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The triple benefits of slimming and greening the Chinese food system

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The Chinese food system has undergone a transition of unprecedented speed, leading to complex interactions with China's economy, health and environment. Structural changes experienced by the country over the past few decades have boosted economic development but have worsened the mismatch between food supply and demand, deteriorated the environment, driven obesity and overnutrition levels up, and increased the risk for pathogen spread. Here we propose a strategy for slimming and greening the Chinese food system towards sustainability targets. This strategy takes into account the interlinkages between agricultural production and food consumption across the food system, going beyond agriculture-focused perspectives. We call for a food-system approach with integrated analysis of potential triple benefits for the economy, health and the environment, as well as multisector collaboration in support of evidence-based policymaking.

Despite having a lower per capita availability of water and cropland than the global average and facing severe resource depletion[1], China recently saw unprecedented economic growth that has not only shifted millions of people out of poverty and hunger but also reshaped its food system. Important dietary and nutrition changes took place within just two generations in the country, while in other high-income countries the same process took place over more than a century. This quick transition shifted consumption patterns from scarce, carbohydrate-dominated diets towards affluent diets (Fig. 1a)—rich in animal protein, sugar, fat and processed industrial foods[2], along with high food wastage[3]. Economic growth and associated structural changes also led to a decrease in physical labour intensity, an increase in more sedentary occupations[4] and, consequently, more obesity and chronic diseases in the population[5] (Fig. 1b). Socio-economic changes in China have led to differences in food consumption, thus impacting the economy, public health and the environment. With ongoing economic growth in China, it is expected that total food demand will continue to rise and affluent dietary patterns will become even more prevalent, exacerbating the mismatch between food demand and supply and imposing additional economic, health and environmental challenges.

Undernutrition, micronutrient deficiency and overnutrition have all been challenging individual and public health, leading to human suffering and high health-care expenditures[6]. Health risks measured as million disability-adjusted life years are attributed to low intake of whole grains, nuts and seeds, fruits, vegetables, legumes, and fibre, and high intake of sugar-sweetened beverages, red meat and processed meat[7] (Fig. 2a). Notwithstanding notable dietary improvements in China from 1982 to 2012, the overall dietary quality remains suboptimal (Fig. 1a) and was estimated to cause 51% of all cardiometabolic deaths and 20.8% of total deaths in 2010–2012 (ref. [2]), underscoring the need for effective public health nutrition strategies to improve diet quality in China. A large gap yawns between poor rural and better-off urban areas, despite the substantially improved overall nutritional status in China[8]. While urbanization is a driving factor behind the dietary shift towards an unhealthy Western diet[9], rural residents had overall less optimal diets than their urban counterparts (Fig. 1a). The prevalence of stunting between 2010 and 2013 among children was 4.2% in urban areas but 11.3% in rural areas[8]. While rural China experienced a larger decrease in underweight prevalence than urban areas, the increase in the overweight population also exceeded growth in urban China[10]. Moreover, food safety remains another urgent issue in China, alongside toxic metals in cropland soils and foodborne bacteria, parasites and viruses[11–13].

Food systems and economic development are closely interconnected. Notably, the share of the value of agricultural outputs in China's total economy dropped from 24.0% in 1991 to 7.7% in 2020 (Fig. 2b), while the whole economy grew. The change in agricultural activity also affected employment in agriculture and the upstream and downstream sectors along the food supply chain. The proportion of the population employed in agriculture in China has declined from 59.7% in 1991 to 25.3% in 2019 (Fig. 2b). Also, as much as 19% of grains in China are lost or wasted throughout the supply chain[3], with 4–5% of China's labour force bound to activities that produce waste and amplify the mismatch between food supply and demand[1,9]. Reducing these inefficiencies would further reduce employment in agriculture and would require either novel agricultural business models or the absorption of employment by other economic sectors.

