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Institute for Global Decarbonization Progress

BUILDING SUSTAINABILITY INTO CHINA'S AGRI-FOOD SYSTEM

FOURTEEN CASE STUDIES

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AUTHORS

Chen Meian, Project Director/Senior Analyst, Institute for Global Decarbonization Progress (iGDP)
Zhu Tongxin, Assistant Analyst, iGDP
Yu Yang Jinqi, consultant, iGDP
Hu Min, Director of iGDP

Translators: He Jun, Yu Nan, Phillip Neel, Kerry Allen

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BACKGROUND

1. The Agri-food System and Climate Change

The agri-food system is a holistic system that encompasses the set of actors and their activities in agricultural production, food processing, packaging, transportation, retail, and consumption. This system includes stakeholders such as farmers, businesses and policymakers, as well as the different social, economic, and natural environments in which these actors operate.[1]

The agri-food system is closely linked to climate change. Many agri-food system activities, such as crop production, livestock farming, use of agricultural machinery, food processing, utilization of packaging materials, cold chain transportation, and cooking, contribute to greenhouse gas (GHG) emissions. Globally, the agri-food system generates approximately one-third of the total GHG emissions annually.[2] In 2019, China's agri-food system emissions reached around 1.65 billion tons of CO_2e, accounting for 14% of that year's total GHG emissions.[3]

Meanwhile, the increased frequency of extreme events due to climate change can exacerbate the volatility of agricultural production, posing a challenge to agricultural productivity. Between 2008 and 2018, 63% of global losses and damages caused by extreme weather occurred in the agricultural sector.[4] Studies indicate that, influenced by climate change, China's rice, wheat, and corn yields face significant risks of substantial decline.[5] Climate change also affects livestock productivity in terms of animal health, growth environment, and feed quality, and has implications for China's food security.[6] The variability in grain production due to climate change has reached around 10% in certain years. Potential increases in the demand for agricultural irrigation water may lead to a decrease in grain yield per unit area.[7] This impact of climate change is more pronounced on low-income food producers and consumers, who face greater challenges in coping with climate disasters and ensuring access to safe and healthy food.

A sustainable agri-food transition not only enhances the resilience of the agri-food system to climate change, but also promotes food security, biodiversity conservation, and public health. It can reduce damage to the ecosystem caused by monoculture and intensive farming, and enhanced food security and balanced diets can reduce the incidence of diabetes and cardiovascular disease due to dietary shift.[8]

2. Progress in Policy Actions Driving Agri-food System Transition

The mitigation pathway for the agri-food system is becoming clear. Actions such as fertilizer recommendations, irrigation management, resource utilization of livestock and poultry manure, kitchen waste recycling, and waste sorting, as well as mitigation technologies such as green logistics and precision agriculture, are shaping GHG emissions in the agri-food system and providing opportunities for emission reduction.

Given China's large population and limited arable land, attention to agricultural production and food security has always been at the core of China's policy agenda. The country has formulated and implemented multiple actions for sustainable development in agriculture and rural areas, including strategies and policies for agricultural green development, soil

1. Nguyen, H. (2018). Sustainable food systems: Concept and framework. Food and Agriculture Organization. https://www.fao.org/3/ca2079en/CA2079EN.pdf
2. Crippa, M., Solazzo, E., Guizzardi, D., Monforti-Ferrario, F., Tubiello, F. N., & Leip, A. (2021). Food systems are responsible for a third of global anthropogenic GHG emissions. Nature Food, 1–12.
3. Chen Meian, Hu Min, Yang Li & Ma Zhong (2022). Agri-food Systems and Carbon Neutrality: An Analysis of Agriculture and Food-related Greenhouse Gas Emission Reduction Pathways in China. Working paper. Beijing: Institute for Global Decarbonization Progress (iGDP).
4. FAO. (2021). The Impact of Disaster and Crisis on Agriculture and Food Security. Food and Agriculture Organization.
5. Ahmed, J., Almeida, E., Aminetzah, D., Denis, N., Henderson, K., Katz, J., Kitchel, H., & Mannion, P. (2020). Agriculture and climate change: Reducing emissions through improved farming practices. McKingsey & Company.
6. Liang Hong, Chen Meian, Hu Min, Wu Wanyi & Geng Haomiao. (2022). Envisioning Agricultural Carbon Neutrality—A New Green Revolution. Hillhouse Group, Institute for Global Decarbonization Progress, and Institute of Finance and Sustainability.
7. Liu Litao, Liu Xiaojie, Lun Fei, Wu Liang, Lu Chunxia, Guo Jinhua, Qu Tingting, Liu Gang, Shen Lei & Cheng Shengkui (2018). Research on China's Food Security Issues Under Global Climate Change. Journal of Natural Resources, 33(6), 927–939.
8. Tilman, D., & Clark, M. (2014). Global diets link environmental sustainability and human health. Nature, 515(7528), 518–522.

conservation, rural revitalization, and ensuring food security. Since 2004, the Central Committee of the Communist Party of China and the State Council have annually released the "No.1 Document," outlining work arrangements for agriculture and rural areas. The 2017 "No.1 Document" proposed a shift from over-reliance on resource consumption and meeting quantity demands to pursuing green, ecologically sustainable development and focusing on meeting qualitative demands.[9] In the 2021 " No.1 Document," agricultural green development is identified as an important part of advancing agricultural modernization, emphasizing the need to protect a red line of 1.8 billion *mu* of arable land. The 2019 White Paper *Food Security in China* emphasizes the necessity of not only protecting the red line of arable land but also improving land quality and protecting the natural environment to increase grain production capacity, with the widespread application of agricultural technology expected to contribute to food growth.[11]

To address GHG emissions from food processing, transportation, and consumption, China has implemented mitigation measures such as industrial energy conservation, green low-carbon transportation, and waste management. Although the primary goals of these actions are not necessarily carbon mitigation, they lead to GHG emission reduction co-benefits in the agri-food system. Table 1 summarizes policies that can reduce GHG emissions in the agri-food system by stage.

TABLE 1. Policy Actions Driving GHG Emission Reduction in the Agri-food System

	MAJOR EMISSION SOURCES	POLICY ACTIONS	KEY POLICY DOCUMENTS
Agricultural Production	Nitrogen Fertilizer	• Promote the reduction of chemical fertilizer and pesticide use and substituting with organic fertilizer. • Establish a long-term mechanism for replacing organic fertilizer with chemical fertilizer in the cultivation of fruits, vegetables, and tea. • Provide subsidies for the purchase and use of organic fertilizer.	• *Opinions on Accelerating the Prevention and Control of Agricultural Plastic Film Pollution* • *Action Plan for Controlling Greenhouse Gas Emissions during the 13th Five-Year Plan* • *National Green Development Plan for Agriculture during the 14th Five-Year Plan* • *Scheme for Improving Soil Quality and Protection* • *Opinions on Comprehensively Promoting Rural Revitalization and Accelerating Agricultural and Rural Modernization* • *Digital Agriculture and Rural Development Plan (2019-2025)* • *Working Guidance for Carbon Dioxide Peaking and Carbon Neutrality in Full and Faithful Implementation of the New Development Philosophy* • *Action Plan for Peak Carbon Emissions by 2030* • *Implementation Plan for Agricultural and Rural Emission Reduction and Carbon Sequestration*
	Rice Cultivation	• Select high-yielding and low-emission varieties. • Improve water and fertilizer management.	
		• Increase carbon sequestration capacity through rational farmland management practices.	
	Livestock Farming	• Enhance the resource utilization of livestock and poultry manure.	
		• Promote low-protein feed, whole-plant silage, and technologies for high-yield, low-emission livestock and poultry breeds.	
	Agricultural Machinery	• Promote smart agriculture.	
		• Promote the adoption of green agricultural machinery, support the inclusion of intelligent equipment in agricultural machinery purchase subsidies.	
	Agricultural Input (Pesticides, Fertilizers, Agricultural Film)	• Promote the recycling of agricultural films and the use of environmentally friendly biodegradable films. • Implement a zero-growth policy for chemical fertilizers and pesticides.	

