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Scientific Brief: Sustainable Food Systems in Low- and Middle-Income Countries

The food systems of Low- and Middle-Income Countries (LMICs) are facing specific challenges in meeting the needs of both people and the environment (GloPa, 2016, 2020). These challenges include providing sufficient food and adequate diets to over 3 billion people, while addressing environmental issues such as climate change, loss of biodiversity, and land degradation. Food system drivers and shocks of the kind witnessed during the COVID-19 pandemic exacerbate their vulnerability.

The UN Food Systems Summit (UNFSS) in 2021 confirmed the global consensus that food systems need to change to be more sustainable, inclusive, and resilient to accelerate progress towards achieving the Sustainable Development Goals (United Nations, 2023). Knowledge generated by food system analysis support the identification for entry points for change and in the analysis of trade-offs in the domain of food and nutrition security in LMICs.

The Farm-to-Fork strategy of the European Commission comprehensively addresses the challenges of sustainable food systems (SFS) and recognises the inextricable links between healthy people, healthy societies, and a healthy planet, within and outside its geographical borders. Consequently, in the programming for international cooperation with LMICs the European Union is striving to implement sustainable farming and fisheries practices, reduce deforestation, enhance biodiversity, and improve food security and nutrition outcomes to foster the transition to SFS.

As the term *food systems* has become very popular and the number of scientific publications referring to it is rapidly increasing, this scientific brief aims to support policymakers by giving a comprehensive overview of both the concept and of ongoing discussions.

This scientific brief is structured into two parts. The first part provides a definition and analytical framework of food systems. The second part looks at food systems in LMICs, highlighting some drivers and promising entry points for transforming the food system towards the SDGs.

What are sustainable food systems?

Food systems represent a complex set of interactions of "...all the elements (environment, people, inputs, processes, infrastructures, institutions, etc.) and activities that relate to the production, processing, distribution, preparation, and consumption of food, and the output of these activities, including socio-economic and environmental outcomes." (HLPE, 2014).

Food systems are context-specific and range from traditional systems involving few people and short supply chains to modern food systems, made up of a complex web of a large number of actors and processes along the food chain (Gómez and Ricketts, 2013; HLPE, 2017b). When talking about it in general terms, the plural form is used. The system boundaries and spatial dimensions are important, as food systems can be looked at on different levels, i.e. global, regional, national (von Braun *et al.*, 2021).

***Food systems are dynamic*.** They are constantly adapting to changing social and economic circumstances. The pace of these changes has accelerated in the last 30 years with an increased human population and increasing urbanisation. Despite being dynamic, most of current food systems cannot respond to recent shocks and stresses, such as the effect of climate change and market chain disruption, while at the same time progressing towards ending hunger and securing adequate nutrition for all (HLPE, 2017a). Their dynamic character however remains a pre-condition for the ability to change; a strength that needs to be built upon to achieve food system transformation.

Sustainable food systems (SFS) refer to the long-term ability of food systems to provide food security and nutrition today in such a way that it does not compromise the environmental, economic, and social bases that generate food security and nutrition for future generations (FAO, 2018). SFS support the seven dimensions of food security: to ensure the i) ***availability*** of sufficient food, ii) ***access for all*** people to food, iii) ***agency*** for all people to make choices about what they eat, how it is produced and to engage in policy processes, iv) ***stability*** in the face of shocks and crises, v) ***sustainability*** encompassing long-term natural, social and economic regeneration, vi), an adequate diet that guarantees nutrient uptake and ***utilisation***, vii) the ***right to food*** (HLPE, 2020).

A food system approach takes a holistic, big-picture view on a specific subject, even if is not covering the whole food system.

Food system analytical framework

Many frameworks aiming to structure and analyse food systems have been proposed in the last 15 years, each highlighting certain aspects or properties of the food systems (Ericksen, 2008; GloPa, 2016, 2020; UNEP, 2016; European Commission, 2017; HLPE, 2017b, 2020; van Berkum, Dengerink and Ruben, 2018; Woodhill, Hasnain and Griffith, 2020; von Braun *et al.*, 2023).

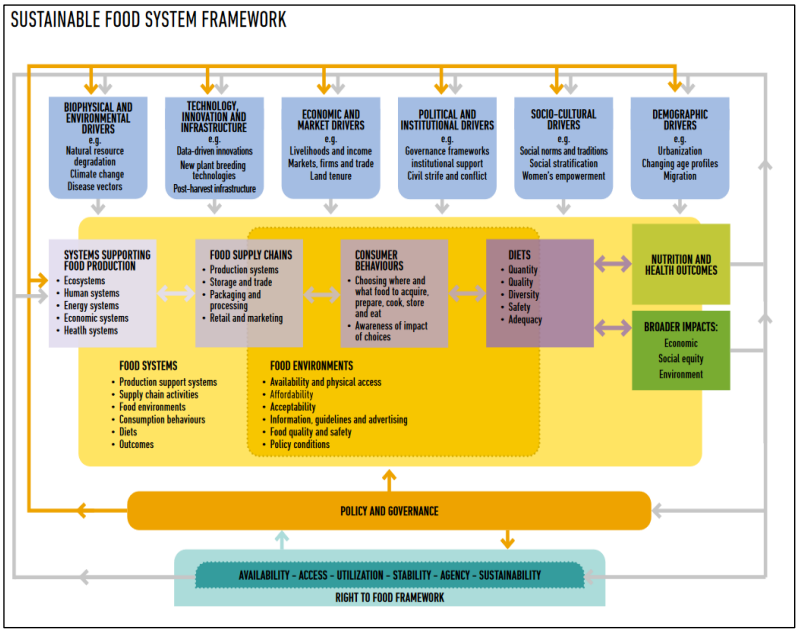
The most common encompassing and widely accepted framework is currently the framework of the High Level Panel of Experts (HLPE) of the Committee of World Food Security (CFS) (HLPE, 2020).