While agricultural employment declines, finding alternative livelihoods is difficult for rural residents[14,15], as a strict household registration system prevents population mobility[16] and reduces access to the urban education system[14,15]. Under these circumstances, structural changes fuel the urban–rural divide and social inequality in China[17,18]. Similarly, migration and the lifestyle of migrant workers lead to lower intake of fruits and vegetables but higher alcohol

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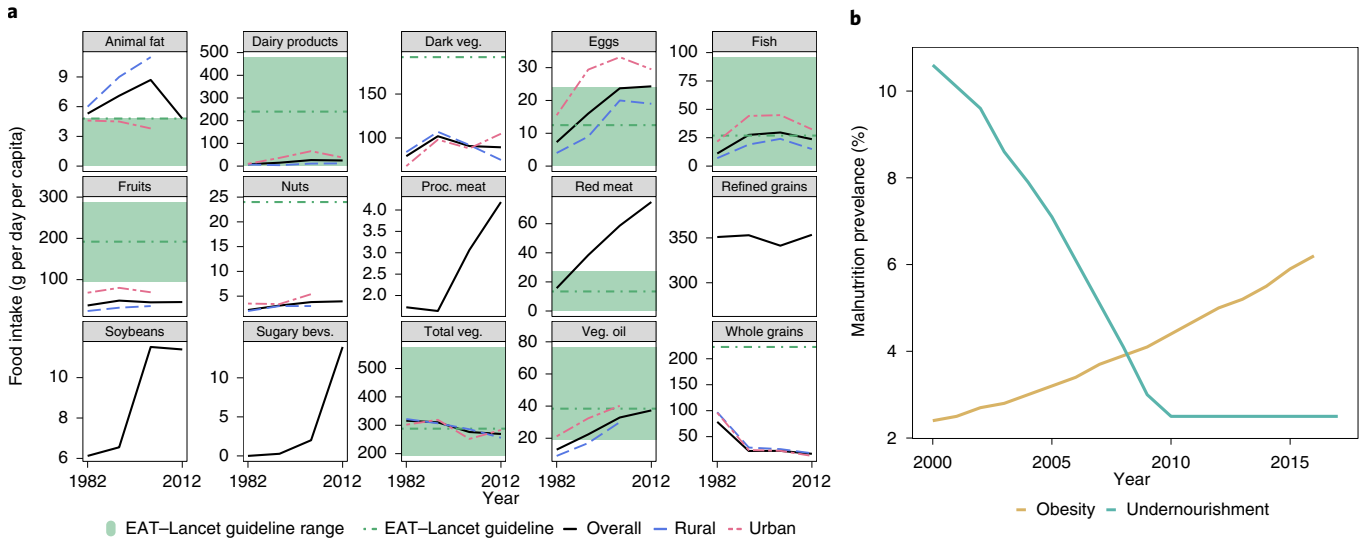

Fig. 1 | Food intake per day per capita and malnutrition prevalence in China. a, Food intake per capita with the unit of grams per day in China (solid black lines) and in its rural and urban areas (blue and red dashed lines) between 1982 and 2012, based on the China National Nutrition Surveys (CNNS) national representative survey data[2] and the China Nutrition Statistics Yearbook (CNSY)[76] with regard to the EAT–Lancet guidelines (in green, with the levels as dashed lines and the ranges as shaded areas)[28]. There are 15 food groups considered in CNNS. 'Dairy products' indicates total dairy products; 'red meat' includes ruminant meat and pork; 'fish' includes fish, shellfish and other seafood; 'sugary bevs.' indicates sugar-sweetened beverages; 'dark veg.' indicates dark-coloured vegetables, including dark-green, red and orange vegetables; and 'veg. oil' indicates vegetable oils for cooking. The intake of refined and whole grains, red and processed meat and sugary beverages was scaled to a total energy of 2,400 kcal from CNNS[2]. The intake of total and dark-coloured vegetables, vegetable oils, eggs, dairy products, fish, and animal fat was from the CNSY[76]. Intake of fruits, soybeans and nuts in 1982–2002 was from the CNSY and that in 2012 was from CNNS[2]. For the rural and urban statistics, all data were from the CNSY, among which intake of whole grains was partitioned from total grains according to their shares[2]; there are no related data available for the intake of processed meat, red meat, refined grains, soybeans and sugar-sweetened beverages in urban and rural areas. **b**, Shares of undernourishment and obesity in China's total population (age ≥ 18 years old); the share of undernourishment is reported as <2.5% after 2009–2011 on the basis of FAOSTAT[77].

consumption than those of urban residents[19]. While the reduction of undernutrition has improved labour productivity, both undernutrition and newly rising overnutrition are still threats to public health and the economy. Suboptimal dietary patterns with the simultaneous occurrence of undernutrition on the one hand and overweight and obesity on the other (that is, the double burden of malnutrition[8,20]) impair working forces despite the improvements made from better food accessibility. The loss of individual productivity due to malnutrition is estimated to be more than 10% of people's lifetime earnings, while the corresponding loss of gross domestic product (GDP) is as high as 2–3%[21].

