CHINA COUNCIL FOR INTERNATIONAL COOPERATION
ON ENVIRONMENT AND DEVELOPMENT
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CCICED / UN Food Systems Summit

White Paper

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Three international conferences this year will help close a global deal toward a sustainable future for the planet and its people: Climate Conference of the Parties to the United Nations Framework Convention on Climate Change (COP26), Biodiversity Convention on Biological Diversity (CBD 15), and the Food Systems Summit. Current CCICED work related to food systems includes green supply chains, basin-wide freshwater management, biodiversity, climate, and oceans. This white paper provides a frame of reference for experts to map opportunities for synergies with these three United Nations processes from the perspective of China's food system and help identify possible next steps for CCICED's work in this area.

1. CHINA'S FOOD SYSTEM TRANSFORMATION

Over the past 20 years, China's food systems have undergone a significant transformation: from modernization and intensification of food production to retail food diversification to multiple dietary transitions. Some of the most remarkable outcomes of this globally unprecedented transformation have been the reduction of hunger and poverty. These outcomes and emerging trends have profound implications for a sustainable food future in China and beyond. Details of this transformation are reviewed below.

A. Sustainable Food Systems

Food production in China has been modernizing with the increasing adoption of synthetic inputs, machines, and the advancement of farm infrastructure. To begin with, the usage of synthetic inputs grew steadily between 2000 and 2010. By 2010, the application of chemical fertilizers per hectare in China had reached 346 kilograms, about four times the world average (Luan et al., 2013). At the same time, China has become the world's largest consumer of chemical pesticides by both total amount and

per-hectare application. Figures 1 and 2 show the recent trend of nitrogen fertilizer and pesticide application per hectare in China, in comparison to the United States, EU, and world average.

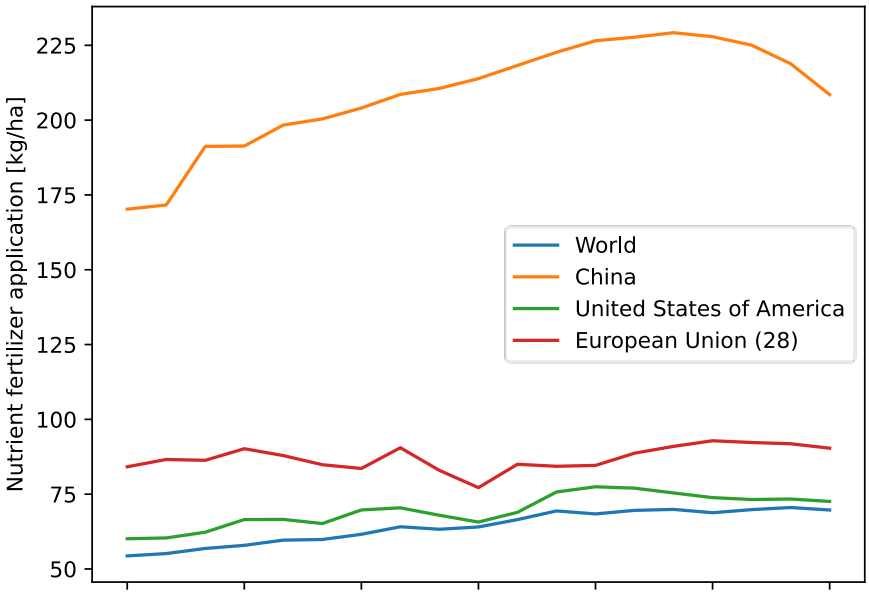

Figure 1. Nitrogen fertilizer application (kg/ha) in China, the United States, European Union, and world average between 2000 and 2018. Source: FAOSTAT (Global Food and Agriculture Statistics of Food and Agriculture Organization), 2021a.

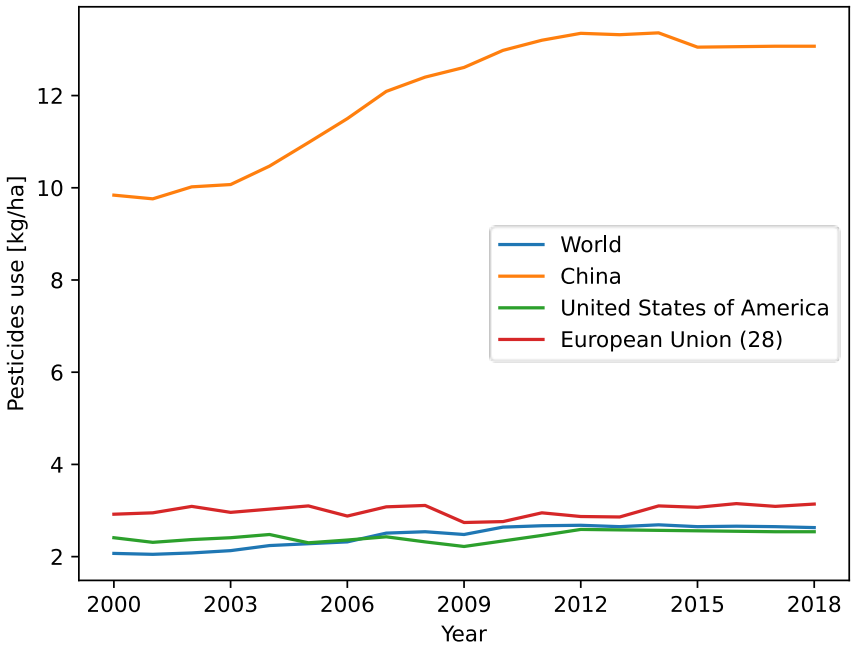

Figure 2. Pesticide application (kg/ha) in China, the United States, European Union, and world average between 2000 and 2018. Source: FAOSTAT, 2021b.

Over the last two decades, China made substantial progress in agricultural mechanization. According to the Ministry of Agriculture and Rural Affairs (2019), by 2019, China reached 70% in comprehensive mechanization[1], almost doubled from 1999 (38%) (Jiao & Dong, 2018). The comprehensive levels of mechanization for rice, wheat, and maize production have all exceeded 80%. Across China, over 450 counties have achieved full mechanization and are designated by the state as demonstration sites.

China has expanded the total area of modern agricultural infrastructure. By 2017, the total area of protected horticulture (3.7 million ha) had more than doubled from 2000 (1.8 million ha) (Jiang & Zhang, 2009; Sun et al., 2019) and accounts for over 85% of the global total. In addition, within the protected horticulture, technological advancement has been reached in heat retention, automated irrigation, and fertilizer application (Sun et al., 2019).