The HLPE framework is composed of ***the core of the food system***:

- ***Food supply chains*** which describes the production, storage and trade, packaging, marketing and the distribution of food,
- ***Consumer behaviour*** which drives the purchasing of food on the market,
- ***Food environments*** which are in short the spaces where, how and why food consumers purchase food. This also includes the institutional regimes that provide guidance (such as standards) and governance framework that guide the quality, safety and access of food (Brouwer, Mcdermott and Ruben, 2020),
- ***Diets*** which are the sum of food and drinks typically eaten by a specific group of people.

These core functions are influenced by:

- ***Drivers*** that either secure the functioning of the system, make the systems change over time or create shocks and stresses (HLPE, 2017b; Béné *et al.*, 2019, 2020; Dury *et al.*, 2019; GloPa, 2020; Zurek, 2021), they can either influence parts of the food system (impact of climate change on production) or all activities (e.g. economic and market drivers),
- ***Other systems*** that are partially outside of the food systems and influence the food systems and vice versa get influenced; such as ecosystems, health systems, economic and governance systems (von Braun *et al.*, 2021). In this respect, non-food agricultural activities and incomes from outside the food systems also need to be reflected. Depending on the questions these can be very relevant.



Reference: HLPE, 2020

The ***outcomes*** of SFS are:

- Food and nutrition security,
- Social equity and-economic outcomes, e.g. livelihoods, employment,
- Environmental outcomes, i.e. impacts on natural resources and climate.

The framework acknowledges that trade-offs and synergies between the different outcomes exist, e.g. dilemmas arise between dietary transition and climate change, intensification of production and environmental constraints (Brouwer, Mcdermott and Ruben, 2020). Policy makers require sound evidence: on the functioning of the food system, on synergies and trade-offs; on how policy proposals would affect stakeholders; citizens' values and preferences (OECD, 2021).

How to analyse Food systems

Policymakers require robust evidence not only to formulate their policies but also to monitor, evaluate, and adjust measures (van Berkum, Dengerink and Ruben, 2018; HLPE, 2020). The effect of the drivers, the relationship between the components of the food chain, as well as the changes in outcomes need to be analysed in their forward and backward effects and feedback loops.

Data-driven analysis can be applied to enhance efficiency, sustainability, and detect new relationships and patterns within the food system. Examples are analysis of value chains and food markets, consumer behaviour analysis, traceability and food safety. Available data is being analysed to uncover patterns, trends, correlations, and other valuable information. It relies on statistical methods, data visualization, and exploratory data analysis.

Monitoring approaches track food system performance along different dimensions and compare food system performance in different countries. An examples of rigorous monitoring for food systems outcomes is the Food systems Countdown Initiative (Fanzo *et al.*, 2020; Food Systems Countdown Initiative, 2023), and on hidden costs the True Cost Accounting Initiative (FAO, 2023). Such monitoring can help align decision-makers around key priorities, incentivize action, hold stakeholders accountable, sustain commitment by demonstrating progress, and enable course corrections.

Modelling of food systems takes note of the complex networks of drivers, the interaction of living organisms with each other and their environment. These models rely on a wide range of data and incorporate theories of how the world works. Results must be interpreted considering the assumptions and scope, the uncertainties, the spatial and temporal scale, and the purpose of the model, the accuracy and precision of underlying data (Peters and Thilmany, 2022).

Food Systems Dashboard

The dashboard provides a complete view of food systems by bringing together data from multiple sources. Currently data is available for 230 countries and territories. Additionally, sub-national data is needed for decision making.

https://www.foodsystemsdashboard.org

Qualitative participatory approaches build on **multi-stakeholder learning approaches,** joint learning and reflection among actors in order to generate transformative agency of the system, such as **mapping exercises, scenario development and foresight, decision support tools** taking their values and perspectives into account (Posthumus *et al.*, 2020).

Rapid Food Systems Analysis for Development

The FAO and CIRAD, with the technical and financial support of the EC, conducted Food System Analysis studies in over 50 countries. They examine four key outcomes: nutrition and food security, economic well-being, territorial equity, and environmental protection using quantitative and qualitative data. Food system actors were included in the analysis in the full research process, contributing to i) framing the main research question, ii) documenting food system performance, risks and opportunities, iii) identifying the key sustainability issues and the levers for change.

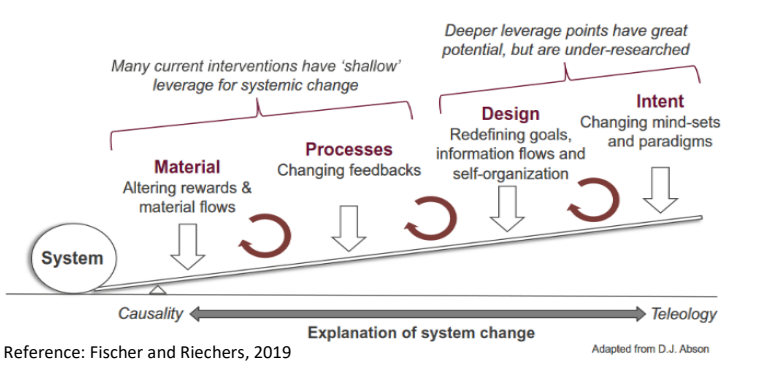
https://www.fao.org/support-to-investment/our-work/projects/fsa2021/en/

Analytical tools from **value chain approaches** can be used to analyse the operations (logistics, processing) and market connectivity, but need to take a broader view by taking social and environmental systems into account. On the outcome level the economic values are as important as health, nutrition, social, and individual welfare. The food system perspective further enlarges the classical value chain approach by recognizing the interdependency of various food value chains on all levels (Halberg and Westhoek, 2019; Alarcon *et al.*, 2021).

Food system transformation

Food system transformation entails the changes of the structure and functioning that are necessary to make food systems sustainable and provide healthy food for all. "This transformation will not happen unless there is widespread, multi-sector, multi-level action to change what food is eaten, how it is produced, and its effects on the environment and health, while providing healthy diets for the global population. Solutions to the problems (…) will require hard work, political will, and many resources." (Willett *et al.*, 2019).