The Chinese food system is currently a major driver of environmental damage, contributing 19% of China's greenhouse gas (GHG) emissions[22] (Fig. 2c). The decline from 51% in 1990 (ref. [22]) reflects more the industrialization and rising emissions from other economic sectors than an absolute decline of agricultural emissions. The large increase in the diet-related carbon footprint, from 2.15 in 1980 to 3.04 kg CO_2e per day per capita in 2017 in urban Beijing, is attributed to the growing consumption of animal-sourced foods[23]. China is the country with the highest ambient nitrogen pollution levels in the world, with agriculture contributing 95% of ammonia emissions and 51% of nitrous oxide emissions[24]. This poses great challenges for reducing air pollution[24] and the eutrophication of aquatic systems[25]. Additionally, food production drives soil erosion and biodiversity loss and intensifies the competition for scarce fertile land and freshwater resources[26–29]. The ongoing diet transition, if not modified, is expected to further exacerbate pressure on the environment and land in China[30]. While evidence is still being built in China, adjusting the dietary patterns of Chinese residents has great potential to reduce environmental pressure.

The expansion of agriculture into natural ecosystems, the sprawl of urban areas[1], the underregulated livestock sector and the strong interrelations between wild and domestic animals also contribute to the emergence and reassortment of novel pathogens[31,32]. China has been a hotspot of the reassortment of avian influenza viruses in poultry[33], which can be linked to the intensification of the livestock industry in wetland habitats[34]. Livestock farming[35], aquaculture (for example, China accounting for 58% of global antibiotics in aquaculture)[36] and even crop farming[37] are contributing to the creation of antibiotic resistance. Next to the appearance of novel diseases, agriculture may also impede the health system's response to such pathogens due to increased antibiotic resistance[35,38].

Towards slim and green growth

Solving the issues mentioned above is paramount given the large scale of the Chinese food system and the importance of its impact both domestically and internationally. As these issues cannot be addressed separately and are in fact forming a "syndemic"[39], we propose to adopt a macro-perspective on the food system that integrates macro-economic thoughts on sustainable transformation and cross-sectoral externalities with regard to health and the environment. To achieve 'slim and green growth', a food-system approach is needed that entails an integrated analysis framework able to take into account the interlinkages between agricultural production and food consumption across the overall food system—and that goes beyond agriculture. Slim growth means that those production factors that are used for revenue-generating but not welfare-creating activities (such as food losses or unhealthy foods) need to be freed and relocated to more productive use. Green growth means that hidden costs (such as environmental, health and social external effects) have to be subtracted to reveal the true growth of a sector[40].