Food production in China has been intensifying through the scaling up and consolidation of farmland. Compared to most industrialized Western countries, farmland is overall less concentrated in China due to the legacy of the Household Responsibility System and collective land ownership. Roughly 200 million small-scale farming households in China comprise the majority of farming entities (Ju et al., 2016). However, since the late 1990s, farmland consolidation has become a common trend in rural development. By 2016, 36% of farmland, involving 70 million farming households, had been transferred to large agribusinesses or farmers' cooperatives (Chen, 2017; Liu, 2017). As farm size increases, food production scales up. Land consolidation also enables the vertical integration of farming, processing, and agritourism, particularly for agribusinesses. The growth of large domestic agribusinesses not only accelerates agricultural modernization in China but also strengthens China's engagement with the global food economy (Schneider, 2017).

B. Food Retail Diversification

During the 1990s, China witnessed the initial development of supermarkets (Hu et al., 2004), which embarked on rapid growth in 2004 following the relaxation of restrictions on foreign investment in food retail (Si et al., 2019). Initially, foreign supermarket chains, including Carrefour, Metro AG, and Walmart, shaped China's supermarket landscape, but with substantial growth in the past two decades, domestic supermarket chains such as Vanguard and Yonghui have overtaken foreign chains in total sales. China's supermarket landscape has been further diversified by the recent entrance of e-commerce retailers such as Alibaba and Jingdong. It is important to note that, despite their growing presence in the Chinese market, supermarkets have yet to replace the role of traditional markets in food retail. Especially with regard to fresh food, the traditional "wet markets" remain the primary choice among urban consumers in China (Si et al., 2019). Wet markets make up over 80% of the vegetable retail (Zhang & Pan, 2013), while consumers increasingly turn to supermarkets for processed and packaged foods (Zhou et al., 2015). Additionally, China's food retail landscape goes beyond the supermarket/wet market dualism and is diversifying with the rise of alternative food networks and online retail businesses.

The rise of alternative food networks was driven by widespread food safety anxiety. Food safety anxiety is one of the by-products of modernization in China's food systems. Consumers are increasingly

[1] According to the Yearbook of China's Agricultural Machine Industry, comprehensive mechanization is calculated by the weighted sum of mechanization rate in plowing (40%), seed drilling (30%), and harvesting (30%).

concerned about soil contaminants and residue of chemical inputs in fresh food, as well as counterfeiting or adulteration in processed foods. Food scandals such as the melamine-tainted milk tragedy heightened the food scare and stimulated the formation of alternative food networks, where consumers pay a price premium to purchase food directly from trusted farmers (Si et al., 2015). Despite being a market niche, alternative food networks have experienced substantial growth over the past decade, exceeding 500 initiatives across the country.

Digitalization of food retail took off during the past decade in China, thanks to expansion in Internet access and online delivery services. The online grocery market accounted for 32.5 % of total grocery transactions in China in 2018, a dramatic rise from only 1.4% in 2010 (van Ewijk et al., 2020). Between 2014 and 2018, total online grocery sales in China grew by an average of 35% annually, making China the largest online grocery market in the world; in contrast, online grocery shopping made up less than 5% of grocery expenditures in the United States in 2018 (Van Ewijk et al., 2020). COVID-19 and quarantine measures further boosted China's online grocery market. Based on a survey of 5,013 consumers by McKinsey, 74% of Chinese consumers visited online grocery channels more frequently at the onset of the pandemic, and 55% are likely to continue buying more food online after the pandemic subsides (Zipser & Poh, 2020). This analysis also shows that online food sales in China had monthly growth rates consistently above 25% between April 2019 and September 2020. The deepening digitalization of food retailing in China will have profound nutritional, economic, and environmental implications.1. NbS should be a topic of future CCICED work, including through the creation of a new Special Policy Study. Such work should be coordinated with CCICED's ongoing work related to biodiversity, climate mitigation, climate adaptation, and integrated water resource, as well as international work including the green Belt and Road Initiative (BRI), green supply chains, and green/conservation finance.

C. Dietary Transitions

One of the most dramatic outcomes of dietary transitions in China is the improvement of nutritional status indicators. The percentage of China's population that is undernourished has dropped from 10.6% in 2001 to less than 2.5% in 2019. During the same period, consumption of meat grew 50%, of fish 100%, and of dairy 300%, resulting in levels of daily calorie, protein, and fat intake per capita of 3,000 Kcal, 100 g, and 97 g, respectively. At the current rate, China is on track to reach nutritional levels on par with those of Organisation for Economic Co-operation and Development (OECD) countries withithis decade.

Growing purchasing power among Chinese consumers, exposure to Western and processed food, and increasing dining out at restaurants are drivers of China's changing dietary structure. As Huang et al. (2020a) summarize, the traditional diet in China of mostly cereals, low-fat, and diversified dishes has been transitioning toward a more Westernized diet that features lower cereal, tuber, and vegetable intake and more animal product (see Figure 3), processed foods, and sweetened beverage consumption. Intake of salt and cooking oils is far above the levels recommended by the Chinese Nutrition Guidelines. As a consequence, the Chinese diet is evolving from a high-carbohydrate diet to a high-fat diet. These changes have alarming health and environmental implications.

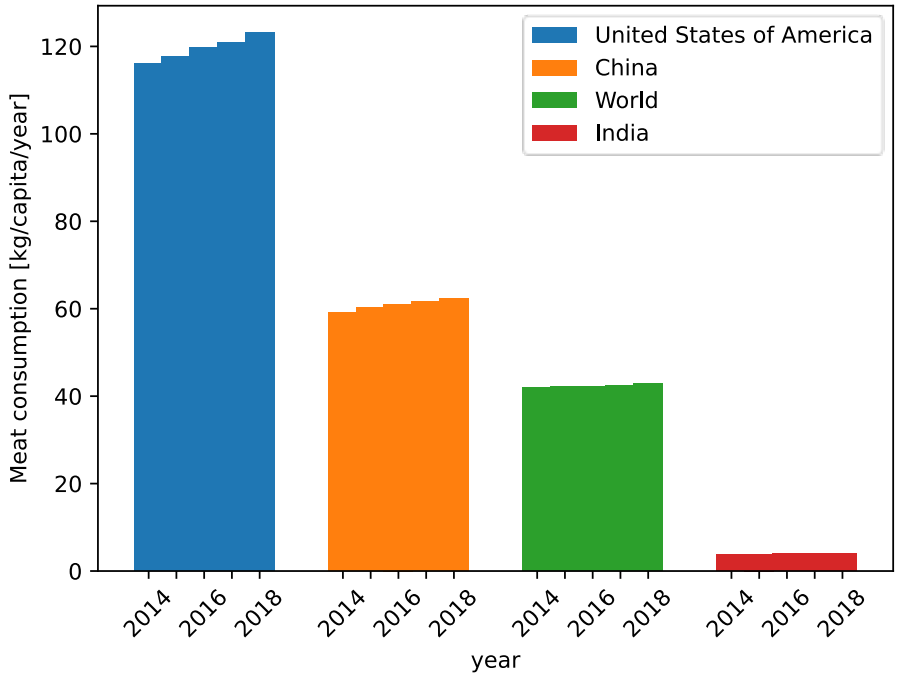

Figure 3. Per capita meat consumption (kg/capita/year) in the United States, China, India, and world average between 2014 and 2018. Source: FAOSTAT, 2021c.