Leverage points are: "places within a complex system where small shifts in one thing can produce big changes in everything" (Meadows, 1999). She distinguishes between a) different degrees of achievable change and b) the difficulty of using these levers. The leverage points perspective postulates that transformative change is unlikely if only shallow leverage points are acted upon; but it also recognises that acting on deep leverage points is difficult in practice, even if the benefits could be substantial (Abson *et al.*, 2017; Fischer and Riechers, 2019).



Reference: Fischer and Riechers, 2019

Applied to food systems these are for example:

Material	Energy/ water saving production processes and increases in productivity
Processes	Standards, flexibility and connectivity
Design	Policies that govern national resources, taxes and regulations
Intent	Norms and values consumer behaviour, green economy

Forward-looking pathways need to address a 'menu of change', taking into account multiple mechanisms of change. Revealing their impacts of change can only be made visible through comparison with a 'business as usual' pathway (Zurek, 2021). Food systems transformation from a social perspective relies on dialogue, common understanding, and negotiations. Transitioning food systems may have costs before the benefits can be realised. Therefore, it is vital to identify, understand, and manage their distribution and impacts effectively (Webb *et al.*, 2021).

National Pathways for Food System Transformation

126 countries conducted national multi-stakeholder dialogues and provided national pathways on how they intend to engage in changing their food systems. Most LMICs recognise the importance of food system transformation. The UNFSS has described objectives in the action tracks:

1. Ensuring access to safe and nutritious food for all (enabling all people to be well-nourished and healthy);
2. Shifting to sustainable consumption patterns (promoting the change of consumer behaviour, and reducing waste.);
3. Boosting nature-positive production at sufficient scale (acting on climate change, reducing emissions, and increasing carbon capture, regenerating and protecting critical ecosystems and energy usage, without undermining health or nutritious diets);
4. Advancing equitable livelihoods and value distribution (raising incomes, distributing risk, inclusion, creating jobs);
5. Building resilience to vulnerabilities, shocks and stresses (ensuring the continued functionality in geographies subject to conflict, climatic and natural resource disasters).

https://www.unfoodsystemshub.org/member-state-dialogue/dialogues-and-pathways/en

Food systems in LMICs

The world is not on track to reach SDG 2 on Zero Hunger. Despite the progress made, the number of people facing food insecurity is on the rise again. In 2022, approximately 900 million people were facing severe food insecurity globally (FAO *et al.*, 2023a). In the last three years inflation in consumer food prices resulting from the economic impacts of the COVID-19 pandemic and the counter-measures, as well as the disruption of the grain exports from Ukraine due to the Russian's war, has increased the cost of a healthy diet and compromised its affordability. 70% of the population in lower-middle-income countries and 86% of the population in low-income countries can't afford healthy diets. (https://www.fao.org/faostat/en/#data/CAHD)

Additionally, many LMICs are now facing a "triple burden" of malnutrition with a rapid upsurge in non-communicable disease risk factors such as obesity and overweight. (Webb *et al.*, 2020; FAO *et al.*, 2023a). Taking diabetes as an example, approximately 80% of the 463 million adults living with diabetes worldwide are in LMICs (GloPa, 2023).

Drivers of food systems in LMIC

Food system drivers can be global or local, they can be outside of the food systems, or coming from within. They affect different or all parts of the food system and need to be analysed context-specific. Drivers of LMICs food system[1] can have stabilising or transformative effects (HLPE, 2017b; Béné *et al.*, 2019, 2020; Dury *et al.*, 2019; GloPa, 2020; Zurek, 2021):