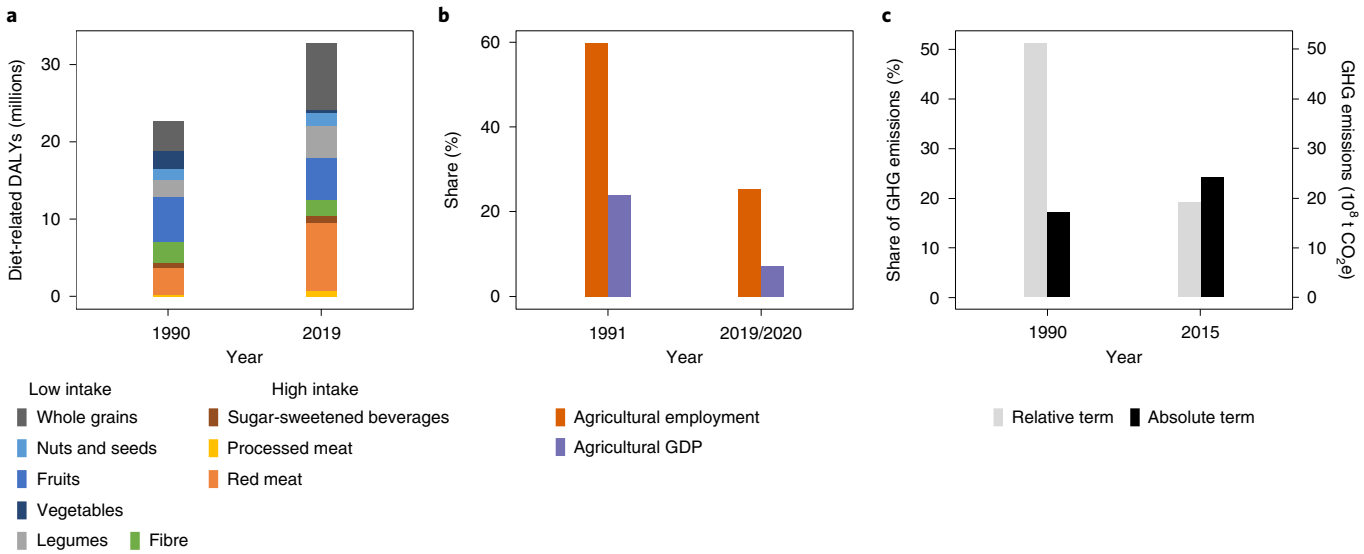

Fig. 2 | Economic, public health and environmental impacts of the Chinese food system. a, Risks measured as million disability-adjusted life years (DALYs) related to diets that are categorized by low intake of whole grains, nuts and seeds, fruits, vegetables, legumes and fibre, and high intake of sugar-sweetened beverages, red meat and processed meat, based on the Global Burden of Disease[7]. **b**, Share of agricultural employment in 1991 and 2019 and GDP in 1991 and 2020, based on world development indicators[78]. **c**, GHG emissions from the Chinese food system in relative and absolute terms in 1990 and 2015 (ref. [22]).

In line with slim and green growth, a broader perspective on sustainable diets should also target a general reduction of diet-related health risks, including under- and overnutrition, and diet-related chronic diseases, which are closely related to public health[41]. Food security can be understood in multiple ways, such as nutrition security[41], although it is often narrowly interpreted in the Chinese context with emphasis on food availability[42]. Slim and green growth requires economic growth and social policies to provide people at all life phases with the income to purchase healthy diets. A mix of economic incentives, food and nutrition education, and improved food environments (for example, food availability, affordability, stability and messaging)[43] are further needed to support healthy diet choices.

Slim and green growth also requires broader health objectives that consider indirect risks, ranging from novel and resistant pathogens to agriculture-led air pollution. Recent prospective cohort analyses of Chinese older adults indicate that adopting healthy plant-based diets reduces all-cause mortality[44] and mitigates air pollution hazards to cognitive function[45]. Strategies can be borrowed from the Healthy China 2030 action plan, with a focus on the promotion of public health and disease prevention, which can help reduce health-care needs and the economic burden of disease[46,47]. Under such a national plan, in our view, the development of a preventive health-care system emphasizing the role of nutrition education and clinical nutrition and promoting the prevention-first principle offers an opportunity for mitigating health risks rather than treating diseases[47]. A broader scope with consideration of potential impacts on the food system could make the nutrition and health industry a new driving force for health promotion and economic growth and could consider environmental pollution and food safety issues in concert. Such a transformation would also provide employment and advanced training possibilities for educated and unskilled labour, ranging from caregivers, nurses, doctors, and food and nutrition educators to people employed in canteens and gastronomy.

For slim and green growth, more explicit environmental objectives need to define spatially explicit critical loads[48] depending on the vulnerability of local ecosystems and the exposed population. To this end, regulating agriculture is not enough; the entire food supply chain needs restructuring, cuts in food losses, increased resource efficiency, circularity and the provision of decent livelihoods. Concepts such as the green GDP or the gross ecosystem product as applied to Qinghai Province in China provide useful guidance in policy decision-making in China[49]. Yet, these concepts need to be broadened to include the public health sector as well.

Transformation by evidence-based policy

The current situation is ripe for change and, in fact, has good initial conditions. Even more importantly, policymakers are aware of the necessity of this change, as reductions of the urban–rural divide in the health and economic dimensions and of environmental pollution are core pillars of the fourteenth five-year plan (2021–2025)[50] in China. China's agricultural sector has changed substantially since the beginning of the twenty-first century, with particular efforts on reducing agrochemical inputs and promoting organic and ecological agriculture. In 2015, China's Ministry of Agriculture introduced two national strategies to achieve zero growth in the use of chemical fertilizer and pesticides by 2020 (ref. [51]). As important measures of environmental protection, the individual sets of ten principles addressing air[52], water[53] and soil[42]; ecological fiscal transfer schemes[54]; and the recent pledge of the climate neutrality ambition in 2060 also put forward higher requirements for sustainability in agricultural production and food processing. As an important measure of the improvement of dietary behaviour and population health, the updated Chinese Dietary Guidelines (taking the EAT–Lancet guidelines into consideration)[28] stress the key role of diet and nutrition in both public and planetary health.