The health implications of the dietary transition include the rising prevalence of overweight, obesity, hypertension, diabetes, and other non-communicable diseases. According to Huang et al. (2020a), the prevalence of overweight and obesity increased from 16.4% and 3.6% in 1992 to 30.1% and 11.9% in 2012. Between 2002 and 2012, the occurrence of hypertension and diabetes climbed by 34% and 273%, respectively.

D. From a Net Exporter to a Net Importer of Food

In 2014, China transitioned from a net exporter to a net importer of agricultural products when the value of agricultural imports exceeded exports (Zhu, 2018). This change reflects China's rapidly expanding import of land-intensive food products, including oilseeds, vegetable oil, and meat (see Figure 4). At the same time, robust growth is seen in China's export of labour-intensive food products, such as vegetables, fruits, and aquatic products, as Figure 5 shows.

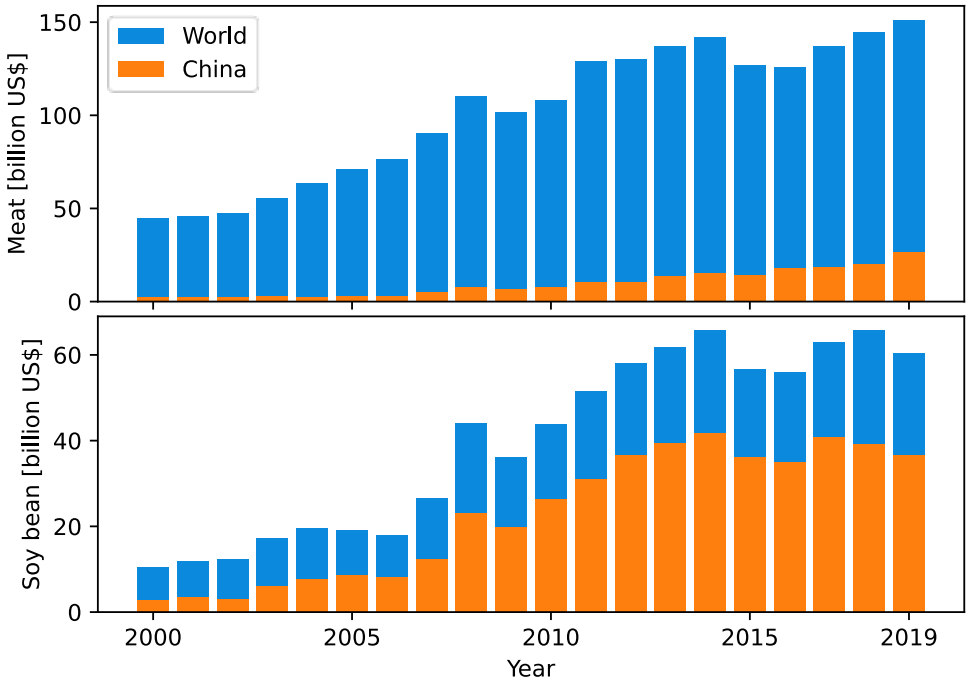

Figure 4. Meat and soybean imports for China and the world total imports between 2000 and 2019. Source: FAOSTAT, 2021d.

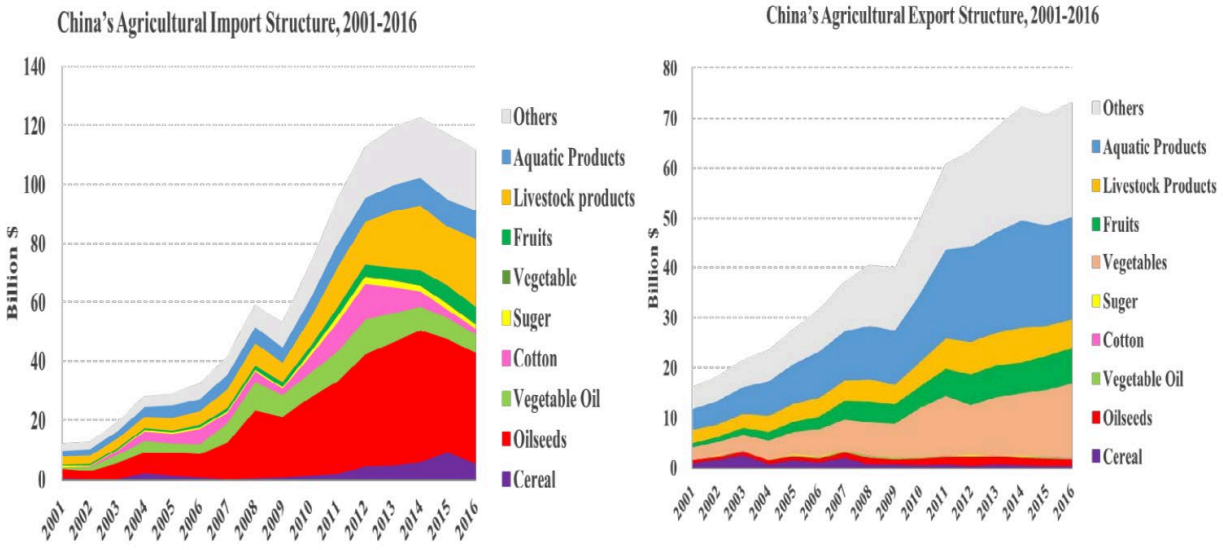

Figure 5. China's agricultural import and export structure between 2001 and 2016. Source: Zhu, 2018.

China's dietary transition and changing trade structures contribute to what has been conceptualized as the global grain–oilseed–livestock complex (Weis, 2013). Weis argues that the expansion of intensive animal agriculture and the growth in the industrialized production of grain and oilseeds are mutually reinforcing. More specifically, cheap grain and oilseeds produced through unsustainable monocropping enable the expansion of the livestock industry, which renders the

structural grain/oilseed surpluses into profits and sustains the crop producers. This complex nexus amplifies the environmental impact of agriculture on a global scale. Soybean is a key crop in this complex. The soybean trade between China and Brazil is associated with deforestation, land degradation, biodiversity loss, and greenhouse gas (GHG) emissions in Brazil. A 2020 study by Escobar et al. found that China is associated with the most GHG emissions embedded in soy imports, six times greater than the second importing country (see Figure 6).