Drivers can be stressors for the food systems, they can be stabilising or transforming	
Climate change affects food production and food security due to warming, changing precipitation patterns, and greater frequency of some extreme events. For example, heat-related events, such as droughts, have increased in the Mediterranean, West Asia and much of Africa (IPCC, 2019). There is a pressing need to adapt to the changing conditions for all components of food systems (Mirzabaev *et al.*, 2023).	**Development of new technologies, and innovations** is a major engine for food system transformation. This includes production technologies (e.g. mechanisation, irrigation, plant breeding), production systems, digital solutions and social innovations (HLPE, 2017b; Béné, 2020; Hendriks *et al.*, 2023). They need to be adapted to the specific local context and the specific needs of the people. Meaningful collaborations among researchers, societal stakeholders, and policymakers are required (den Boer *et al.*, 2021).
Biodiversity, freshwater, oceans, land, and soils: these ecosystem services are the basis for food production, while agriculture is the primary cause for their depletion and degradation (HLPE, 2014; IPCC, 2019; Tubiello *et al.*, 2022). For example, Africa is particularly vulnerable to land degradation and desertification with around half of its land area affected (ELD Initiative & UNEP, 2015). Aridity is the main factor in the degradation of arable land in subtropical regions and soil erosion rates are higher in tropical countries (Prăvălie *et al.*, 2021).	**Infrastructure** that allows the access to urban centres and international markets can benefit the income of food system actors, the availability and the access to food. An extensive literature review suggests that the availability of mobile phones improves coordination between producers and traders and hence reduces the price dispersion (Foster *et al.*, 2023). The study also shows that electrification supports the process of structural transformation, and that rural roads - particularly for Sub-Saharan Africa - reduce poverty and contribute to household welfare.
Conflicts (state and non-state) are shocks and stresses for the food system. Olsen et al. have shown by using multisource satellite images that cultivated croplands in South Sudan were reduced by 16% during the armed conflict from 2016 to 2018. The abandoned croplands could have supported at least a quarter of the population in the southern states (Olsen *et al.*, 2021). Conflict can also lead to high inflation, indebtedness, and the deterioration of the macroeconomic conditions in many LMICs and reduces the ability to invest in food systems (GloPa, 2023).	**Social equity, women's empowerment and education** are seen as drivers of change, as food and agriculture are also closely connected to people's values (Njuki *et al.*, 2022). However, sociocultural drivers create barriers that produce and enforce existing inequalities and inforce inequity in food security and nutrition (HLPE, 2023). These sociocultural drivers intersect with all other drivers. While inequalities in food security particularly affect populations in Africa, South Asia and the Caribbean, inequalities in nutritional status exist globally (HLPE, 2023).
Urbanisation plays a pivotal role in shaping food consumption patterns. While some studies have found urban diets to be more diverse and contain more nutrient-rich foods, urban lifestyles and urban food environments are most commonly believed to contribute to a transition towards unhealthy diets high in saturated fats, added sugars, salt, and ultra-processed foods (Ruel *et al.*, 2020). Sub-Saharan Africa had the highest rate of urbanisation in the world since the 1990s. Yet, while urbanization often goes hand in hand with economic growth and structural transformation, this has not been the case for sub-Saharan Africa. (FAO *et al.*, 2023b).	**Trade** can have a positive impact on food systems and benefit consumers as well as producers (Béné et al., 2020). For trade to drive inclusive and sustainable growth of nutritious food production in food deficit LMICs, policies and investments must focus on three key priorities: 1) Diversifying production and markets to increase resilience to external shocks; 2) Enhancing competitiveness and improving market access for local farmers and small and medium enterprises (SMEs), and 3) Incorporating externalities in international trade (van Berkum, 2021). However, trade can also pose threats to food security by increasing dependency on food imports, leading to indebtedness, making food supplies more vulnerable and threaten the competitiveness of smallholder farmers (van Berkum, 2021).
Population growth is a prominent driver in many LMICs. The latest projections by the United Nations suggest that the global population could grow to around 9.7 billion in 2050 (United Nations, 2022). More than half of the projected increase will be concentrated in just eight countries: the Democratic Republic of the Congo, Egypt, Ethiopia, India, Nigeria, Pakistan, the Philippines and Tanzania (United Nations, 2022). This population growth means there will be a quantitative increase in food demand and a need to create employment.	**Research** can help to design context-adapted pathways based on a sound understanding of the food system, mainly for setting out actions suited to the particular economic, agricultural, social, and dietary preferences of the particular nation and considering the trade-offs and co-benefits (Njuki *et al.*, 2022). Transdisciplinary research approaches can catalyse change, fostering meaningful collaborations among researchers, societal stakeholders, and policymakers and also empower stakeholders to enhance their situation (Halberg and Westhoek, 2019; den Boer et al., 2021).

[1] There are many drivers, this is not a comprehensive list. It also needs to be mentioned that drivers can have positive and negative effects.

Entry points[2]

Increase sustainable food production for healthy diets

Agroecological and related nature-positive approaches are considered to be more transformative than other approaches targeting sustainable agricultural production systems and the achievement of global goals on sustainability and equity as a whole (HLPE, 2019). The use of agroecological principles and practices that work with natural processes is also seen as an effective strategy for adapting to and reducing climate risks and enhancing agroecosystem resilience (IPCC, 2019). The analysis of the literature on 26 countries has shown that agroecological practices - in at least 50 percent of the analysed reports - contributed to better food security, mostly due to improved yields and/or a better economic situation of producers. Diversified crop systems, including the introduction of agroforestry, improve household nutritional status and have positive links to better health conditions (Paracchini *et al.*, 2020, 2022). Another review analysing 56 case studies also concluded that agroecological practices have positive outcomes on food security and nutrition of households in LMICs in 78 percent of the cases: "More complex agroecological systems, that included multiple components (e.g., crop diversification, mixed crop-livestock systems and farmer-to-farmer networks), were more likely to have positive food security and nutrition outcomes." (Bezner Kerr et al., 2021). Investing in agriculture will not only address increasing domestic food demand but also contribute to poverty reduction (World Bank, 2015).

Addressing the triple burden of undernutrition, over-nutrition, and micronutrient deficiencies requires a profound transformation towards a more diversified diet. Historically, an undue focus of plant research and policy on just five crops - wheat, rice, maize, potato, and soy - has eroded dietary diversity. Besides the limited production of diverse nutrient-dense fruits, vegetables, legumes and animal-source foods, changes are needed on the consumer side to stimulate demand and on the side of the value chain that is able to store, transport and process the perishable goods while maintaining the quality (Gillespie and van den Bold, 2017).

Aquatic food (from marine and aquaculture sources) has the potential to increase and be a more efficient source of protein for a healthy diet with less impact on climate change and land use than that of terrestrial animal proteins (Herrero *et al.*, 2023; Leape *et al.*, 2023). However, the production and distribution of aquatic foods faces many challenges, such as overfishing, unsustainable practices, unequal access to resources and markets, and other environmental impacts (FAO, 2022). Aquaculture could be more sustainable, if circular principles were adapted. Species that contribute to food and nutrition security should be prioritised as their impact on the environment is far smaller than the footprint of luxury aquaculture, such as shrimps (Chary *et al.*, 2023).

Reduce food loss and waste

The FAO defines food loss and waste as the "decrease in quantity or quality of food along the food supply chain" (FAO, 2019). For LMICs, the main problem lies in losses that occur before the products reach the market. These post-harvest losses are due to unfavourable climatic conditions, improper handling, and a lack of information, education, technology, infrastructure, affordable financing, and market access. These losses can be as high as 40-50 per cent for root crops, fruits and vegetables, 30 per cent for cereals and fish, and 20 per cent for oilseeds (FAO, homepage) and are expected to increase with further climatic changes (Stathers, Lamboll and Mvumi, 2013). The African Postharvest Losses Information System is the foremost international effort to collect, analyse and disseminate data on postharvest losses of cereals, legumes, and roots and tubers in sub-Saharan Africa (APHLIS, homepage).

The reduction of food losses and waste was titled as one of the three big game changers in preparation for the UNFSS (von Braun *et al.*, 2023). Value chains of perishable and nutrient-rich foods are significantly affected and require managing and preserving these nutritious foods, fostering attention to food safety (Harris et al., 2023).