9. 2017 CPC "No. 1 Document" http://www.gov.cn/xinwen/2017-02/05/content_5165613.htm

10. 2021 CPC"No.1 Document"http://www.gov.cn/zhengce/2021-02/21/content_5588098.htm

11. The State Council Information Office of the People's Republic of China. (2019). White Paper on Food Security in China. http://www.gov.cn/zhengce/2019-10/14/content_5439410.htm

TABLE 1. Policy Actions Driving GHG Emission Reduction in the Agri-food System

	MAJOR EMISSION SOURCES	POLICY ACTIONS	KEY POLICY DOCUMENTS
Farm to Table	Food Processing	• Energy efficiency improvement in the food processing industry.	• *Guiding Opinions on Accelerating the Transformation and Development of the Packaging Industry in China during the 14th Five-Year Plan* • *The 14th Five-Year Plan for the Circular Economy* • *Opinions on Accelerating the Development of Cold Chain Logistics to Ensure Food Safety and Promote Consumption Upgrading* • *The 14th Five-Year Plan for the Development of the Green Economy* • *Kigali Amendment* • *Green and Efficient Refrigeration Solutions* • *The 14th Five-Year Plan for the Energy System* • *The 14th Five-Year Plan for the Development of Cold Chain Logistics*
	Food Packaging	• Promote green packaging, and apply recyclable packaging for express delivery packaging up to 10 million units.	
	Food Transportation	• Develop green and low-carbon transportation for agricultural products.	
	Food Retail	• Improve the energy efficiency of commercial refrigerators and display cabinets. • Promote the use of low global warming potential (GWP) refrigerants.	
Food Consumption	Cooking	• Guide cooking electrification.	• *The 14th Five-Year Plan for Building Energy Efficiency and Green Building Development* • *Implementation Plan for Coordinated Reduction of Pollution and Carbon Emissions*
		• Promote the use of renewable energy in rural cooking, agricultural product processing facilities, etc.	
	Kitchen Waste Disposal	• Promote waste sorting and resource utilization of household waste and restaurant waste.	• *Implementation Plan for the Classification of Household Garbage* • *Law of the People's Republic of China on the Prevention and Control of Environmental Pollution by Solid Waste* • *Outline of China's Food and Nutrition Development (2014-2020)* • *China's Anti-Food Waste Law* • *China's Residents' Dietary Guidelines*
		• Reduce food waste, formulate and revise relevant national standards, industry standards, and local standards to prevent and reduce waste.	
	Behavioral Changes	• Adjust residents' dietary structure.	

3. Case Studies

This report presents fourteen case studies on actions being taken to drive China's sustainable agri-food transition. The selection of cases is based on key mitigation actions that have been identified in previous research (Table 2). They explore local practices under specific abatement actions and briefly analyze the key elements needed for replication. The cases show how different stakeholders in the agri-food system can help achieve emissions reduction through mechanism design and innovation, leading to economic, environmental, and social benefits.

TABLE 2. Key Mitigation Actions in the Agri-food System and Associated Case Studies

PRIORITY ACTIONS	MAIN MEASURES	MITIGATION POTENTIAL IN 2050	CASE STUDIES
AGRICULTURAL PRODUCTION			
Nitrogen Fertilizer Reduction	Adoption of nitrogen fertilizer enhancers, slow-release fertilizers, continued promotion of soil testing and conservation tillage.	10%	Case 1: Technology-Assisted Precision Fertilization – Reducing the Use of Chemical Fertilizers Case 2: Turning Barren Land into Fertile Soil – Promoting Conservation Tillage
Emission Reduction in Enteric Fermentation	Selective breeding, feeding strategy adjustment, feed additives.	3%	Case 3: Culinary Arts for Ruminants – Reducing Livestock Enteric Fermentation
Methane Emission Reduction in Rice Cultivation	Adjust irrigation management, adopting dry-wet alternate irrigation, and promote dry direct seeding.	6.6%	Case 4: Climate-Friendly Rice Cultivation
Livestock and Poultry Manure Management	Biogas recovery: biogas generated by anaerobic fermentation of livestock and poultry manure.	11%	Case 5: Manure Matters – Livestock and Poultry Manure as a Resource
Energy Efficiency and Electrification in Agricultural Machinery	Improve the efficiency of agricultural machinery and promote the electrification of medium and small-scale farm machinery.	5.8%	Case 6: A Preliminary Exploration of Agricultural Machinery Electrification
FARM TO TABLE			
Energy Efficiency and Emission Reduction in Food Processing	Improve energy efficiency and promote renewable energy use in food processing.	5%	Case 7: Energy Efficiency Improvement and Energy Substitution in Food Processing and Manufacturing
Low Carbon Transportation	Improve transportation efficiency and promote the electrification of light-duty freight and the use of low-GWP refrigerants.	7%	Case 8: Solving the First Mile - Mobile Cold Storage in the Field Case 9: Carbon Reduction in Food Transportation - Electrification of Light Freight Transport
Plastics Reduction and Recycling	Simplify packaging, using recyclable and biodegradable packaging materials.	2.8%	Case 10: A New Dawn for Surplus Food – Innovating Business Practices to Reduce Food Waste Case 11: Reducing Food Packaging to Cut Down on Plastics
FOOD CONSUMPTION			
Energy Efficiency and Electrification in Cooking	Promote energy-efficient cooking and electrification of cooking.	12.8%	Case 12: Electrification Empowering Low-Carbon and Safe Chinese Cooking
Resource Utilization of Kitchen Waste	Promote waste sorting and kitchen waste resource utilization.	5%	Case 13: Leftover Food - A Hot Commodity in Terms of Power and Compost
Dietary Shift and Behavioral Change*	Promote dietary guidelines for residents and advocate for local food consumption.	-	Case 14: Advocating Environmentally-Friendly Diets in the Pearl River Delta Region - How Restaurant Orders Can Reduce Food Emissions

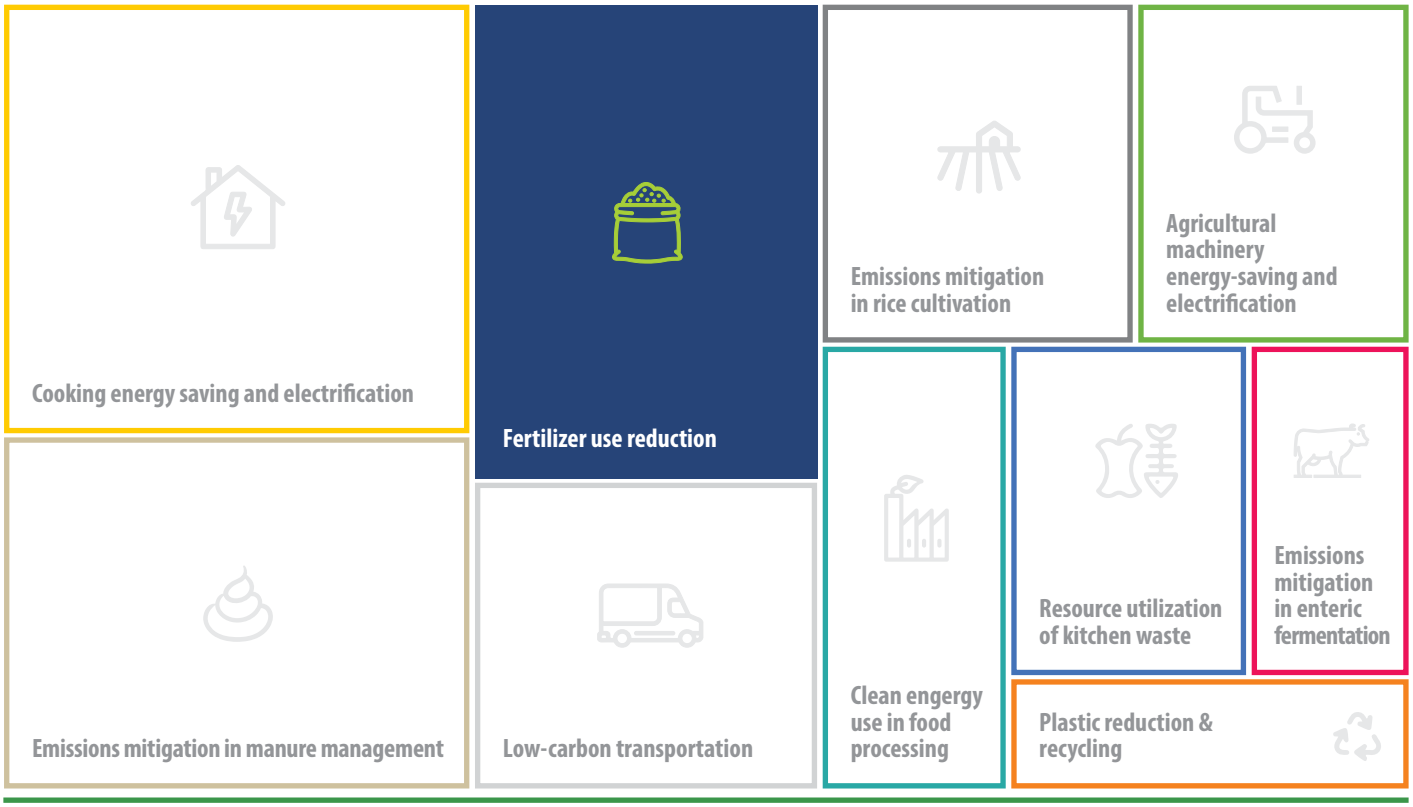
***Note:** Dietary shift mainly refers to reducing animal-based food consumption and encouraging local food consumption, which can reduce emissions in agricultural production and food transportation. Considering the large uncertainty surrounding behavior change, quantitative analysis is not performed here. Numerous studies have shown that reducing animal food consumption has large emissions reduction potential, a dynamic that deserves greater attention.