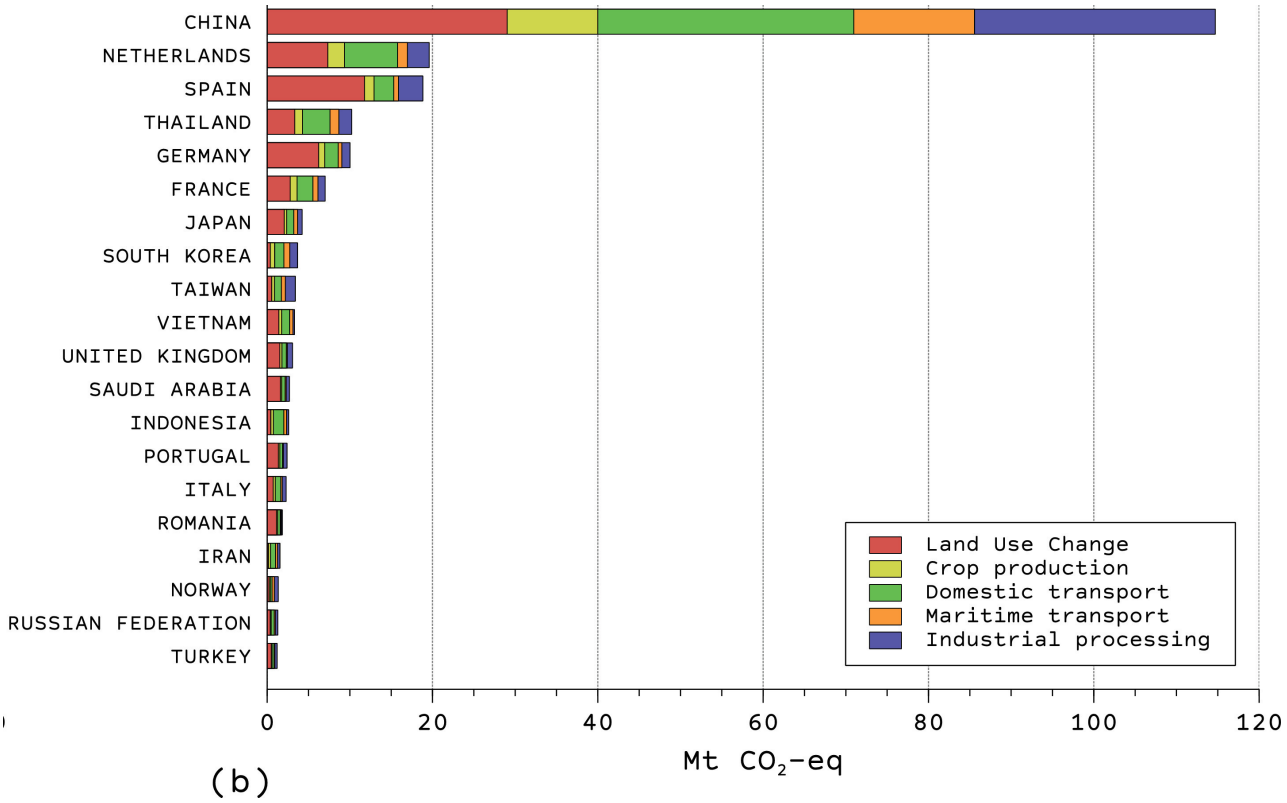

Figure 6. Total carbon dioxide-equivalent (CO2-eq.) embedded in soy imports in major soy-importing regions in the period 2010–2015, million tons (Mt). Source: Escobar et al., 2020.

If China continues on the current trajectory, its contribution to global warming, land degradation, biodiversity loss, and deforestation will intensify. Interestingly, as Figure 7 indicates, China ranks 9th among importing countries in terms of GHG emissions per ton of soybeans from Brazil. This is because the major Brazilian states that export soybeans to China are associated with comparatively lower land-use change and emission density (Escobar et al., 2020). The data suggest that China could reduce the embedded GHG emissions from food imports by seeking sustainable sources of production and adopting sustainable processing practices.

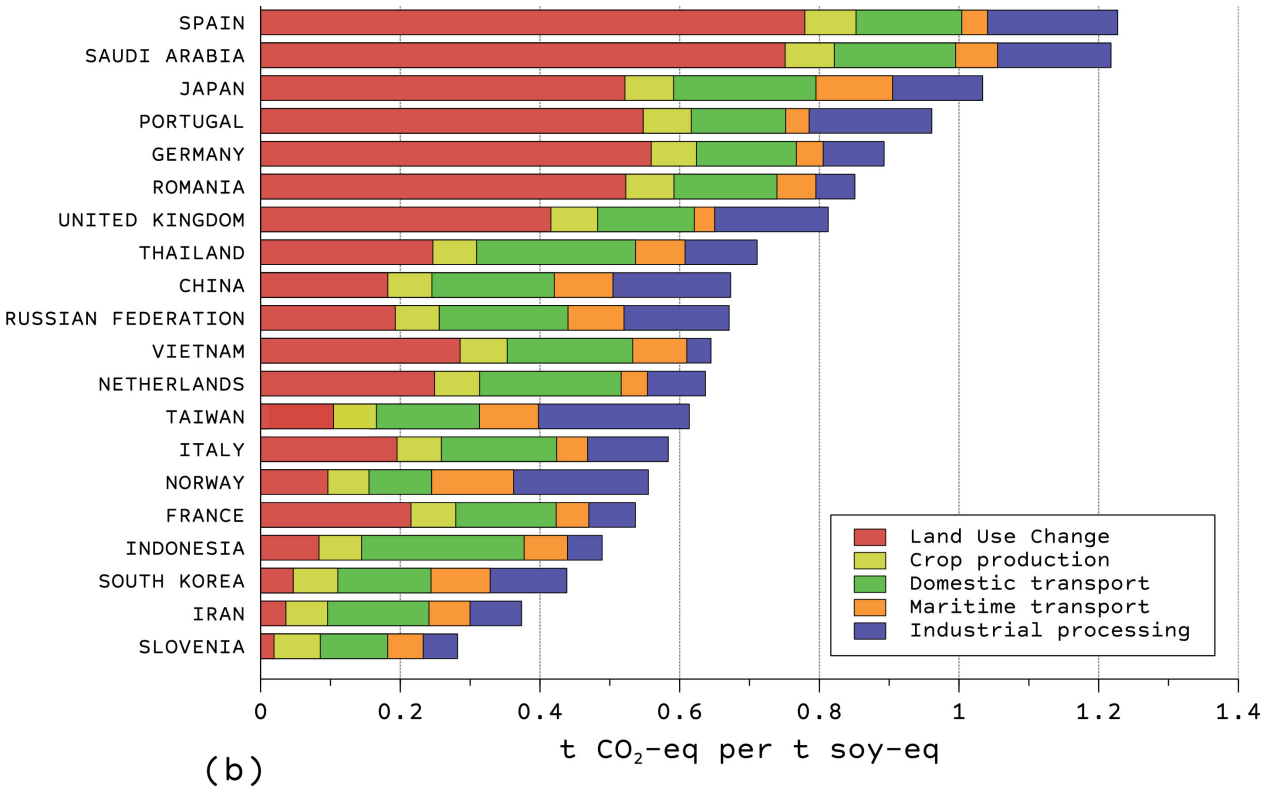

Figure 7. Carbon footprint of major soy-importing regions, as CO2-eq. per soy-eq. (t t−1). Source: Escobar et al., 2020.