For the transformation of the food system towards slim and sustainable growth, certain practices need to be changed to simultaneously reduce hidden environmental, social and health costs. Tables 1 and 2 provide a cross-sectoral overview of potential interventions in the Chinese food system. For instance, practices such as wild animals being sold in wet markets and highly polluting aquaculture production must be reduced. Livestock industries have to be shrunk, particularly in high-risk areas such as wetland habitats to avoid the emergence of novel pathogens[34]. The economic activities and employment of the labour force in the upstream and

Table 1 | Objectives for the Chinese food system transformation with regard to the subsystems of agricultural and food production and of food processing and retail

Subsystem	Objectives	Interventions to achieve primary targets	Examples of co-benefits with secondary targets
Agricultural and food production	• Operate agricultural and food production within planetary boundaries • Promote future-proof and resilient business models • Use and preserve ecosystem services	Promote agricultural extension and educational programmes for smallholders on regenerative agricultural practices (en: +)	• Diversified production improves nutritional status (h: +) • Integration of ecosystem services reduces costs (ec: +) • Improved rural livelihoods reduce the urban–rural divide (ec: +)
		Phase out subsidies to rectify price distortion and repurpose subsidies to promote green agricultural technologies (en: +)	• Increases support of structural change of food systems (ec: +) • Improves health via reduced pollution (h: +)
		Internalize environmental externalities (for example, via tax reform) (en: +)	• Creates double dividend of Pigouvian taxes (ec: +) • Improves health via reduced pollution (h: +)
		Facilitate structural change within agriculture (for example, advanced training or professional reorientation, support for major investments and exit payments) (ec: +; en: +; h: +)	• Diverts support from polluting to sustainable farm systems (en: +)
		Promote diverse and hybrid business models (for example, agritourism, direct marketing and collaborations with water works or city councils) (ec: +)	• Allows pioneers of sustainable farming to gain more from agritourism and direct marketing (en: +; h: +/−) • Pays for ecosystem service provision (en: +)
		Invest in research and development (ec: +)	• Orients research programmes towards environmental and nutritional targets (en: +; h: +)
Food processing and retail	• Reduce the extent of food processing • Reduce the environmental footprint (for example, energy requirements in transport, cooling and processing) • Reduce food loss and the resulting overproduction	Improve tracking of products within food supply chains to safeguard food safety (h: +)	• Facilitates life-cycle inventories to better assess environmental footprints through food value chains (en: +) • Increases trust in the food system and willingness to pay for environmental, animal welfare and health attributes of products (en: +; ec: +)
		Develop new food preservation and transport technologies (ec: +)	• Reduces food loss (en: +) • Improves food safety but may also reduce fresh product consumption (h: +/−)
		Promote modern direct marketing of products by farmers (ec: +)	• Empowers consumers via direct feedback to express their wishes for sustainable products (en: +)
		Improve regulations and legislation about food advertising and labelling to restrict unhealthy products (for example, ultra-processed foods) (h: +)	• Creates large synergies between healthy and environmentally friendly consumption (en: +) • Economic public health benefits may outweigh reduced added value in the food industry (ec: +/−)
		Label and pre-select healthy and sustainable options in food delivery apps (en: +; h: +)	• Trustworthy labelling can improve profit margins (ec: +)

Exemplary interventions with a primary target may also have co-benefits with regard to secondary targets. We indicate potential (co-)benefits for the economy (ec), public health (h) and the environment (en) with '+' for clear implications and '+/−' for neutral implications.

downstream industries of agriculture could also undergo substantial changes. Rather than subsidizing agricultural production and thereby escalating pollution, exiting payments to reduce livestock density may facilitate rapid structural change[55]. Diverting subsidies into education programmes can help build up food and nutrition knowledge and practices[17], which would provide an opportunity to foster healthy diets and change consumption preferences[56]. These education programmes, particularly targeting younger people and their families in rural areas[57,58], could help reduce the urban–rural divide; left-behind children are the primary group facing micronutrient deficiency, stunting and cognitive issues[17,18]. There is evidence that parents' diets changed for the better as a consequence of nutrition education in kindergartens[59]. The long-term benefits of promoting food and nutrition education programmes for improving human capital, preventing human health risks and reducing environmental damages deserve more research and evidence. At the same time, alternative livelihoods in rural areas are needed that allow for structural change and have higher real productivity.