ACTIONS AND CASES

Action: **Nitrogen Fertilizer Reduction**

Mitigation Potential: **10%**

Specific Practices:
Promoting the reduction of nitrogen fertilizer usage, enhancing efficiency, and improving soil health.



Case 1: Technology-Assisted Precision Fertilization — Reducing the Use of Chemical Fertilizers

Problems

Although fertilizers play a crucial role in promoting crop production and increasing agricultural yields, their excessive use has led to a series of environmental problems. While China's fertilizer use decreased from 602.2 million tons in 2015 to 519.1 million tons in 2021[12], its fertilizer use intensity was around 307 kg/hectare, still far beyond the internationally accepted limit of 225 kg/hectare.

Approach

With the rise of smart agriculture, information technologies such as big data, remote sensing, and unmanned aerial vehicles (UAVs) have been applied and promoted in crop cultivation and management. For example, using sensors on UAVs to collect information on soil, crops, as well as environmental data like weather and temperature, and then employing big data analysis to provide farmers with suggestions on planting, irrigation, and fertilization, can increase yield and conserve resources.

Smart Fertilizer Blending Machine: Sinofert, one of the largest fertilizer producers in China, has introduced smart fertilizer blending service stations nationwide since 2014, using smart fertilizer blending machines for soil testing and fertilization.[13] Farmers can use the corresponding application software on the internet-connected smart fertilizer blending terminal to input planting information and provide soil samples. The fertilizer blending machine conducts a rapid soil test and transmits the results to the cloud. The cloud server calculates planting schemes, required fertilizer formulas, and prices based on the soil test results. It eventually generates a fertilizer blending order and sends it to the farmer's smartphone.[14] Calculations show that the smart fertilizer blending system can directly reduce fertilizer application and cost by 10% to 30%, while increasing crop yield by 5% and farmers' income by 10%.[15]

FIGURE 1. A drone flying above a rice paddy

Photo credit: viya0414 on Pixabay

Smart Farm: In a small town in Jiangsu Province, farmers have established an unmanned planting demonstration farm with the help of smart agriculture equipment.[16] The 5000 acres of farmland are operated by a three-person management team. Before planting, remote sensing drones are used to survey the fields, obtaining high-resolution maps, including information on the area and topography of the farmland. Based on this information, precision management of the plots is carried out. During the growth of rice, remote sensing drones, combined with AI models, analyze the growth of the rice and monitor for diseases and pests. Meanwhile, smart cameras with sensors installed on the field embankments provide data on soil moisture and temperature, reminding farmers to perform various tasks.[17] Moreover, the drone can carry out precise fertilization and pesticide spraying when needed in the rice field.[18] Under the management of smart agriculture, the use of pesticides and fertilizers per unit area of crops in the farm has been reduced by 10%, and crop yields have increased by 10%, compared with traditional production.[19]

Key takeaways

- The collection and updating of soil data on farmland is the basis for precise fertilization, so regular soil nutrient testing and analysis and data updating are needed to select fertilizers with the right nutrients.
- As a technology- and knowledge-intensive industry, smart agriculture requires the participation of farmers who master modern agricultural production skills and operate modern agricultural equipment, so it is crucial to provide technical training to farmers and attract young farmers to join the industry.
- Given the high cost of intelligent monitoring and remote sensing equipment and China's smallholder farming-dominated agriculture, the promotion of industrialized management in agriculture can help reduce per-unit costs.

12. National Statistical Yearbook.
13. Farmer's Daily. (2016). Building a New Situation of Reduction and Writing a New Chapter of Efficiency http://www.sinofert.com/s/4368-12223-56364.html
14. Yicai.(2016). Chinese Farmers Experience Precision Agriculture, Completing Smart Fertilization on Mobile Phones. https://www.yicai.com/news/5003423.html
15. Farmer's Daily. (2016). Soil Testing and Fertilization, One-Click Ordering, Precision Fertilization with Mobile Operation. http://www.sinochem.com.cn/s/1375-5662-19811.html
16. Senning. (2022). Three Post-90s Individuals Manage 5,000 Acres of Farmland in Jiangsu: Cultivating, Managing, and Harvesting with Smart Agriculture Systems. The Paper. https://m.thepaper.cn/newsDetail_forward_19944206
17. Zhang Ye, Wu Ting. (2022). "Flying" Agricultural Activities with Drones — Digital Technology Makes Agriculture Smarter. Science and Technology Daily. (2022). http://www.news.cn/fortune/2022-09/21/c_1129018878.htm
18. Same as above.
19. XAG. (2023). XAG Corporate Social Responsibility Report 2022. https://www.xa.com/about/csr

Case 2: Turning Barren Land into Fertile Soil — Promoting Conservation Tillage

In enhancing agriculture's resilience to climate change, restoring soil fertility and improving soil health can reduce the use of pesticides and fertilizers while increasing the carbon sequestration capacity of soil. Globally, a systematic agricultural production management model based on sustainable land use, with the main goal of realizing regenerative agriculture is beginning to be promoted.

Although China has not explicitly applied the concept of regenerative agriculture to manage agricultural production, some existing agricultural practices are in line with its principles. Taking the adoption of conservation tillage, a key technique in regenerative agriculture featuring no-tillage, less tillage and the use of straw cover, as an example, China has been experimenting with no-tillage in wheat cultivation in Heilongjiang Province since the 1960s. In 2005, the "No. 1 Document" elevated the development of conservation tillage to a national policy.[20]

Problem

Northeast China's black soil is one of the most fertile soil types in the world, and it accounts for a quarter of China's grain production, which is critical to national food security. However, since its cultivation began, the black soil layer has decreased from 50 centimeters to 30 centimeters, and organic matter content has declined by one-third, with a 20% reduction in productivity.[21]

Approach

In 2007, the Chinese Academy of Sciences, in collaboration with the Agricultural Technology Extension Center of Lishu County and the Soil and Fertilizer Workstation of Jilin Province, established the "Chinese Academy of Sciences Conservation Tillage Research and Development Base." Local pilot projects conducted between 2007 and 2018 revealed significant improvements, with soil organic matter increasing from 22.5g/kg to 24g/kg. The practice of straw returning to the field not only enhanced the accumulation and activity of nutrients like nitrogen, phosphorus, and potassium in the plow layer but also increased the soil's nutrient supply capacity. Moreover, there were improvements in soil structure, enhanced soil biodiversity, and increased resistance to drought.[22] Beyond emission reduction and environmental benefits, conservation can also improve yields and incomes. In 2017, the experimental base in Lishu achieved an increase in yield of approximately 1000 kg/ha. Conservation tillage also raised nitrogen fertilizer utilization by 4.7%, and reduced fertilizer use, the number of times farm machinery entered the field, fuel consumption, and labor costs, saving an average cost saving of 1650 yuan ($226) per hectare.[23]

Problem

In the Huang-Huai-Hai Plain, China's main grain-producing area, despite the winter wheat yield in this region having increased from around 2.6 tons per hectare to 5.7 tons per hectare, over the past 40 years the intensive cultivation of winter wheat-summer maize has brought a decline in land quality and water scarcity.

Approach

In May 2020, the "Run Tian" project was jointly initiated by the Agricultural Mechanization Institute of the Ministry of Agriculture and Rural Affairs, Syngenta China, China Agricultural University, and The Nature Conservancy. The project conducted trials and demonstrations of conservation tillage techniques for winter wheat in the Huang-Huai-Hai region. The key technical points of conservation tillage involve completing sowing, fertilization, and compaction operations in one go under

20. Ao Man, Zhang Xudong, Guan Yixin. (2021). Research and Practice of Conservation Tillage Technology in Northeast Black Soil. Bulletin of the Chinese Academy of Sciences, 36(10), 1203-1215.