To reduce food losses across the supply chain, harvesting techniques and improved on-farm and warehouse storage, as well as cold chain infrastructure and better packaging, need to be developed. Further planning and marketing tools, as well as recycling concepts such as composting would help to reduce the losses and waste (Caleffi, Hawkes and Walton, 2023).

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Invest in the infrastructure of trade and food processing

The transformation of food systems in LMICs requires a combination of investments in infrastructure (roads, energy, financial instruments, digital technologies) to build strong local food economies and accompanying coherent policies to increase efficiency, and productivity.

Investments and innovations are often fuelled by the private sector and this middle part of the value chain. Thus they need to become actors for change. This is even more true for the informal sector, such as street vendors, that need more research attention (Béné, 2020). SMEs, especially in LMICs, are often scattered, and numerous. They face high transaction costs due to their size but also weak infrastructure, while their growth is limited by insufficient access to finance, lack of support for accessing improved technologies, and lack of policy initiatives targeting their growth. The existence of multiple constraints limits

[2] These entry points can be addressed simultaneously. They are neither comprehensive nor exhaustive.

their potential to accumulate assets and expand operations, including sources of employment and income diversification and as contributors to healthy diets (FAO *et al.*, 2023b).

Besides the general need for investment in specific value chains that contribute towards increased availability of nutritious foods (FAO, 2023), there is a need to have a better understanding how the different spheres interact and finally, also to have better statistical data in relation to transformation, transport, retail, and distribution (Béné *et al.*, 2020).

Promote the consumption of nutritious food that is available and affordable to all

Governments play a pivotal role in making healthy diets accessible to all. An inventory of evidence in LMICs suggests that healthy meals in schools or at workplaces, compulsory nutrition labelling, fortified foods, as well as taxing of unhealthy food have proven to be powerful tools to influence consumer behaviour (Lecoutere, Berg and Brauw, 2021).

Furthermore, scientists recommend a thorough examination of food poverty thresholds and the establishment of nutritional safety nets. These safety nets might comprise of cash transfers, vouchers, or in-kind support, supplementing households' own incomes or food production (Masters *et al.*, 2023). Free school meal programmes can be seen as a far-reaching social safety nets, providing wholesome, nutritious meals to children while simultaneously reinforcing local food systems (WFP, 2022).

More than 100 countries worldwide have developed food-based dietary guidelines that are adapted to their nutrition situation, food availability, culinary cultures and eating habits (FAO homepage). These guidelines do not only serve to educate consumers on what constitutes a healthy diet but also enable detailed analysis of the unique requirements of various population groups, such as pregnant women, the elderly, displaced individuals, and others. This knowledge helps policymakers to effectively target their food-related initiatives (Herrero *et al.*, 2023). They should be accompanied by implementation plans including monitoring and evaluation of progress and impact on healthy diets from SFS (Brouwer *et al.*, 2021). The guidelines are often not used to their full potential.

Diverse food choices should be readily available at affordable prices. The creation of conducive food environments is important to make the acquisition and preparation of nutritious food, cooking equipment and fuel easy (Masters *et al.*, 2023). To empower consumers to make informed, healthy, safe and sustainable choices can be achieved by large-scale information campaigns raising awareness about unhealthy food habits; and campaigns that provide information on the nutrition of infants and young children could be effective. More knowledge on what works is needed. Drivers of food choice have been well studied in Sub-Saharan African cities, but more information is needed for rural and peri-urban areas (Brouwer *et al.*, 2021).

Invest in research and innovation in a partnership approach

Investment in Research and Innovation (R&I) is needed to help develop and test solutions, overcome barriers and uncover new market opportunities. R&I also contributes to a better understanding of the complex interactions between the components of our current food systems, and innovative ways to accelerate and develop solutions that can contribute to systemic change. The European Commission's Food 2030 initiative, launched in 2016, pioneered the systems approach and steers R&I policy to transform food systems in such a way that they deliver multiple benefits simultaneously. These benefits will be felt in nutrition and health, climate mitigation and adaptation, sustainability and circularity, and will ultimately empower communities.

The EU-African Union research and innovation partnership on Food and Nutrition Security and Sustainable Agriculture provides support for joint food systems transition projects between the two continents through Horizon Europe projects and other funding instruments (European Commission, 2023).

Conclusions

Food system transformation is high on the policy agenda and runs the risk of becoming a buzzword. The complexity of food systems can be overwhelming, and it's not easy to identify critical linkages and feedbacks to inform policymakers on specific interventions. Nevertheless the framework is useful i) to keep the full picture in sight when pursuing a specific path to solve a problem, ii) to reflect on the normative goals of sustainable food security and nutrition, iii) to search for the root causes and bottlenecks.

The concept makes clear that it needs a bundle of measures at different levels simultaneously: from farm to fork. National pathways need to target context-specific leverage points from the easier (e.g. implementing monitoring systems) to the more difficult (slow variables like soil conservation, and consumer behaviour). Simultaneously locally adapted solutions adapted to the context need to be strengthened. The different food systems need to be linked from community-based systems to regional, national and global systems.

In this scientific brief, we highlight a few entry points that address the current challenges and drivers:

- Undoubtedly, climate change, depletion of natural resources and a growing population call for a sustainable intensification of food production. Diversified crop systems, agroecological practices (including the production of fruits, vegetables, legumes, nuts, improved forages) and the development of aquatic food can contribute to better food security. For this farmers need access to finance, inputs, innovations and an enabling legal environment, especially for women, to improve their resilience, productivity and incomes.
- Food System Transformation is knowledge-intensive. Small holders need better advice and information systems. Further, co-creation of knowledge is important. All stakeholder in the food system need to be involved in the process.
- The infrastructure of the market chain needs to be more efficient, sustainable and beneficial to all actors, i.e. to smallholder. This includes food storage, road infrastructure, preservation, processing and new market linkages. More research is needed on the role of SMEs and the informal sector.
- The uniqueness of the food system concept is that it puts the desired outcome, and therefore the consumers, in the centre. Diverse food choices should be readily available at affordable prices (urban and rural). Consumer knowledge on diverse and nutritional diets, conducive food environments, and support for the vulnerable population are among the most important measures.
- Food policy and governance have a central role in shaping the food system and in supporting smallholder farmers, SMEs, and vulnerable consumers.