Table 2 | Objectives for the Chinese food system transformation with regard to the subsystems of food consumption, public health and the health-care system, and the non-food economy

Subsystem	Objectives	Interventions to achieve primary targets	Examples of co-benefits with secondary targets
Food consumption	• Improve food security and nutrition quality • Reduce food waste and the resulting overproduction • Improve access to and affordability of healthy and sustainable diets	Institute income transfers for food-insecure population groups (h: +)	• Helps people overcome the poverty trap (ec: +) • Improves human capital (ec: +) • Reduces economic inequality (ec: +)
		Develop dietary guidance (for example, dietary guidelines) for healthy and sustainable food (en: +; h: +)	• Improves human capital (ec: +) • Reduces medical expenditure and economic burden (ec: +)
		Enforce healthy and sustainable offers in canteens and expand population coverage of public food provision, improving their financial resources (en: +; h: +)	• Permanent direct marketing between canteens and farmers can offer business models for sustainable farming (ec: +) • Preventive health services reduce treatment costs (ec: +)
		Introduce nutrition classes in kindergartens and schools (h: +)	• Preventive health services reduce treatment costs (ec: +) • Healthy plant-based nutrition is positive for the environment (en: +)
		Institute nutrition counselling for prevention in the health-care system (h: +)	• Preventive health services reduce treatment costs (ec: +) • Offers novel career perspectives for caregivers with low education (ec: +)
		Introduce campaigns for consumers to adopt practices to improve efficiency in cooking, food preservation and waste disposal (en: +)	• Reducing waste and preserving food surpluses means reducing food expenditure and improving food security for people with low income (ec: +; h: +)
Public health and the health-care system	• Prevent chronic disease and improve the resilience of the population by using dietary interventions • Adopt a one-health perspective and extend the health-care system to more societal spheres	Educate nutritionists, dietitians, and so on (h: +)	• Preventive health services reduce treatment costs (ec: +) • Healthy plant-based nutrition is positive for the environment (en: +)
		Improve nutrition in hospitals and sanatoriums, initiating healthier diets after treatment (h: +)	• Permanent direct marketing between canteens and farmers can offer business models for sustainable farming (ec: +) • Public health prevention measures reduce treatment costs (ec: +)
		Include public health experts and one-health experts in planning councils (for example, for urban and rural development) (h: +)	• Improves labour productivity (ec: +) • Mitigates and reduces exposure to environmental pollution (en: +)
Non-food economy	• Reduce economic and health inequality and integrate urban and rural areas • Develop holistic concepts of public welfare and economic development • Improve cross-sector and rural–urban labour migration	Invest in high-quality education in rural areas (ec: +)	• Improves resource efficiency (en: +) • Raises awareness of health and pollution (h: +)
		Adopt holistic indicators for measuring welfare and account for cross-sectoral external effects, such as the green GDP (ec: +; en: +; h: +)	• Reveals hidden costs related to the economy, public health and the environment (ec: +; en: +; h: +)
		Divert premiums towards retraining programmes (for example, for livestock farmers) (ec: +)	• Facilitates convergence on a more sustainable food system (en: +) • Facilitates successful migration (ec: +)

Exemplary interventions with a primary target may also have co-benefits with regard to secondary targets. We indicate potential (co-)benefits for the economy (ec), public health (h) and the environment (en) with '+' for clear implications.