21. Chongqing Morning Post. (2022). Experts Say Productivity of Northeast Black Soil Decreased by 20%. The Black Soil Becomes Thinner, Leaner, and Harder. http://henan.china.com.cn/m/2022-06/16/content_42004701.html

22. Ao Man, Zhang Xudong, Guan Yixin. (2021). Research and Practice of Conservation Tillage Technology in Northeast Black Soil. Bulletin of the Chinese Academy of Sciences, 36(10), 1203-1215.

23. Ibid.

FIGURE 2. TNC staff and local farmers on a fieldtrip observing demonstrations of conservation tillage techniques for winter wheat in the Huang-Huai-Hai region

Photo credit: TNC

the straw cover of crop residues. Compared with traditional cultivation methods, this method saves the number of agricultural machinery operations and reduces farmers' costs and time for planting grain.[24]

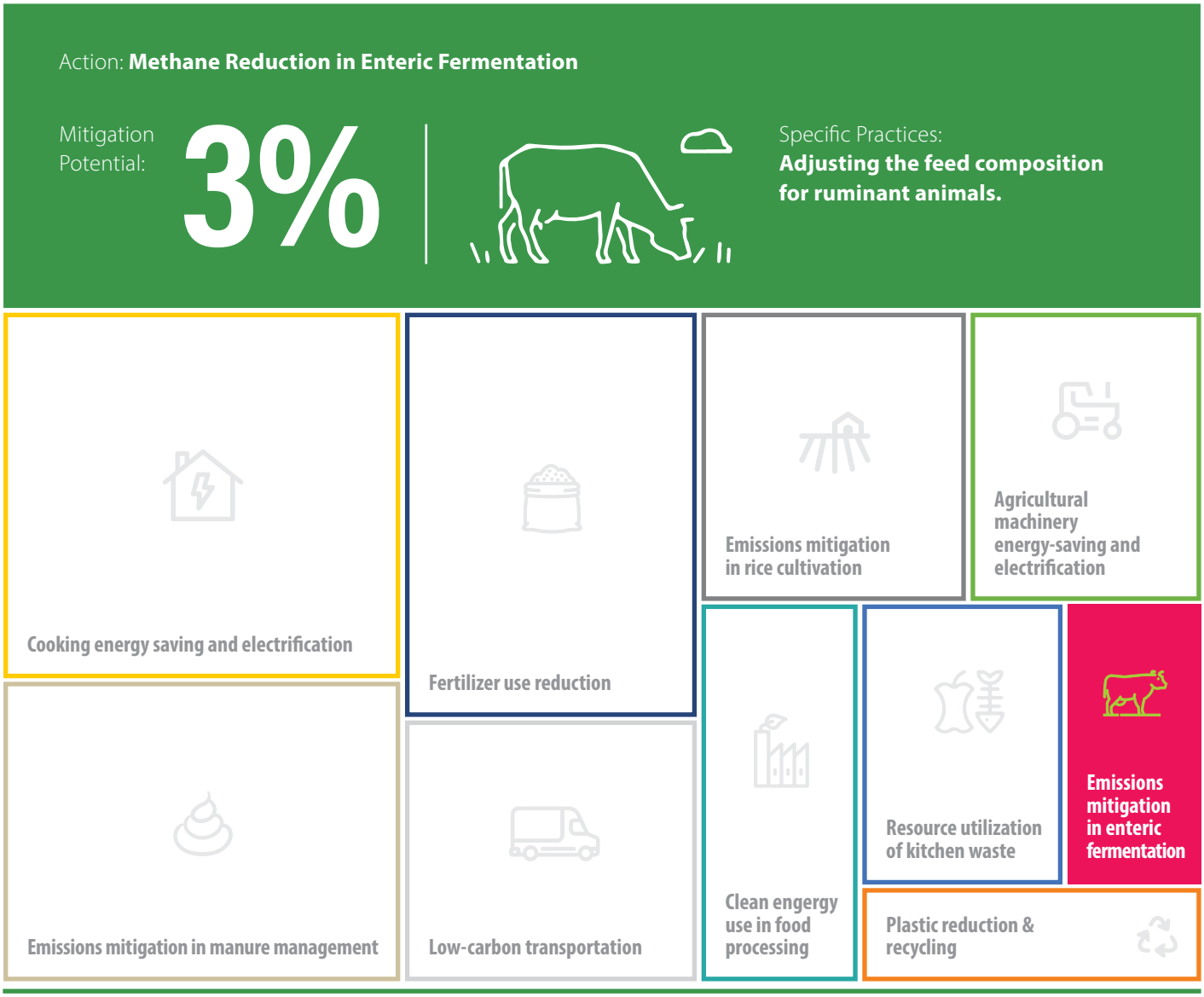
Through the promotion of conservation tillage, both water and nutrient use efficiency have been improved in the wheat-maize zone of this region. Data from the 2020 to 2022 trials indicate that conservation tillage can improve soil fertility compared to local conventional tillage.[25] In the 0-40 cm soil layer, the total nitrogen and phosphorus content increased by approximately 13% and 10%, respectively, and soil organic carbon content increased by about 7%. It also increased soil water storage by about 7%. The demonstration project also showed that conservation tillage yielded the same or slightly higher wheat yields than conventional tillage, resulting in lower production costs and higher net benefits for farmers. Reducing the frequency of agricultural machinery operations can simultaneously reduce fossil fuel usage by around 58% and greenhouse gas emissions by 60%.

Key takeaways

- The joint participation of governments, research institutions and enterprises can support the demonstration and promotion of conservation tillage from different dimensions.
- Conservation tillage requires the combination of agricultural machinery and technology, including variety selection, planting density, fertilization plans, plant protection plans, harvest methods, etc. It especially requires interdisciplinary experts to provide locally adapted solutions.
- Capacity building for farmers to change their traditional concepts of intensive farming; information sharing on the concepts, practices and effects of regenerative agriculture can facilitate farmers' participation.
- Implementing conservation tillage practices requires a high level of machinery and equipment, and accelerated research and development of specialized equipment can facilitate greater dissemination of the practice.

24. Traditional winter wheat cultivation in the Huang-Huai-Hai region involves three to five agricultural operations, including crushing straw, rotary tillage with straw incorporation, fertilization, seedbed preparation, sowing, and post-sowing compaction.

25. Experimental data were collected from small-scale control fields (<5 mu) in Gao County and Ren County of Hebei Province, Linying County of Henan Province, and Funan County of Anhui Province. The experimental design, data collection, and analysis were conducted by China Agricultural University.



Case 3: Culinary Arts for Ruminants – Reducing Livestock Enteric Fermentation

Problems

Ruminants such as beef cattle, dairy cows, and goats can emit large amounts of methane through belching. In 2020, global methane emissions from ruminant animals reached 2.8 billion tons of CO_2e, accounting for 17.5% of global agri-food system GHG emissions in that year.[26]

Approach

Cultivating salt-tolerant crops, such as sweet sorghum, on saline-alkali land, and mixing it with corn to produce silage for livestock farming improves land utilization and alleviates the shortage of forage, while also increasing forage uptake and reducing methane

26. FAO. (2022). Greenhouse gas emissions from agrifood systems: Global, regional and country trends, 2000–2020. Food and Argriculture Organization. https://www.fao.org/3/cc2672en/cc2672en.pdf

emissions. This planting and feeding method is being tested and promoted on 5000 acres of saline-alkali land in northern Jiangsu Province. With the increasing demand for meat and dairy consumption, some large dairy production enterprises have set up large farms along the Jiangsu coast. Since the local saline-alkali land has low corn yield, livestock enterprises used to face a shortage of local forage. Now, by mixing sweet sorghum and corn silage, which are suitable for different salinity levels on the local coastal saline-alkali land, the silage is processed after mixed harvesting, and is then sent to the farms, where necessary nutritional supplements are added to make it into the dairy cow's diet. The processed silage is highly digestible and improves milk quality.[27] Data shows that the mixed planting model of sweet sorghum and silage corn generates around 3000 yuan per acre, increasing overall efficiency by 24%. This mixed diet led dairy cow milk yield to increase by 11%, with methane decreasing.[28]

FIGURE 3. Farmers in Chifeng City, Inner Mongolia producing silage

Photo credit: Yao Zhe

Methane abatement is a synergistic effect of saline sorghum cultivation - a practice that has a methane abatement effect while improving the utilization of saline-alkali land and forage quality. However, it is important to note that there are challenges to utilizing sweet sorghum as a forage, such as the lower starch content compared to corn, as well as the impact of high tannin and dry matter content on feeding, which remains to be explored.[29]