2. SYNERGIES AND CHALLENGES

This section outlines the synergies between the transformation in China's food systems and the vision of the United Nations Sustainable Food Systems Summit ("the Summit"). It also maps out key challenges that China faces in developing healthier, more sustainable, and equitable food systems. Because the Summit will be guided by five Action Tracks, the analysis of synergies and challenges is organized around them. The analysis of synergies intends to highlight the best practices and policy tools in China that could be drawn on by other countries to deliver progress in sustainable development. The analysis of challenges invites dialogue on possible solutions through domestic innovations and international collaboration.

Action Track 1: Ensure access to safe and nutritious food for all

The goal of Action Track 1 is to eradicate hunger and all forms of malnutrition by ensuring all people at all times have access to nutritious, affordable and safe food. The following analysis highlights China's progress in ensuring access to safe and nutritious food and points out the remaining challenges.

Synergies

- Since 1996, China has committed to becoming self-sufficient in the provision of staple grains. Policy measures include direct subsidies to farmers, input subsidies, and government procurement of staple grains with price floors to protect grain farmers. The latest analysis indicates that, as of 2019, China maintains 98% self-sufficiency in rice, wheat, and maize (Yang et al., 2019). As for non-grain foods, China employs the Vegetable Basket Project to secure the provisioning of vegetables, meat, fish, and eggs. This project holds prefecture-level city mayors accountable for the production, distribution, and safety of non-grain foods (Zhong et al., 2019). It also mandates the construction and maintenance of wet markets, which are the primary source of fresh food to urban Chinese consumers. The mandate ensures that the development of markets sufficiently matches the expansion of cities and urban populations (Zhong et al., 2019). In order to further improve physical access to fresh food, some municipal governments require supermarkets to carry adequate fresh produce. For example, the government of Nanjing stipulates that supermarkets must dedicate at least 20%–30% of their business areas to fresh produce (Zhong et al., 2019).

- Food safety governance in China has implications for the domestic food economy, public health, social stability, and even the political legitimacy of the ruling party (Kang, 2019). As Chinese President Xi commented in 2013, food safety management was a test of the Chinese Party's governance ability. In response to major food safety scandals in the 2000s, the Chinese State enacted the first version of a food safety law in 2009. The food safety law progressed and received two amendments in 2015 and 2019, which extended the scope of the law to specify the process of food safety supervision and to emphasize comprehensive risk management from farm to fork. The progression of the law reinforced safety standards, added sanctions for violations, and enacted the Criminal Code for the production of toxic food (Kang, 2019). The law pushed for the nationwide extension of the food traceability system. By 2019,

over 58 cities in China had established a traceability system for meats and vegetables, involving over 80,000 enterprises and 500,000 businesses.[2]

Challenge

Box 1

Multidimensional food safety risks and governance challenges in China

1. Three categories of food safety contamination and risk factors

- Microbiological contamination (meat from diseased animals; zoonotic diseases) is aggravated by increasing international trade, consolidation of livestock farming, changing human/animal interactions.
- Chemical contamination (pesticide residue; processing additives) is aggravated by agricultural industrialization and growth of the processed food industry.
- Physical contamination (adulteration and non-food substances in food processing) is aggravated by growth in processed food industry and insufficient supervision.

2. Inefficiency in food safety regulatory implementation

- Institutional fragmentation at national and local levels between food safety regulatory agencies.
- Strong will of central government in strengthening food safety governance but weak local government incentive and capacity in implementation.

3. Lack of engagement with private sector and civil society stakeholders

- Government recommendations are prescribed for large food companies, although 70% of food businesses in China have 10 or fewer employees and struggle to follow government guidelines.
- Government sets food safety regulatory standards, and civil society initiatives lack institutional channels to have their food safety guarantee measures integrated into the government standards.

Source: Koberinski et al., 2019; Kang, 2019.

Box 1 shows the complexity of food safety risks in China and outlines the multidimensional challenges to executing food safety regulations. Governing China's food safety is a daunting task, considering the sheer scale of the country, its diversified food geographies, and the multilevel bureaucratic system. In light of limited government engagement with industry or civil society actors, scholars have raised concerns about the efficacy of China's current food safety regulatory approach (Connolly et al., 2016; Kang, 2019). Therefore, it is essential to investigate what institutional mechanism the Chinese government could incorporate in order to enable co-governance of food safety with the private sector and civil society.

[2] https://zycpzs.mofcom.gov.cn/html/guowuyuanxinxi/2019/1/1548379101888.html

Action Track 2: Shift to sustainable consumption patterns

This action track focuses on reshaping consumption patterns to support sustainably produced food and to reduce food waste and embedded waste of land and water resources.

Synergies

- China's food certification scheme classifies food products as organic, green, hazard-free, or non-certified.Organic and green food standards are found to have integrated agroecological principles to an extent, whereby certification standards of organic foods are more stringent than green foods (Scott et al., 2014). Organic and green food markets have been steadily expanding in China over the past decade, despite comparatively high price premiums (300%–500% for organic foods). As of 2019, China is the world's 4th largest market for organic food, after the United States, Germany, and France. The total retail turnover of organic foods in China exceeded EUR 8.5 billion (Willer et al., 2021). At the same time, China's total retail sales of green food reached EUR 59.8 billion. Certified green food has penetrated over 7% of China's rice market, as well as 5% of its fresh fruit and soybean markets.[3] Chinese consumers have a growing appetite for sustainably produced food in light of rising purchasing power and health awareness.

- As Section I discussed, the ongoing dietary transition in China is linked to the rise of non-communicable diseases and food-related ecological footprint. To reorient China's dietary transition, the state is promoting a Balanced Diet Pyramid (Pingheng Shanshi Baota) through the 2016 Dietary Guidelines and the Health China (2019–2030) campaign. The Balanced Diet Pyramid recommends sufficient intake of dairy products, grains, fruits and vegetables, and moderate consumption of meat, eggs, and fish. Complete implementation of the Balanced Diet Pyramid will cut half of per capita meat consumption and improve vegetable consumption. However, the Balanced Diet is only advice for the public and unlikely to be widely adopted without effective policy incentives.

- China's food waste is on the rise. The growth in consumer food waste indicates not only waste of land and water resources in food production but also aggravates the pressure on municipal waste management. Food waste in Chinese cities makes up 50%–70% of municipal solid waste, three to four times the average in U.S. cities and twice the average in European cities (Freese & Han, 2019). Most of the food waste is landfilled or incinerated, aggravating soil, air, and groundwater pollution as well as GHG emissions. To counter the growth in food waste, the government has endorsed the "Clean Plate" campaign to discourage excessive food ordering at restaurants and in 2021 enacted the Anti Food-Waste Law to penalize food service providers for causing substantial food waste.