References

Abson, D.J. *et al.* (2017) 'Leverage Points for Sustainability Transformation', *Ambio*, 46, pp. 30–39. Available at: https://doi.org/10.1007/s13280-016-0800-y.

Alarcon, P. *et al.* (2021) 'The Importance of a Food Systems Approach to Low and Middle Income Countries and Emerging Economies: A Review of Theories and its Relevance for Disease Control and Malnutrition', *Frontiers in Sustainable Food Systems*, 5(April). Available at: https://doi.org/10.3389/fsufs.2021.642635.

Béné, C. *et al.* (2019) 'Understanding Food Systems Drivers: A Critical Review of the Literature', *Global Food Security*, 23(May), pp. 149–159. Available at: https://doi.org/10.1016/j.gfs.2019.04.009.

Béné, C. *et al.* (2020) 'Global Drivers of Food System (Un) Sustainability: A Multi-country Correlation Analysis', *PLoS ONE 15(4): e0231071.*, pp. 1–22. Available at: https://doi.org/10.1371/journal.pone.0231071.

Béné, C. (2020) 'Resilience of Local Food Systems and Links to Food Security – A Review of some Important Concepts in the Context of COVID-19 and other Shocks', *Food Security*, 12(4), pp. 805–822. Available at: https://link.springer.com/article/10.1007/s12571-020-01076-1.

van Berkum, S. (2021) 'How Trade can Drive Inclusive and Sustainable Food System Outcomes in Food Deficit Low-income Countries', *Food Security*, 13(6), pp. 1541–1554. Available at: https://doi.org/10.1007/s12571-021-01218-z.

van Berkum, S., Dengerink, J. and Ruben, R. (2018) *The Food Systems Approach: Sustainable Solutions for a Sufficient Supply of Healthy Food*, *Wageningen Economic Research, Memorandum*. Available at: www.wur.eu/economic-research%0Ahttp://library.wur.nl/WebQuery/wurpubs/538076.

Bezner Kerr, R. *et al.* (2021) 'Can Agroecology Improve Food Security and Nutrition? A Review', *Global Food Security*, 29(April). Available at: https://doi.org/10.1016/j.gfs.2021.100540.

den Boer, A.C.L. *et al.* (2021) 'Research and Innovation as a Catalyst for Food System Transformation', *Trends in Food Science and Technology*, 107, pp. 150–156. Available at: https://doi.org/10.1016/j.tifs.2020.09.021.

von Braun, J. *et al.* (2021) 'Food System Concepts and Definitions for Science and Political Action', *Nature Food*, 2(10), pp. 748–750. Available at: https://doi.org/10.1038/s43016-021-00361-2.

von Braun, J. *et al.* (2023) *Science and Innovations for Food Systems Transformation*. Springer Nature. Available at: https://doi.org/10.1007/978-3-031-15703-5.

Brouwer, I.D. *et al.* (2021) 'Reverse Thinking: Taking a Healthy Diet Perspective towards Food Systems Transformations', *Food Security*, 13(6), pp. 1497–1523. Available at: https://doi.org/10.1007/s12571-021-01204-5.

Brouwer, I.D., Mcdermott, J. and Ruben, R. (2020) 'Food Systems Everywhere: Improving Relevance in Practice', *Global Food Security*, 26. 100398(March). Available at: https://doi.org/10.1016/j.gfs.2020.100398.

Caleffi, S., Hawkes, C. and Walton, S. (2023) '45 Actions To Orient Food Systems Towards Environmental Sustainability: Co-Benefits and Trade-Offs'. London: Centre for Food Policy, University of London.

Chary, K. *et al.* (2023) 'Transforming Sustainable Aquaculture by Applying Circularity Principles', *Reviews in Aquaculture*, (August), pp. 1–18. Available at: https://doi.org/10.1111/raq.12860.

Dury, S. *et al.* (2019) *Food Systems At Risk*. Rome, Montpellier, Brussels: FAO, CIRAD and European Commission. Available at: https://doi.org/10.19182/agritrop/00080.

ELD Initiative & UNEP (2015) 'The Economics of Land Degradation in Africa. Benefits of Action Outweigh the Costs: A report of ELD Initiative', p. 156. Available at: www.eld-initiative.org.

Ericksen, P.J. (2008) 'Conceptualizing Food Systems for Global Environmental Change Research', *Global Environmental Change*, 18, pp. 234–245. Available at: https://doi.org/10.1016/j.gloenvcha.2007.09.002.

European Commission (2017) *Food 2030: Future-Proofing our Food Systems through Research and Innovation*. Available at: https://doi.org/10.2777/249082.

European Commission (2023) *Food 2030 : Research and Innovation Pathways for Action 2.0*. Available at: https://doi.org/10.2777/365011.

Fanzo, J. *et al.* (2020) 'The Food Systems Dashboard is a New Tool to Inform Better Food Policy', *Nature Food*, 1(5), pp. 243–246. Available at: https://doi.org/10.1038/s43016-020-0077-y.

FAO (2018) *Sustainable Food Systems - Concept and Framework*. Rome. Available at: https://doi.org/10.1016/B978-0-12-821292-9.00015-7.

FAO (2019) *The State of Food and Agriculture 2019 - Moving Forward on Food Loss and Waste Reduction*. Rome. Available at: https://creativecommons.org/licenses/by-nc-sa/3.0/igo.

FAO (2022) *The State of World Fisheries and Aquaculture 2022 - Towards Blue Transformation*. Rome. Available at: https://doi.org/10.4060/cc0463en.