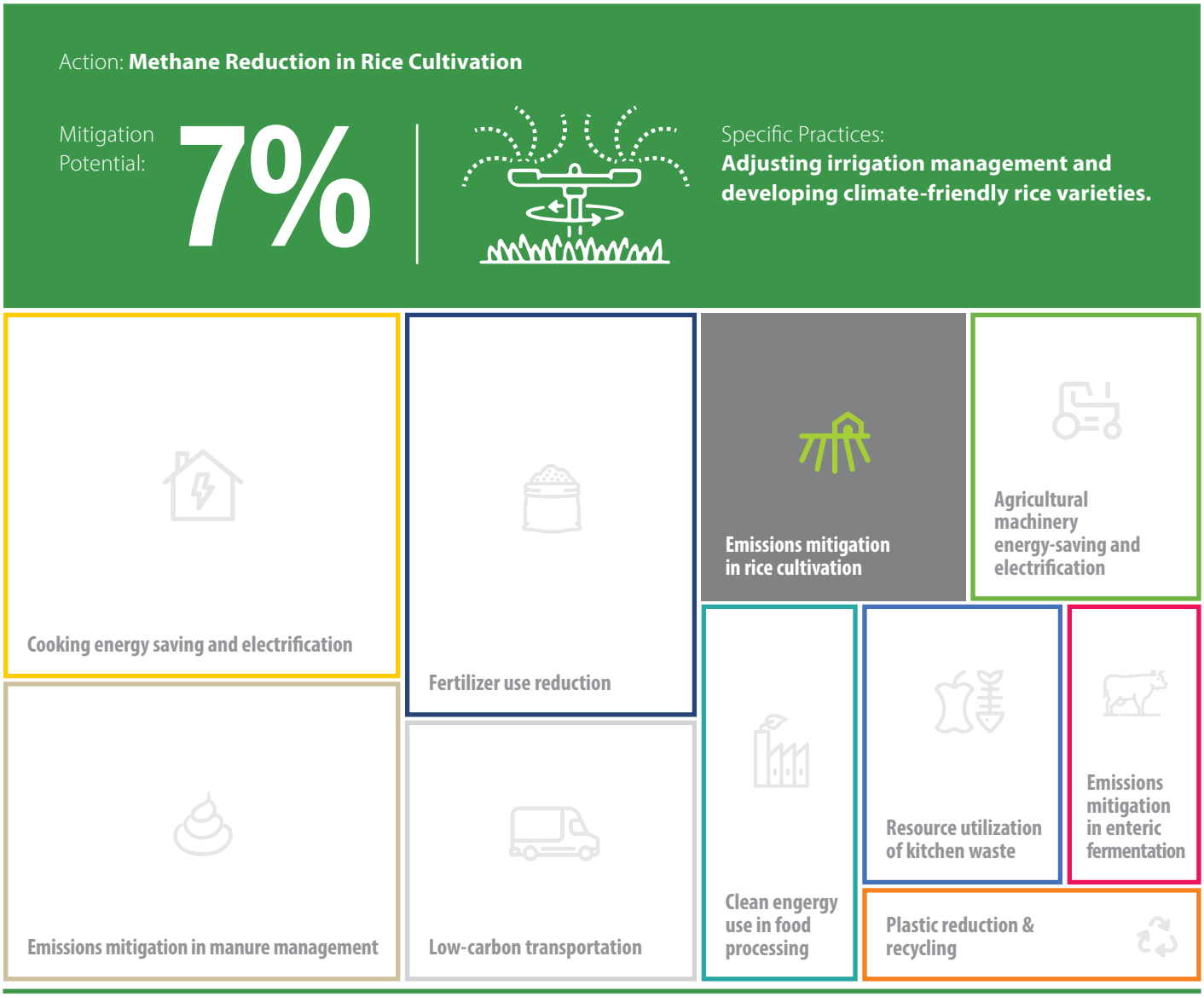
Key takeaways

- Consider similar planting methods based on local geographical conditions and the scale of livestock farming. In areas with abundant saline-alkali land and a sizable scale of livestock farming, planting sweet sorghum, which is adapted to drought conditions, and making silage to replace maize silage and supplying it to local livestock farms, can generate both environmental and economic benefits.

27. Zhang Ye. (2022). Sweet Sorghum Mixed with Silage Corn: Growing High-Quality Silage Feed on Saline-Alkali Land. Liberation Daily. http://digitalpaper.stdaily.com/http_www.kjrb.com/kjrb/html/2022-12/12/content_545946.htm?div=-1

28. The same as above.

29. Institute of Genetics and Developmental Biology, Chinese Academy of Sciences. (2019). Sweet Sorghum Plus Ruminants: A New Model for Modern Efficient and Sustainable Agriculture. http://www.genetics.cas.cn/dzqk/2019/04/01/kyjz/201904/t20190418_5277308.html



Case 4: Climate-Friendly Rice Cultivation

Problems

Rice, one of China's main staple crops, is widely cultivated in different regions. During rice cultivation, methane emissions from the decomposition of organic matter in flooded rice fields is one of the major sources of agricultural GHGs in China.

Approach

Selecting suitable rice varieties for direct dry seeding involves planting directly on well-prepared land and adopting regular irrigation. This method can reduce methane emissions from flooded soil conditions and the amount of water needed to grow rice by reducing the area and duration of flooding of rice paddies. It also eliminates the need for labor-intensive activities in seedling raising and transplanting.

FIGURE 4. Rice field with raised beds in Zhangzi Village, Tashui Town, Jianyang, Sichuan

Photo credit: iGDP

In the mountainous regions of Yunnan, where drought frequency and severity are increasing due to climate change, a local team dedicated to monitoring agricultural climate change has experimented with direct dry seeding of rice, exploring climate-friendly rice cultivation methods adapted to drought conditions. In cooperation with local agricultural technology extension centers and farmers, they selected high-yield, low-emission rice varieties for testing direct dry seeding.

In some villages in the mountainous regions of Yunnan and Sichuan Provinces, a local approach to rice cultivation involves creating raised beds by digging trenches in well-leveled fields. Rice is then planted on top of these raised beds (known as ridges), and irrigation is conducted in the lower areas between the ridges (known as furrows). This method significantly reduces the contact time between rice fields and water, thereby decreasing methane emissions.[30] In a village in Jianyang, Sichuan, farmers are adopting a combination of no-till and ridge-furrow planting for rice cultivation. They minimize soil disturbance with no-tillage, reduce the duration of flooding with furrowing, use rapeseed cake as fertilizer instead of chemical fertilizers, and employ local rapeseed husks as mulch to increase temperature and moisture. With most of the farmers interviewed for ths case study growing rice for their own consumption, the scale of rice cultivation is around 1-2 acres.

Xitang, a county in Zhejiang Province, has a Low-Carbon Smart Farm Demonstration Project which uses a low-carbon rice cultivation technique developed by the China Rice Research Institute and Aliyun. The project covers an area of about 400 acres, employing various IoT sensors, high-precision positioning, and unmanned operations to manage the farmland. This includes precise irrigation and drainage for each rice field. The system automatically adjusts the water inflow and outflow based on the rice growth stage and sets corresponding water level standards. After adopting the new technological solution, the average water consumption of the farmland has been reduced from around 400 cubic meters to 230 cubic meters, and methane emission has been reduced.[31]