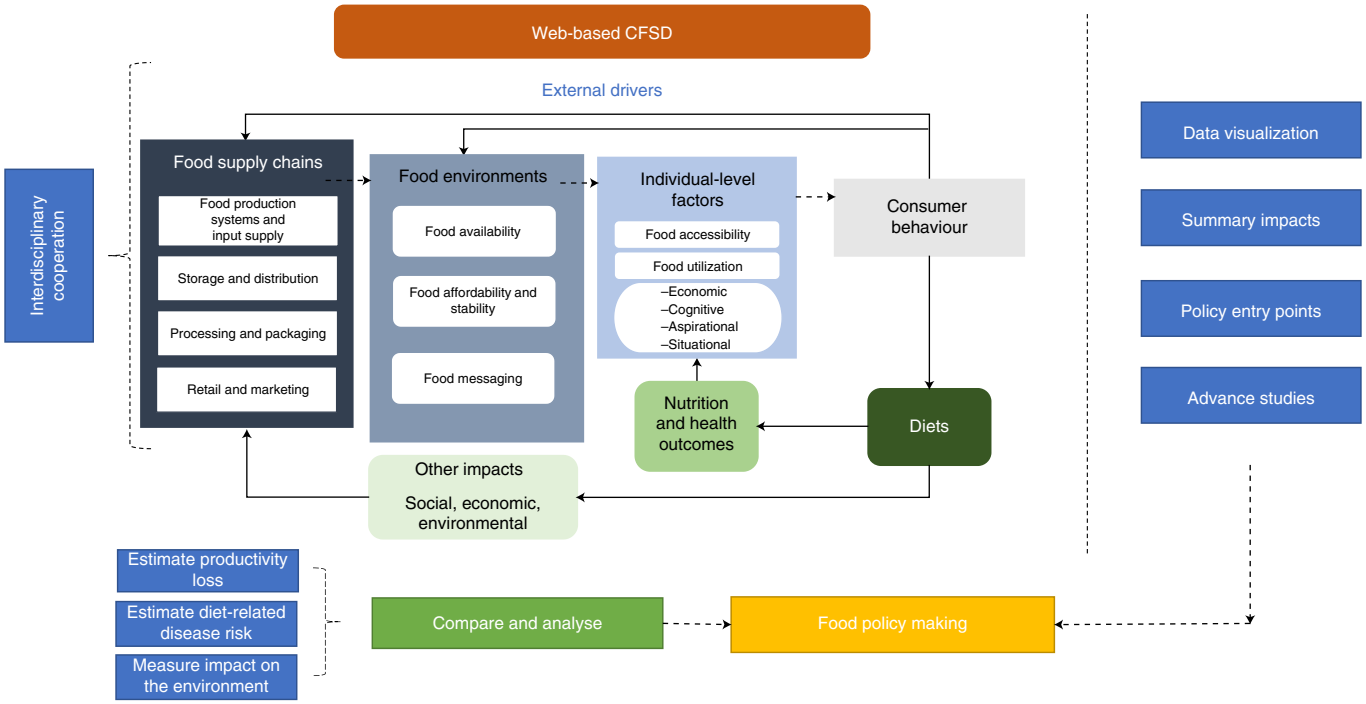

Fig. 3 | The CFSD framework to visualize and analyse the food system indicators. This framework serves as a harmonized and curated basis that connects integrated assessment models for integrated analyses to explore food system sustainable pathways. This framework is adapted from the JHU FSD framework[74].

One opportunity may lie in the horticultural sector, which can provide a synergetic effect on the economy and the environment. In contrast to the livestock industry[24,25], the horticultural sector in combination with strict sustainability targets (and facilitated by improved production technology[60,61]) has benefits with respect to public health and the environment[62] through reduced resource consumption and stronger soil conservation than the cultivation of grain crops. In addition, the horticulture industry has proved to provide livelihoods for many smallholders[63] and much higher labour intensity on average than the livestock sector[64].

These changes indicate potential trajectories through which research will have to show how constraints on agricultural production do not jeopardize past gains in food security. The linkage between the food system and the environment and health sectors is central to its transformation because of synergies and potential trade-offs among food, environmental and health plans. Metrics with a sustainability focus (for example, green GDP[65]) will help illustrate the connectedness of these different sectors so that improvements in one sector (for example, increased food security) at the expense of another (for example, higher GHG emissions) can be more easily detected and thus avoided. The potential major challenges associated with food system transformation are lock-ins of infrastructure investments and unwillingness to pay for the true cost of food, as well as the need to understand the scope of the problem at the actor level—all of which require strategies of maximizing the co-benefits between the economic, public health and environmental aspects while minimizing potential trade-offs. Our perspective provides a food-system viewpoint and solicits a range of potential measures; more scientific evidence on the synergies and trade-offs between these measures is warranted.

Integrative analysis for a systemic transformation

China needs a systemic transformation of the food system with an economy-wide perspective instead of incremental changes towards single-targeted objectives. Thus, integrative analysis of potential triple benefits for the economy, health and the environment is necessary despite some activities already being implemented (for example, regulations about zero growth in chemical fertilizer and pesticides[51,66]).

Lessons can be learned from the climate change community—for example, with respect to the energy transition[67]. Here pathways were designed for a sustainability transition that achieve the overarching goals, mapping out the technological measures, the required scale and the timing of the transformation, as well as suitable policy instruments. Such pathways can be further improved to account for market imperfections, novel technologies or even side effects of the transformation, such as employment impacts on unskilled labour. The big advantage of these pathways compared with the large body of literature on individual policy interventions is that they allow for investigating the optimal relative ambition levels across individual measures, assessing whether the overall targets can be met and combining them in a way that does not impair the achievement of side goals.