[3] https://www.sohu.com/a/412499976_730526

Challenge

Box 2

China's food waste conundrum

1. No consensus on food waste measurement methodology or results

A. There is no official data on the scale of food waste in China. Existing research provides a wealth of food waste estimates, but substantial variation is found between different estimates, particularly in the case of household waste. Lack of data consistency undermines the efficacy of policy response.

2. Waste reduction efforts at odds with food customs and increasing restaurant dining

A. In the traditional food culture, hosts show hospitability and respect to guests by serving more dishes than can be finished, especially at businesses banquets and social dining. To save face, many shy away from taking leftovers.

B. Increasing restaurant dining is associated with growth in consumer food waste. The 2021 anti-food-waste law aims to penalize food service providers with excessive food waste, but details of enforcement remain unrefined and the efficacy are unclear.

3. Barriers to legislation and enforcement of waste disposal at municipal level

A. The central government outlines the principles and standards of waste management, while municipal governments create and implement specific local waste management policies within their jurisdiction.

B. Most cities have not codified the administration of food waste and lack binding laws on business/household food waste separation and collection. Businesses lack financial incentives to comply with waste management rules.

Source: United Nations Environment Program, 2021; Freese and Han, 2019.

Action Track 3: Boost nature-positive production

The objective of Action Track 3 is to reduce biodiversity loss, pollution, resource consumption, soil degradation, and GHG emissions through the adoption of resource-efficient and ecologically sound production practices. Action Track 3 emphasizes the inclusion of small-scale farmers and enterprises, whose opportunities and challenges are analyzed in detail below.

Synergies

- In 2015, the concept of agricultural supply-side reform was published at the Central Conference of Rural Work in light of new food challenges in China. As the State Council (2017) articulated, China's major food challenge has shifted from insufficient production to a structural imbalance between supply and demand. In order to address the challenge, recent national-level agricultural policies have prioritized quality improvement and market connectivity of food production. China's 14th Five-Year Plan emphasizes the "greening" of agriculture and aims to reduce chemical inputs, improve animal manure treatment, and improve administration of food certifications (organic, green, hazard-free, and geographical indication).

- The general guideline on agricultural pollution mitigation was released in 2015 by the Ministry of Agriculture: one control, two reductions, and three fundamentals (yikong erjian sanjiben). Namely, the government aims to cap water use in agriculture, to reduce application of chemical fertilizers and pesticides, and to recycle plastic mulch, reuse rice stubble and repurpose animal manure. In practice, due to the government's promotion of water-efficient irrigation technologies, the total irrigated farmland area in China overtook the rainfed farmland area in 2019, and 46% of the irrigated area is equipped with water-saving technologies (Xinhuanet, 2019; Zhang & Jia, 2018). By 2017, China reached the goal of zero growth in the application of chemical fertilizers/pesticides by promoting soil testing-based fertilization methods and organic fertilizer substitution (Ministry of Agriculture and Rural Affairs, 2018).

Challenge

Box 3

Barriers to ecological farming for small-scale farmers

1. **Government subsidies for ecological farming concentrate on large agribusinesses**
   A. 200 million small-scale farmers make up the majority of producers in China, so a meaningful transformation to nature-positive production requires inclusion of small-scale farmers.
   B. The dominant forms of government support for ecological agriculture are providing capital for green technology application, infrastructure upgrade, and eco-agritourism. Large-scale agribusinesses are the main beneficiaries of the support because they can help local governments display immediate outcomes by commencing capital-intensive transformation.

2. **Limited market connectivity**
   A. A proportion of small-scale farmers in China practice traditional farming methods and use little to no chemical inputs, but they lack access to market platforms where their ecologically produced foods can be sold at fair prices.

3. **Current certification schemes too costly and stringent**
   A. The certification process, particularly for organic foods, are too costly and complicated for small-scale farmers.
   B. Consumers in China have limited exposure to and misunderstandings about food certification standards. Scandals around fake food certifications undermine consumer trust.

Source: Scott et al., 2014.

Action Track 4: Advance equitable livelihoods

The mission of Action Track 4 is to "leave no one behind" in the food systems by eliminating poverty and providing employment and decent work conditions for all actors in the food systems.

Synergies

- After economic restructuring and market liberalization in the 1980s, household incomes in both rural and urban China have been rising, although the rural–urban income gap has intensified over decades of development. In 2009, the urban-to-rural ratio of per capita income peaked at 3.3 to 1 (UNICEF, 2018), drawing attention to the dramatic income disparity between rural and urban households in China. In the last decade, the state has ramped up efforts to mitigate rural/urban inequality by financing rural infrastructure, incubating rural entrepreneurship, and targeted poverty alleviation programs. With these efforts, the urban-to-rural income ratio started to decline in 2010 and continued to decrease to 2.7 in 2017. It has been announced that by the end of 2020, China had lifted 98.99 million rural people, 832 poverty-stricken counties, and 128,000 villages out of poverty (Xinhuanet, 2021). This announcement implies the completion of China's mission to eradicate extreme poverty by 2020.

Challenge

Box 4

Livelihoods and re-employment of landless farmers in cities

1. **Rapid urbanization and farmland expropriation creates approximately 50 million landless farmers agribusinesses**
   - By 2013, rapid urbanization had resulted in around 50 million farmers losing their land and migrating into resettlement communities in cities. Research indicates 60% of surveyed landless farmers encountered livelihood challenges, and only 30% retained the same quality of life as they had prior to migration.

2. **Limited access to re-employment opportunities and urban social services**
   - Landless farmers lack education, skills, training, and work experience to find skill-based employment in cities. To enrol themselves in urban pension and health care systems, landless farmers have to pay into these social services with savings and/or relocation compensation. Substantial variation is found in the amount of relocation compensation, and many cannot afford health care and decent pension plans.

3. **Relocating the rural poor: Solving the problem or only relocating it?**
   - As part of poverty alleviation measures, between 2001 and 2020, 13 million rural residents were relocated by the government from ecologically fragile and least-developed regions into resettlement communities. However, due to underfunded infrastructure and lack of proximity to education and health services, some of the resettlement communities suffered low occupancy, and residents migrated back. Lacking employment, some residents gradually fall back into poverty after resettlement.

Source: Huang et al., 2020b; Yang et al., 2013

Action Track 5: Build resilience to vulnerabilities, shocks, and stresses

Action Track 5 focuses on building the resilience of food systems in the face of natural disasters, conflict, or pandemics. The goal is to ensure all actors in the food systems can prepare for, withstand, and recover from unexpected stresses and shocks.