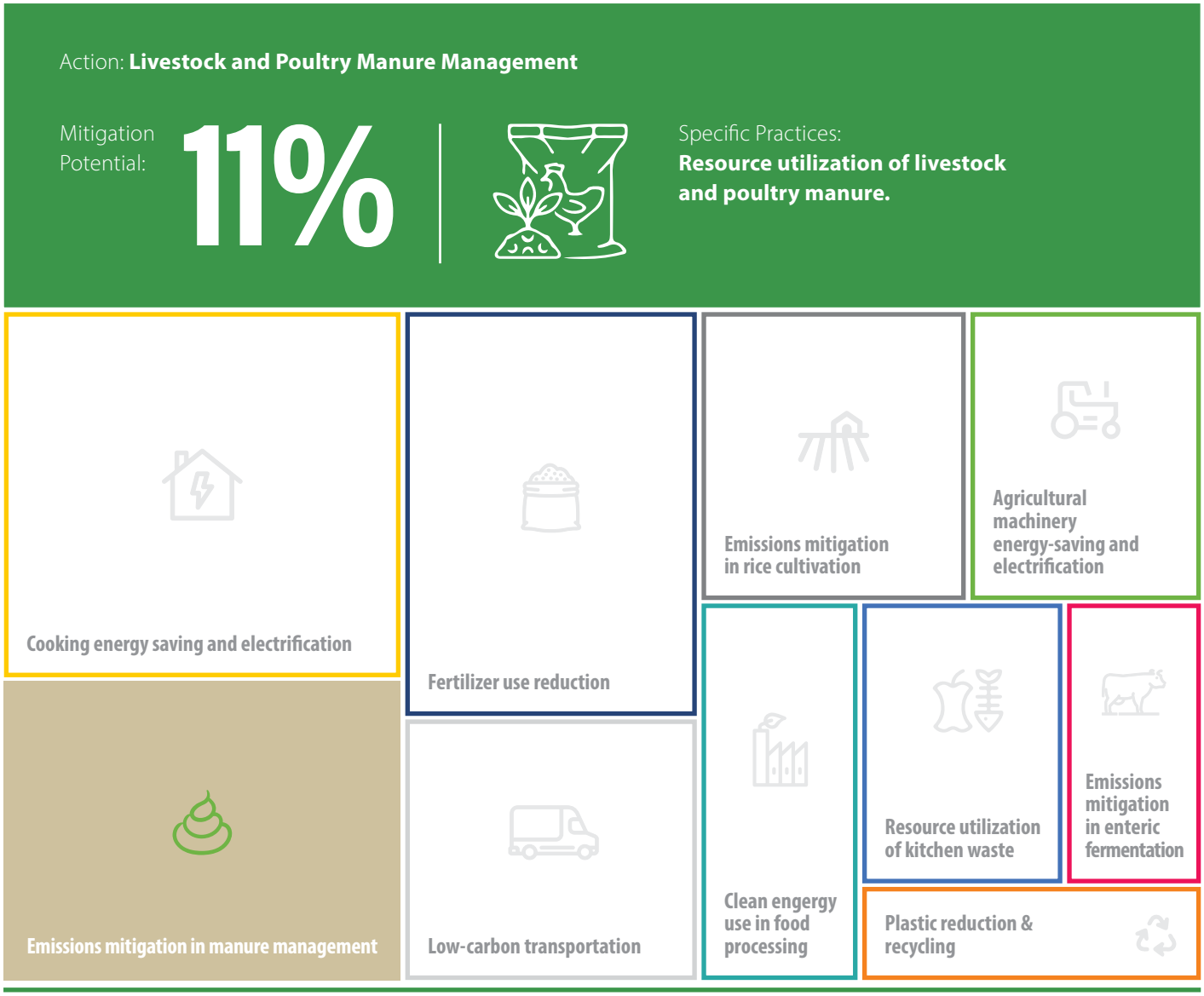
Key takeaways

- Farmer acceptance and adoption of climate-friendly rice field cultivation practices is key. The promotion of such practices needs to take into account and address farmers' actual needs, including the impact on crop yield, labor inputs, pest and disease control, and the overall cost-benefit balance. On this basis, developing capacity building programs for interested farmers based on these considerations can encourage broader participation.

- Moderate-scale land consolidation will facilitate the expansion of smart farming. Implementing these technologies on "large fields" formed through land transfer will reduce unit costs and is more likely to generate economies of scale.

30. Xia Zhijian. (2023). Methane Reduction in Rice Fields: Changes in Chinese Rice Cultivation. China Dialogue. https://chinadialogue.net/zh/5/96736/

31. Zhu Mei (2022). Demonstration in a 400-Mu Farmland in Jiashan Proves — Smart Rice Fields Can Reduce Carbon Emissions by 20%. Zhejiang Daily. https://zjnews.zjol.com.cn/zjnews/202209/t20220922_24832448.shtml



Case 5: Manure Matters – Livestock and Poultry Manure as a Resource

Problems

With the growth in demand for animal protein due to the improvement of living standards, the utilization of waste from livestock and poultry farming has faced challenges. The outdated technology and equipment for managing manure in traditional models lead to excessive waste production on farms. This results in a large amount of agricultural waste and contributes to environmental pollution.

Approach

In Jiangxi Province, a local enterprise called Zhenghe Enviromental Protection Group has pioneered the "N2N" ecological circular agriculture model. This model focuses on an agricultural waste harmless treatment center and an organic fertilizer

production center. It involves the comprehensive collection and processing of manure from N upstream livestock farms, generates biogas for power generation on the production end, provides biogas for domestic use on the living end, and supplies organic fertilizer to N downstream planting fields. This innovative approach constructs a green circular industry chain, contributing to the government's efforts to address a comprehensive set of agricultural non-point source pollution issues.

FIGURE 5. Organic fertilzer in the ecological agriculture park in Nanchang, Jiangxi

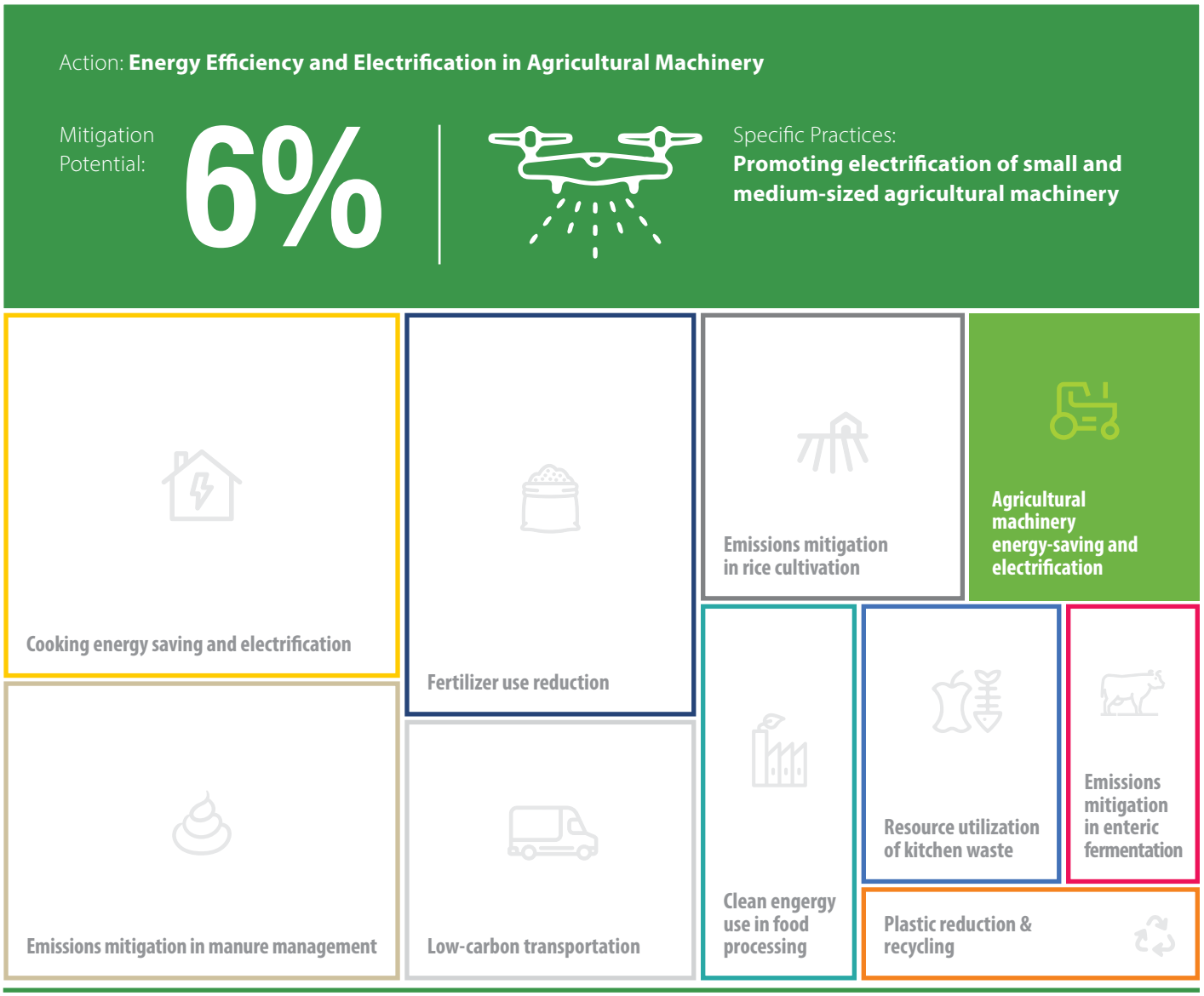
Photo credit: iGDP

Zhenghe Group has implemented ecological transformation in 229 large-scale farms in Nanchang City, Jiangxi Province. They have coordinated the treatment of human and livestock manure, involving waste from rural and public toilets. The entirety of human and livestock manure is collected and transported in sealed vehicles to the processing center for anaerobic fermentation. This process generates biogas used for on-site electricity, and the resulting slurry and residue are used to produce commercial organic fertilizer for sale. The park processes 300,000 tons of manure annually, producing 5 million cubic meters of biogas, generating 10 million kilowatt-hours of electricity, and producing 20,000 tons of organic fertilizer and 1,000 tons of soil conditioner. The annual biogas production can replace 7,400 tons of standard coal, reducing carbon dioxide emissions by 18,000 tons. The use of biogas fertilizer is equivalent to reducing the application of chemical fertilizer by 10,000 tons.[32] Zhenghe Group operates more than ten projects in Jiangxi Province under the N2N model. In accordance with local conditions, they use biogas slurry to help restore abandoned tailings areas by planting pennisetum. This plant serves as both fodder and a raw material for biogas production, contributing to the gradual recovery of the soil ecosystem over time.