FAO (2023) *The State of Food and Agriculture 2023 - Revealing the True Cost of Food to Transform Agrifood Systems.* Rome. Available at: https://doi.org/https://doi.org/10.4060/cc7724en.

FAO *et al.* (2023a) *The State of Food Security and Nutrition in the World 2023*. Rome: FAO; IFAD; UNICEF; WFP; WHO; Available at: https://doi.org/10.4060/cc3017en.

FAO *et al.* (2023b) *The State of Food Security and Nutrition in the World 2023 - Urbanization, Agrifood Systems Transformation and Healthy Diets across the Rural–Urban Continuum*. Rome. Available at: https://doi.org/https://doi.org/10.4060/cc3017en.

Fischer, J. and Riechers, M. (2019) 'A Leverage Points Perspective on Sustainability', *People and Nature*, 1(1), pp. 115–120. Available at: https://doi.org/10.1002/pan3.13.

Food Systems Countdown Initiative (2023) 'The food systems countdown report 2023: The state of food systems worldwide'. Available at: http://www.fao.org/3/cc8697en/cc8697en.pdf.

Foster, V. *et al.* (2023) *The Impact of Infrastructure on Development Outcomes: A Meta-Analysis*, *World Bank Policy Research Working Paper 10343*. Available at: http://hdl.handle.net/10986/39515.

Gillespie, S. and van den Bold, M. (2017) 'Agriculture, Food Systems, and Nutrition: Meeting the Challenge', *Global Challenges*, 1(3), p. 1600002. Available at: https://doi.org/10.1002/gch2.201600002.

GloPa (2016) *Food Systems and Diets : Facing the Challenges of the 21rst Century*, *Global Panel on Agriculture and Food Systems for Nutrition*. London, UK. Available at: https://glopan.org/sites/default/files/ForesightReport.pdf.

GloPa (2020) *Future Food Systems: For people, our planet, and prosperity*, *Global Panel on Agriculture and Food Systems for Nutrition*. London, UK. Available at: https://foresight.glopan.org/.

GloPa (2023) *Pursuing Food Systems Transformation despite Financial Constraints*, *Global Panel on Agriculture and Food Systems, Policy Brief No. 18*. Available at: https://www.glopan.org/download/4102/.

Gómez, M.I. and Ricketts, K.D. (2013) 'Food Value Chain Transformations in Developing Countries: Selected Hypotheses on Nutritional Implications', *Food Policy*, 42, pp. 139–150. Available at: https://doi.org/10.1016/j.foodpol.2013.06.010.

Halberg, N. and Westhoek, H. (2019) 'The Added Value of a Food Systems Approach in Research and Innovation', *Policy Brief by Standing Committee on Agricultural Research (SCAR) Strategic Working Group on Food Systems* [Preprint]. Available at: https://doi.org/10.2777/407145.

Harris, J. *et al.* (2023) 'Fruits and Vegetables for Healthy Diets: Priorities for Food System Research and Action', in J. von Braun (ed.) *Science and Innovations for Food Systems Transformation*. Springer I, pp. 87–104. Available at: https://doi.org/10.1007/978-3-031-15703-5_6.

Hendriks, S. *et al.* (2023) 'Ensuring Access to Safe and Nutritious Food for All Through the Transformation of Food Systems', in J. von Braun (ed.) *In Science and Innovations for Food Systems Transformation*. Springer I. Springer International Publishing, pp. 31–58. Available at: https://doi.org/10.1007/978-3-031-15703-5_4.

Herrero, M. *et al.* (2023) 'A Shift to Healthy and Sustainable Consumption Patterns', in J. von Braun (ed.) *Science and Innovations for Food Systems Transformation*. Springer I, pp. 59–85. Available at: https://doi.org/10.1007/978-3-031-15703-5_5.

HLPE (2014) *Food Losses and Waste in the Context of Sustainable Food Systems*, *A Report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security of Sustainable Food Systems*. Available at: www.fao.org/cfs/cfs-hlpe.

HLPE (2017a) *Critical and Emerging Issues for Food Security and Nutrition*, *A Note by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security*. Available at: www.fao.org/3/a-mt651e.pdf.

HLPE (2017b) *Nutrition and Food Systems*, *A Report by the High Level Panel of Experts on Food Securtiy and Nutrition of the Committee on World Food Security*. Available at: http://www.fao.org/3/a-i7846e.pdf.

HLPE (2019) *Agroecological and other Innovative Approaches for Sustainable Agriculture and Food Systems that Enhance Food Security and Nutrition*, *A Report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security*. Available at: https://www.fao.org/cfs/cfs-hlpe/publications/hlpe-14.

HLPE (2020) *Food Security and Nutrition: Building a Global Narrative towards 2030.*, *A Report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security*. Available at: http://www.fao.org/3/ca9731en/ca9731en.pdf.

HLPE (2023) *Reducing Inequalities for Food Security and Nutrition.*, *A Report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security*. Available at: https://www.fao.org/cfs/cfs-hlpe/publications/hlpe-18.

IPCC (2019) *Climate Change and Land: an IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems*, *Summary for policymakers*. Available at: https://doi.org/10.1017/CBO9781139177245.003.

Leape, J. *et al.* (2023) 'The Vital Roles of Blue Foods in the Global Food System', in J. von Braun (ed.) *Science and Innovations for Food Systems Transformation*. Springer International Publishing, pp. 401–419. Available at: https://doi.org/10.1007/978-3-031-15703-5_21.

Lecoutere, E., Berg, M. van den and Brauw, A. de (2021) 'Effective Food Systems Innovations: an Inventory of Evidence from Bangladesh, Ethiopia, Nigeria, Viet Nam, and Other Low- and Middle-Income Countries.', *IFPRI Discussion Papers 02022*, (2022), p. 110. Available at: https://doi.org/10.2499/p15738coll2.134401.

