ecological practices and agroforestry, deploying at scale soil carbon sequestration and agricultural greenhouse gas abatement, reducing food losses and wastes, as well as over-nourishment and changing the diets of wealthy populations. Global food systems sustainability also requires to halt the expansion of agriculture into ecosystems and to facilitate the restoration of degraded forests, wetlands and peatlands.

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