Key takeaways

- The comprehensive promotion of the utilization of livestock and poultry manure resources at the county level involves numerous processes and stakeholders, requiring government integration of resources and policy support.
- Tailor strategies to the specific industrial layout characteristics of different counties, emphasizing resource conservation, tiered utilization, and collaborative processing of agricultural and household waste to enhance facility and equipment utilization rates and resource efficiency.
- Shift investment patterns towards asset-light investments to alleviate financial pressures on enterprises, thereby increasing the likelihood of widespread adoption.
- Facilitate close collaboration between upstream and downstream livestock and poultry farming and cultivation enterprises within the county, ensuring a stable supply of manure and efficient utilization of organic fertilizers.

32. Data and information are provided by interviewees.



Case 6: A Preliminary Exploration of Agricultural Machinery Electrification

Problems

The dispersed nature of arable land and the abundance of hilly and mountainous areas in China pose challenges to the mechanization and electrification of agriculture. As green and low-carbon development and rural modernization advance in the country, the exploration of challenges in promoting the electrification of agricultural machinery will continue.

Approach

Electronic crop protection drones are steadily finding applications and seeing expanded use in Chinese agriculture.[33] These drones, controlled from the ground or through navigation flight control, perform tasks such as seed pollination and

33. Zhang Xiying & Hu Rui. (2018). An Overview of the Development of Agricultural Drone Technology in China with Reference to the Experiences of the United States and Japan. Practice in Foreign Economic Relations and Trade, 2: 26-29.

the application of pesticide and fertilizer. They can also make use of specialized equipment to monitor crop health, pest infestations, and growth.[34]

Crop protection drone operators in Baoqing County, Heilongjiang employ privately purchased electronic crop protection drones to offer pesticide spraying services to local farmers. The service is priced at 6-8 yuan per mu (a Chinese measurement unit for area). Since electronic drones have a limited flight time, operators also bring along generators for battery recharging.[35] However, many of these generators run on diesel, which can contribute to environmental pollution. To address this issue, State Grid Jiangsu Electric Power has developed an unmanned aerial vehicle (UAV) charging station that is now offering recharging services for crop protection drones used in rice field operations in Lianyungang, Jiangsu. The cost of using this charging station is less than 0.1 yuan per mu, in stark contrast to the 0.3 yuan per mu cost of diesel generators.[36] The charging station is a mobile energy storage pod, comprising 56 battery packs with a total capacity of 56.3 kilowatt-hours, equivalent to the capacity of 2,253 smartphone batteries. It has four ports, which can simultaneously meet the outdoor charging needs of four crop protection drones and other agricultural electric machinery.[37]

Electronic crop protection drones are not cheap, typically costing between 50,000 to 100,000 yuan. As a result, drone manufacturers have partnered with agricultural input dealers and cooperatives to facilitate crop protection services. Drone manufacturers supply the drones, handle maintenance, and train professional crop protection drone operators. Agricultural service providers carry out crop protection operations, and pesticide distributors provide the necessary chemicals and technical guidance.[38] Farmers can also access these services by booking crop protection drone services through various platforms.[39]

Electric Tractors:

In 2020, the National Agricultural Machinery Equipment Innovation Center unveiled China's first hydrogen-fuel-cell-powered unmanned electric tractor.[40] In 2021, a tractor manufacturer within the Jiangsu Yueda Group introduced two electric tractors, the YL254ET, designed for light-duty work in greenhouses and orchards, and the YU1004, a paddy field tractor specialized for plowing, seeding, and field management in wet fields. Both electric tractors have now entered small-scale production and are in practical use.[41] Another enterprise actively involved in electric tractor development is Zhulong Machinery Manufacturing Co., Ltd., located in Jiuquan, Gansu Province. The company has developed a series of electric machines, including electric

FIGURE 6. An electric crop protection drone flying over a fruit plantation

Photo credit: DJI-Agras on Pixabay

34. Ibid.

35. ThePaper News. (2021). Northeast China's Heilongjiang Province: The New Generation of Farmers Operating the XAG Agricultural Drones. https://m.thepaper.cn/newsDetail_forward_14512712

36. China Jiangsu Network. (2022). State Grid Jiangsu Electric Power: Innovative Electric Power Technologies Support Agricultural and Rural Economic Development. http://jsnews.jschina.com.cn/nj/mqzc/202209/t20220902_3068275.shtml

37. Xia Yan & Ding Taohong. (2022). Mobile "Power Bank" for Agricultural Drones in the Fields. WoSu Network. http://www.ourjiangsu.com/a/20220810/1660114848228.shtml

38. Duan Qianqian. (2019). With Only 5% Market Penetration, DJI and XAG Take Different Paths to Explore the Blue Ocean of Agricultural UAVs. Caijing.com. https://www.yicai.com/news/100172200.html

39. Zhang Xi. (2016). Farmers in Jiangsu Can Now Book Drone Pesticide Spraying Services via Alipay. Southern Daily News. https://www.csjcs.com/news/show/346/1080114_0.html

40. Henan Daily. (2020). 5G + Hydrogen Fuel Cell Electric Tractors Debut in Henan. http://iot.china.com.cn/content/2020-06/18/content_41190201.html

41. 35 Dou. (2022). National Team Introduces Hybrid Tractors, Advancing Chinese Tractors into the Electric Era. https://m.jiemian.com/article/7840604.html

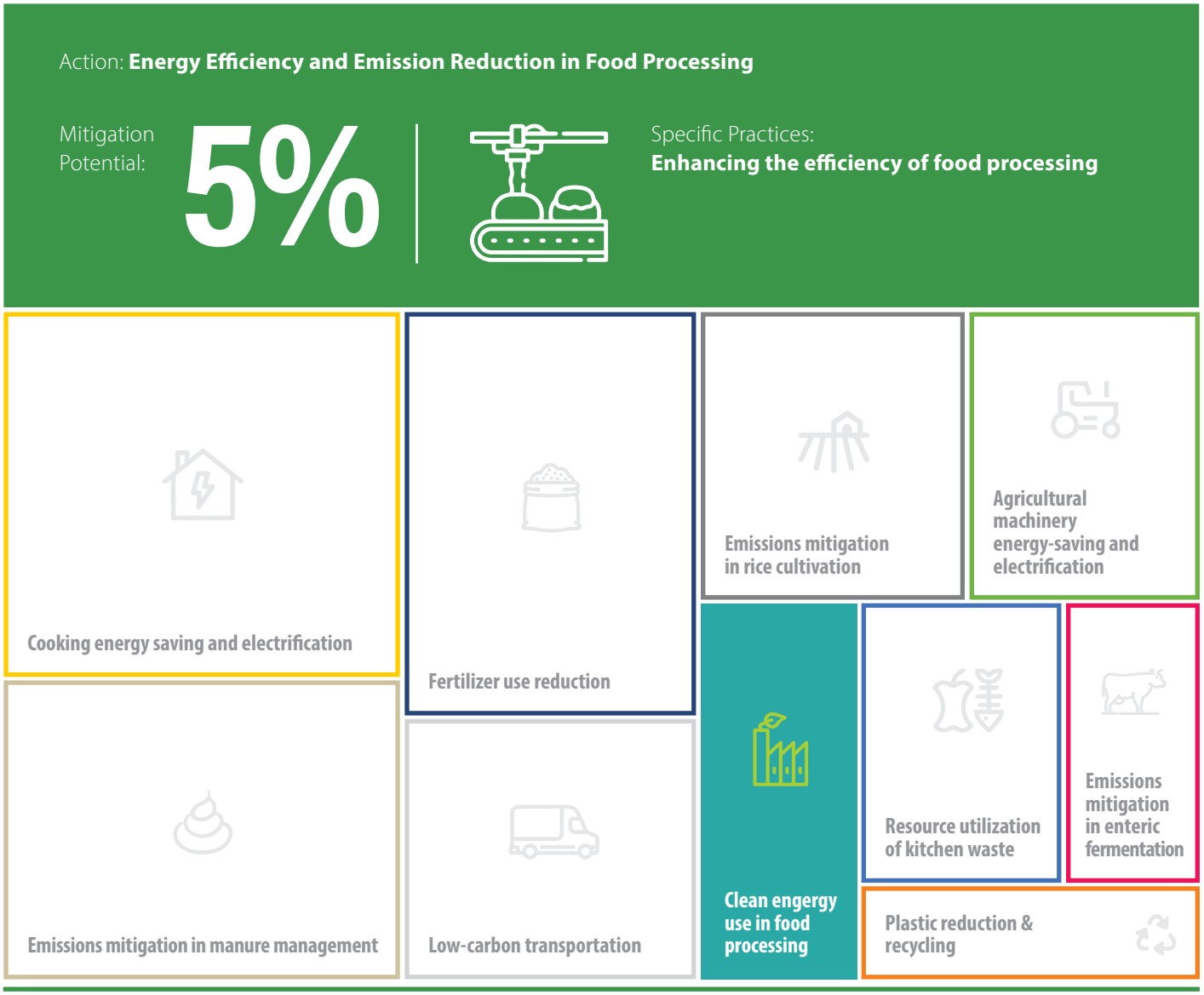
wheat seeders, electric weeders, and electric fertilizer applicators, to meet the needs of the hilly and mountainous terrain in Gansu. They have also established trial and demonstration sites in Gansu.[42] The company's electric handheld soybean-corn integrated seeder, developed and produced in 2022, has also been well-received in the market.[43]