Synergies

- To shore up emergency food supply against disruption in production, distribution, and trade, China has set up grain reserves. Grain reserves are established across the country to store rice, wheat, maize, and soybeans for emergency deployment. Reserves around large and medium-sized cities store refined grains that could supply 10 to 15 days of the city's food demand. According to the official statistics, as of 2018, China's grain reserves have in total the capacity to store 670 million tons of food. The grain reserve system buffers against market instability and helped stabilize grain prices during the COVID-19 outbreak.
- The conventional food supply chain proved vulnerable when facing disruption in logistics and consumer mobility restrictions. During the first wave of the COVID-19 outbreak, residents in affected cities had limited access to food from conventional retail channels due to lockdown measures. Online short food supply chains were created by the government, online businesses, and volunteers to enable farm-to-household food delivery, which greatly improved food access for households with limited mobility (Dai & Qi, 2020).

Challenge

Box 5

Dilemma between self-sufficiency and economic efficiency

China has been a net food importer since 2004, but the state remains committed to being fully self-sufficient in staple foods and mostly self-sufficient in cereals. However, China faces a dilemma between self-sufficiency goals and economic efficiency when it comes to agricultural policy-making. On the one hand, self-sufficiency of staple grains and strategic foods reduces China's reliance on food imports and thus hedges against the volatility of global markets and food trade conflicts. On the other hand, maintaining self-sufficiency goals regarding foods with comparative disadvantages will add to the government's financial burden of providing farm subsidies and procurement price floors to incentivize production. For example, between 2008 and 2016, the government maintained a minimum procurement price for domestically produced maize. This policy stimulated maize production and improved maize farmer incomes, although it led to inflation of the price of maize, increased production costs in animal agriculture, and increased pressure on grain reserve management, causing economic inefficiency. In addition to the economic concerns, the farm labour ethics involved and environmental footprint of food imports further complicate this dilemma. A delicate balance is needed between government intervention for self-sufficiency and market self-adjustment for economic efficiency, with consideration of the ethical and environmental consequences.

Source: Huang, 2018.

3. CONNECTIONS BETWEEN CHINA'S FOOD SYSTEM TRANSFORMATION AND STATED GOALS OF UN COP26 AND COP15

A. Connections to the United Nations Climate Change Conference (COP26)

COP26 will focus on four goals: mitigation, adaptation, financing, and collaboration. This section will analyze how the sustainable transformation of China's food systems contributes to the mitigation and adaptation goals. More specifically, it will discuss policy measures and innovations in China that help reduce food-related greenhouse gas emissions and build climate-resilient food systems. It will also highlight some of the most pressing challenges to fulfilling China's climate action goals.

In 2019, China's national greenhouse gas emissions reached over 14 gigatons CO2eq. (around 27% of the total global emissions), exceeding the level of emissions of all OECD countries combined (Larsen et al., 2021). In response to climbing GHG emissions, China released an ambitious plan in 2020 to have carbon emissions peak by 2030 and to achieve carbon neutrality by 2060. Much of the climate action policies and research in China have focused on emission reduction in the energy sector, transportation, and heavy industry; however, 10% of GHG emissions result from agriculture. Mitigating GHG emissions in China's food production has profound implications for China's and the world's carbon neutrality goals.

Agricultural Policies That Align With Climate Change Mitigation Goals

- The main GHGs emitted by agricultural activities include methane, nitrous oxide, and carbon dioxide. Net carbon dioxide emissions are not significant due to the carbon sequestration process of agriculture. In China, the main GHG emissions are methane and nitrous oxide, respectively bearing 34 and 298 times the warming effect of carbon dioxide (Cheng & Pan, 2021). Nitrogen fertilizer application (24%), livestock digestion and manure (29%), and methane emissions from rice paddies (15%) are the main sources of GHGs emissions in China (Cheng & Pan, 2021). The passages below map out the main sources of GHG emissions in China's agricultural systems and measures taken for mitigation.
- Diminishing nitrogen fertilizer application is an effective means of curtailing agricultural GHG emissions. About 1% of nitrogen fertilizer used in farming is lost in the form of nitrous oxide. In addition, nitrogen fertilizer production is energy intensive and emissions heavy. Since 2005, the Ministry of Agriculture has been promoting soil testing-based fertilizer application, which reached 200 million farmers and successfully cut GHG emissions by 25 million tons CO2eq (Cheng & Pan, 2021). Combined with other measures such as organic fertilizer substitution and green manure cultivation, China managed to achieve negative growth in chemical fertilizer application in 2016, breaking the record of consecutive growth since the 1970s.
- Reusing rice stubble and animal manure has been another important emission reduction strategy. Prior to the release of government subsidies for rice stubble reuse in 2012, burning rice stubble led to 9 million tons of GHG emissions per year. Biofuel reuse (as fertilizer/energy source/livestock feed) policy has enhanced the reuse rate of rice stubbles to 80% in Northern China.

- Methane and nitrous oxide emissions from animal agriculture remain a challenge in China due to high GHG emissions per livestock yield, which is linked to low-grade livestock feed and inefficient manure treatment (Gao, 2021). However, methane emission control has for the first time been included in China's 14th Five-Year Plan for climate action. More stringent measures are expected to tackle methane emissions in animal agriculture.
- Enhancing the role of soil as a carbon sink can mitigate agricultural emissions. During the last decade, the Chinese government has been implementing a Fertile Ground project to increase soil organic matter. This project is estimated to add 25 million tons of soil carbon, equal to 12% of the total agricultural GHG emissions in 2014 (Gao, 2021).

Apart from domestic agricultural practices, food importation is another source of GHG emissions related to China's food systems. Section I introduced the embedded GHG emissions in the soybeans that China imports from Brazil. In addition to soybeans, palm oil is another emission-intensive agricultural product that China imports in large amounts. According to Jiang (2020), China is the world's second largest palm oil importer after India, and in 2019 it imported over 8 million tons of palm oil (17% of total global imports). In the same year, China lifted the import quota for palm oil, liberalizing its import as a food ingredient and biofuel. China imports palm oil mainly from Indonesia and Malaysia, where large areas of peat swamp forests are cleared to make way for palm oil plantations, leading to substantial carbon releases and threats to endangered wildlife.
More sustainable ways of palm oil production have been established, and certification schemes such as the Roundtable on Sustainable Palm Oil (RSPO) were created to distinguish sustainably sourced palm oil in the market. RSPO was introduced to China in 2013, although by 2020, only 2% of Mainland China's imported palm oil received RSPO certification (Jiang, 2020). Despite palm oil being ubiquitous in China's processed foods, consumers have little awareness about its prevalence or its ecological footprint. On the government end, it is argued that "a strong, clear policy signal in favour of sustainable palm oil has yet to emerge in China" (United Nations Development Programme, 2020, p. 43).

However, there are plentiful opportunities for the government to support sustainable palm oil. Despite RSPO imports being marginal in China, the Indonesian and Malaysian governments have official palm oil certification schemes. The Chinese government could collaborate with the Indonesian and Malaysian governments to increase the trade of government-certified palm oil and to ensure that the certification standards meet sustainability requirements. It has been pointed out that smallholder producers are mostly excluded from the RSPO, even though they make up approximately 40% of the total cultivation area of palm oil in both countries (Jiang, 2020). The intergovernmental collaboration has the potential to include smallholder producers in the official certification schemes.