Masters, W.A. *et al.* (2023) 'The Cost and Affordability of Preparing a Basic Meal Around the World', in J. von Braun (ed.) *Science and Innovations for Food Systems Transformation*. Springer I, pp. 603–623. Available at: https://doi.org/10.1007/978-3-031-15703-5_33.

Meadows, D.H. (1999) *Leverage Points: Places to Intervene in a System*, *The Sustainability Institute*. Available at: https://donellameadows.org/wp-content/userfiles/Leverage_Points.pdf.

Mirzabaev, A. *et al.* (2023) 'Climate Change and Food Systems', in J. von Braun (ed.) *Science and Innovations for Food Systems Transformation*. Springer International Publishing, pp. 511–529. Available at: https://doi.org/10.1007/978-3-031-15703-5_27.

Njuki, J. *et al.* (2022) 'A Review of Evidence on Gender Equality, Women's Empowerment, and Food Systems', *Global Food Security*, 33, p. 100622. Available at: https://doi.org/10.1016/j.gfs.2022.100622.

OECD (2021) *Making Better Policies for Food Systems*. Paris. Available at: https://doi.org/10.1787/ddfba4de-en.

Olsen, V.M. *et al.* (2021) 'The Impact of Conflict-driven Cropland Abandonment on Food Insecurity in South Sudan Revealed Using Satellite Remote Sensing', *Nature Food*, 2(12), pp. 990–996. Available at: https://doi.org/10.1038/s43016-021-00417-3.

Paracchini, M.L. *et al.* (2020) *Agroecological Practices Supporting Food Production and Reducing Food Insecurity in Developing Countries : a Study on Scientific Literature in 17 countries.* EUR 30329 EN, Publications Office of the European Union, Luxembopurg. Available at: https://doi.org/10.2760/82475.

Paracchini, M.L. *et al.* (2022) *Agroecological Practices Supporting Food Production and Reducing Food Insecurity in Developing Countries: a Study on Scientific Literature in 9 Countries*, *Volume 2, Publications Office of the European Union,*. Luxembourg. Available at: https://doi.org/10.2760/059189.

Peters, C.J. and Thilmany, D.D. (2022) 'Using Models to Study Food Systems', in C.J. Peters and D.D. Thilmany (eds) *Food Systems Modelling: Tools for Assessing Sustainability in Food and Agriculture*. Elsevier Ltd., pp. 1–12. Available at: https://doi.org/10.1016/B978-0-12-822112-9.00013-8.

Posthumus, H. *et al.* (2020) *Food Systems: From Concept to Practice and Vice Versa*, *Wageningen Economic Research*. Available at: https://doi.org/10.18174/464054.

Prăvălie, R. *et al.* (2021) 'Arable Lands under the Pressure of Multiple Land Degradation Processes. A Global Perspective', *Environmental Research*, 194. Available at: https://doi.org/10.1016/j.envres.2020.110697.

Ruel, M.T. *et al.* (2020) 'Urban food systems and diets, nutrition, and health of the poor: Challenges, opportunities, and research gaps', in *Jonathan Crush & Bruce Frayne & Gareth Haysom (ed.) Handbook on Urban Food Security in the Global South*.

Stathers, T., Lamboll, R. and Mvumi, B.M. (2013) 'Postharvest agriculture in changing climates: Its importance to African smallholder farmers', *Food Security*, 5(3), pp. 361–392. Available at: https://doi.org/10.1007/s12571-013-0262-z.

Tubiello, F.N. *et al.* (2022) 'Pre- and Post-Production Processes Increasingly Dominate Greenhouse Gas Emissions from Agri-Food Systems', *Earth System Science Data*, 14(4), pp. 1795–1809. Available at: https://doi.org/10.5194/essd-14-1795-2022.

UNEP (2016) *Food Systems and Natural Resources*, *A Report of the Working Group on Food Systems of the International Resource Panel. Westhoek, H, Ingram J., Van Berkum, S., Özay, L., and Hajer M.* Available at: https://www.resourcepanel.org/reports/food-systems-and-natural-resources.

United Nations (2022) *World Population Prospects 2022: Summary of Results*. UN DESA/POP/2022/TR/NO. 3. Available at: https://www.un.org/development/desa/pd/sites/www.un.org.development.desa.pd/files/wpp2022_summary_of_results.pdf.

United Nations (2023) *Making Food Systems Work for People and Planet: UN Food Systems Summit +2 Report of the Secretary-General*. Available at: https://www.unfoodsystemshub.org/docs/unfoodsystemslibraries/stocktaking-moment/un-secretary-general/unfss2-secretary-general-report.pdf?sfvrsn=560b6fa6_19.

Webb, P. *et al.* (2020) 'The Urgency of Food System Transformation is Now Irrefutable', *Nature Food*, 1(10), pp. 584–585. Available at: https://doi.org/10.1038/s43016-020-00161-0.

Webb, P. *et al.* (2021) 'The Transition Steps Needed to Transform Our Food Systems', *Food Systems Summit Brief* [Preprint]. Available at: https://sc-fss2021.org/.

WFP (2022) *State of School Feeding Worldwide 2022*.

Willett, W. *et al.* (2019) 'Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems', *The Lancet*, 393(10170), pp. 447–492. Available at: https://doi.org/10.1016/S0140-6736(18)31788-4.

Woodhill, J., Hasnain, S. and Griffith, A. (2020) *Farmers and Food Systems: What Future for Small-scale Agriculture?*, *Environmental Change Institute, University of Oxford*. Oxford. Available at: https://beamexchange.org/uploads/filer_public/2d/aa/2daaf8f1-ffe2-4146-a9bb-9a025e667fbd/future_for_small-scale_agriculture_compressed.pdf.

World Bank (2015) 'Ending Poverty and Hunger by 2030. An Agenda for the Global Food System', May(Second Edition), pp. 3–6.

Zurek, M. (2021) 'Looking Across Diverse Food System Futures: Implications for Climate Change and the Environment', *Q Open 1(1): qoaa001*, pp. 1–39. Available at: https://doi.org/10.1093/qopen/qoaa001.

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