Externalities on the economy, public health and the environment are omnipresent within food systems, and thus the economic problem is how to incentivize socially optimal food production and consumption. Given the wide range of economic, health and environmental problems connected to the food system, the food system transformation is a considerably more 'wicked problem' than the energy transition. Policy instruments in the food system are more heterogeneous than in the energy system, since a central instrument such as GHG pricing is insufficient to transform the food system. These extant hidden costs are due not only to various market failures but also to policy failures that prevent food systems from operating at environmental, social and economic optimal levels. Economists can make key contributions to the analysis of food systems by developing methods and metrics to reveal the true costs of food systems[68]. It is utterly important to break disciplinary silos and integrate these metrics into a system approach with a large-scale view, which alters the frame of the analysis and requires

multisectoral collaboration. We thus suggest considerably widening the perspective beyond agriculture or the food supply chain to capture the entire nature of the problem and to identify solutions subsequently. While most interventions focus on a specific primary policy target, they also have strong interactions with other targets (Tables 1 and 2). Policymaking should therefore be more integrated. Similar to "health in all policies"[69], we need an 'environment in all policies' such that, for example, environmental criteria find entry into nutrition guidelines, or environmental and nutrition targets are integrated into agricultural research and development funding schemes. Finally, while economic evaluations already play a role in today's policymaking, we argue to open the perspective of economic assessments beyond the regulated sector and towards impacts that such policies may have on social inequality, the urban–rural divide, migration and other economic sectors.

Future research needs to show how these (or further policies) can be combined to achieve a transformation and at which ambition level they need to be employed to achieve the food system targets[70]. For many of these policies, it is still unclear how effective they can be at achieving a transformation in quantitative terms (for example, using econometric policy-evaluation methods). To explore feasible transformation pathways, agendas towards sustainable food systems in China will therefore require multidisciplinary and synergistic approaches, more scientific evidence and more collaborative work[71].

There are several important scientific panels and initiatives functioning as science-policy initiatives for food system transformation[72]. In the International Panel of Experts on Sustainable Food Systems, for instance, the Food and Agriculture Organization is playing an important role to promote the agroecological food movement and shift the paradigm from industrial agriculture to diversified agroecological systems. The Chinese government has also been joining forces with its vibrant civil society actors that actively advocate for agroecology. In addition to producer-side measures, transforming the Chinese food systems requires consumer-side measures. This implies a scope systematically utilizing data and modelling tools in the food system to fill in knowledge gaps. The coordination of high-quality data collection, econometric analysis of policy impacts, sophisticated model development and application, and team-based research output as a systematic collaborative action network are prerequisites for supporting targeted policymaking for the Chinese food system transformation[73]. By exchanging with the Food Systems Dashboard[74], the Chinese Food Systems Dashboard (CFSD) has been initiated to provide the public and scientific communities with a holistic data view of the Chinese food system and visualization services for users to obtain and analyse the food system indicators for various regions of China and different economic levels (Fig. 3). As illustrated by Fig. 1a, the CFSD initiative facilitates better understanding about rural- and urban-specific situations related to the consumption of various food groups. The CFSD aims to provide a harmonized and curated basis for integrated analyses to explore food system sustainable pathways by considering synergies in a consistent manner. A unified framework will be further developed by connecting integrated assessment models[75] that incorporate local information. Exchange with national and global science and decision-maker networks will aid successful food system transformation in China. A commissioned China-focused country study by the Food System Economics Commission is one example of such collaborative work. These initiatives are about catalysing sustainability research with a focus on the Chinese food system—seriously considering existing policies, using fine-scale data and involving other Chinese and international research partners[66]. This network has fostered new collaborative research and opinion exchange and increased research capacity[44,66]. The resulting insights can be fed back into international science-policy initiatives such as the Food System Economics Commission and the International Panel of Experts on Sustainable Food Systems, and act as a role model for sustainability promotion in other sectors and regions.

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Author contributions

X.W., B.L.B. and C.Y. developed the initial idea and draft of the paper. X.W., B.L.B., C.Y. and C.M. contributed equally to the further conceptualization and writing of the manuscript. X.W. curated the data and created the illustrations. X.W., B.L.B., C.Y., C.M. and K.Z.C. contributed to the editing and reviewing of the manuscript and agreed on the final version.

Competing interests

The authors declare no competing interests.

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