Agricultural Policies That Align With Climate Change Adaptation Goals

The warming climate could have devastating effects on agriculture. To sustain food security and ensure farmer livelihoods, it is essential to adapt agricultural infrastructure and practices to the shifting climate conditions. More specifically, adaptation measures should be employed to enhance the resilience of farms to changing temperatures, precipitation, and more frequent extreme weather events.

To build resilience around such factors of instability, the Chinese government has financed water-saving agriculture and dryland farming technologies, increased the area of effective irrigated agriculture, and supported breeding of crop varieties resilient to heat, frost, and drought (Ministry of Ecology and Environment, 2019). In 2014, with the support of the Global Environment Fund, the Ministry of Agriculture and Rural Affairs of China collaborated with World Bank to found China's first climate-smart agriculture program. The program was piloted on over 6,000 hectares of farmland in the major grain-producing regions in Henan Province and Anhui Province. As outcomes of this program, technological guidelines have been developed for climate-smart maize, rice, and wheat production (for details see[4]), which shares the lessons learned from the practices of climate-smart agriculture in pilot regions.

Overall, China's agricultural policies are guiding the food system transformation to mitigate GHG emissions and adapt to ongoing climate change. However, a few challenges remain regarding China's carbon neutrality goal: no carbon peaking or carbon neutrality standards or regulations have been published by the authorities for the food systems. The lack of a carbon neutrality mandate for agriculture and rural development impedes the promotion of carbon sequestration technologies. It would be useful to have a clear roadmap for reaching carbon peaking and carbon neutrality goals in agriculture and to set up a workforce on agricultural climate action to integrate existing knowledge and expertise (Zhao, 2021).

B. Connections to the Convention on Biological Diversity Meetings

The Biodiversity Convention meetings (COP15) are scheduled to take place this year in November in Kunming, China. During the meetings, the final decision about the post-2020 global biodiversity framework ("the framework") may be made (CBD, 2021), which presents an opportunity for collaborative efforts to create win–win situations for China's food system transformation and biodiversity conservation. Diversified and ecological food production practices could conserve biodiversity and ecosystem services, which in turn will reduce the need for costly and harmful external inputs and enhance food system resilience to shock and stress. The zero-draft of the framework advances a 2050 vision of living in harmony with nature and proposes the following targets related to food systems.

- Target 8. By 2030, ensure benefits, including nutrition, food security, livelihoods, health and well-being, for people, especially for the most vulnerable, through sustainable management of wild species of fauna and flora.
- Target 9. By 2030, support the productivity, sustainability and resilience of biodiversity in agricultural and other managed ecosystems through conservation and sustainable use of such ecosystems, reducing productivity gaps by at least 50%.

[4] http://www.reea.agri.cn/stgjhz/202009/t20200928_7531516.htm

China is home to incredibly diverse fauna and flora. There are over 9,500 species of agricultural vegetation, 590 of livestock and poultry, 966 of edible fungi, and 17,447 of aquatic crops and animals (Zheng & Yang, 2021). However, biodiversity in agricultural systems is under stress from intensive farming, industrial pollution, invasive species, and climate change. In China, the aggressive adoption of selected commercially viable seeds and livestock breeds is an important contributor to biodiversity decline (Song et al., 2012).

One example of the decline is the changing pig breeds in China's intensifying pork industry. Due to the consolidation of pig farms and the selection of high-yield breeds, most of China's traditional pig breeds have been replaced by imported breeds. As of 2019, over eight of 90 indigenous pig breeds were extinct and 29 had become endangered (Wang, 2019). The decline of indigenous crop and livestock varieties not only undermines the resilience of agricultural systems to economic shocks and diseases but also weakens their capacity to meet diverse dietary preferences and nutrition needs.

To support biodiversity conservation in agricultural ecosystems, the government has taken multiple measures. First, over the last two decades, the government implemented the Long-term Plan for National Agricultural Crop Genetic Resources Protection and Utilization (2015–2030) and the National Livestock and Poultry Genetic Resources Protection and Utilization Plan. Second, the Ministry of Agriculture and Rural Affairs has been promoting ecological agriculture practices such as mixed crop-livestock farming to diversify farm biodiversity and introduced integrated pest management to reduce ecosystem interruption. Third, to preserve the genetic resource of indigenous crops and livestock, China has set up a national genetic resource bank system, preserving over half a million samples of genetic resources of 340 crops (Zheng & Yang, 2021). The Southwestern wildlife genetic resource bank in Kunming preserves over 60,000 samples of 6,450 animal species. Last, eco-compensation schemes have been rolled out by the government to address soil erosion, flooding, and deforestation caused by aggressive agricultural development in the 20th century. Part of the eco-compensation schemes is the Sloping Land Conversion Programme, which incentivizes reforestation of agricultural land through compensation payments to farmers. This Programme is the largest payment for ecosystem services initiative in the Global South, with over USD 69 billion funds being allocated; it successfully increased the national forest cover from 16% in 1999 to 21% in 2018 (Martin, 2018).

In addition to the government measures, civil society initiatives such as the Farmer's Seed Network are protecting agricultural biodiversity by engaging farmers in seed-saving practices and establishing seed-sharing programs in over 30 rural communities.

These government policies and civil society initiatives are contributing to both food system sustainability, biodiversity conservation, and agricultural resilience to climate change. However, to advance China's contribution to the global 2050 vision, the following challenges need to be addressed.

- Government-led biodiversity conservation in agricultural systems has mostly been projects and campaigns. These campaigns and projects have not formulated an institution of agricultural biodiversity conservation and are not closely connected to the strategic planning of the CBD (Zheng & Yang, 2019).

- There are no particular government departments or research institutes designated for agricultural biodiversity. Biodiversity governance is compartmentalized into multiple government ministries and departments and lacks coordination and concerted actions.
- In an increasingly globalized food system, biodiversity conservation not only concerns domestic agricultural systems. China's soybean and palm oil imports are linked to deforestation and wildlife habitat loss. It remains a question for China on how to meet rising domestic demand without furthering its reliance on unsustainably sourced food imports. There is potential for China to collaborate with trade partners to enable the sustainable transition of soybean and palm oil production through taxes, subsidies, or certification schemes. The three UN conferences provide a timely opportunity to envision the avenues to fulfill this potential.

Overall, this paper characterizes China's food system transformation and outlines synergies with the stated goals of the UN Food Systems Summit, COP26, and the CBD. These synergies could inform international stakeholders about some of China's best practices in sustainable development. This paper also calls attention to the challenges China is faced with when balancing the goals of economic growth, food security, poverty alleviation, biodiversity conservation, and climate mitigation. Hopefully, the information here will stimulate discussions on how China can engage the three UN conferences as levers of change toward the sustainable development goals within China and beyond.

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