Key takeaways

- Given the limits to the operational range of large electric agricultural machinery imposed by charging infrastructure and technological constraints, as well as China's unique challenges of land scarcity, high population density, and an aging rural population, small and medium-sized electric agricultural machinery is poised for widespread adoption in the future.
- The high price tag of electric agricultural machinery is a barrier to its adoption. Subsidizing the purchase or operation of electric farming machinery can help to promote its use.
- Achieving a moderate level of land consolidation can help reduce the per-unit cost of promoting and using electric agricultural machinery.

42. China Agricultural Machinery Information Network. (2022). Analysis of the Technological Advantages of Electric Agricultural Machinery and Future Recommendations. http://www.amic.agri.cn/secondLevelPage/info/31/147178

43. Ibid.



Case 7: Energy Efficiency Improvement and Energy Substitution in Food Processing and Manufacturing

Problems

The energy consumption of food processing is a major source of greenhouse gas emissions in the food system. For example, drying and shelling grains, freezing meat, pasteurizing dairy products, and refining animal and vegetable oils all require energy, and these processes are essential for many of the foods we eat.

Approach

Companies in the food processing and manufacturing sector are exploring various methods to reduce energy consumption and enhance the efficiency of resource utilization. Yihai Kerry (Kunming) Food Industry Co., Ltd., based in Kunming, is involved in flour processing, which consumes substantial quantities of energy during wheat cleaning and milling. In 2019, the company began building a green factory in accordance with the National Green Factory Assessment System. To reduce its reliance on traditional energy sources, the company installed distributed photovoltaic panels on the roof, taking advantage of Kunming's

favorable sunlight conditions. The rooftop photovoltaic panels are projected to generate 980,000 kilowatt-hours of electricity annually. The factory is planning to build a second phase of the project in 2023 with a capacity of 2 megawatts, which is expected to generate an additional 4.07 million kilowatt-hours of electricity once completed.[44] In addition to solar photovoltaic power generation, the factory also procures a significant share of its electricity from green sources and uses new technologies and equipment, such as microwave lighting, to conserve energy and reduce carbon emissions. As a consequence, the facility has successfully earned recognition as a National Green Factory.[45]

FIGURE 7. Yihai Kerry Kunming factory buildings with roof-top solar panels

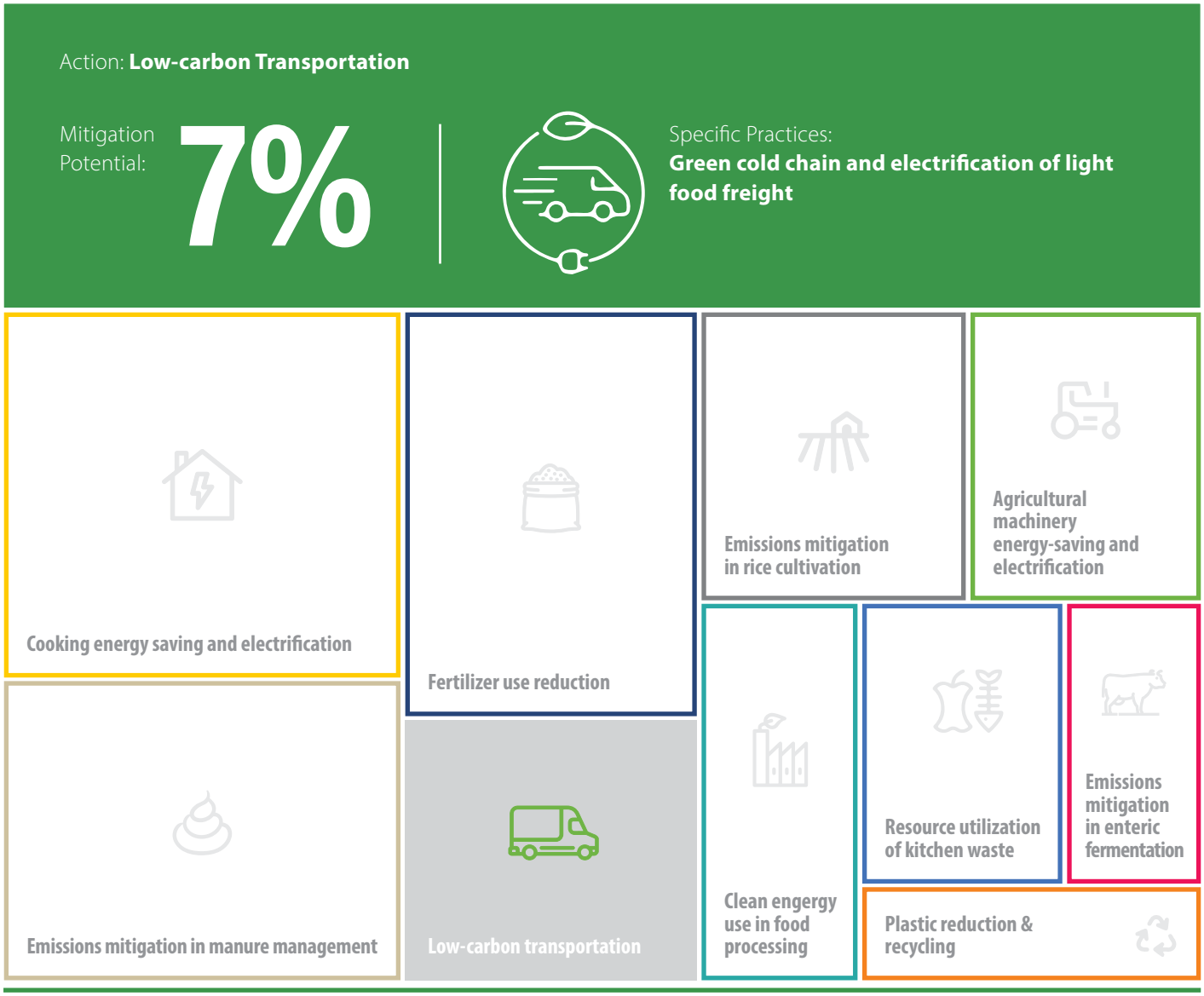
Photo credit: Yihai Kerry news center

Hubei Danone Food and Beverage Co., Ltd., the producer of the "Mizone" Vitamin drink brand, has implemented several initiatives to enhance energy efficiency and reduce emissions. The company has transitioned from using natural gas boilers to generate steam to harnessing waste heat steam, investing more than 2 million yuan in refurbishing the steam pipeline to utilize waste heat from the Hanchuan Power Plant. This transition is anticipated to reduce carbon emissions by about 7,000 tons in 2021. The company has also installed a 4.1-megawatt photovoltaic system on the roof of its main factory building for electricity generation and signed a waterpower renewable energy supply contract with a local hydropower development company. This is expected to reduce carbon emissions by 13,000 tons per year.[46] In addition, the company has implemented heat recovery and other eco-friendly projects during factory operation.[47] These measures helped Hubei Danone Factory to be designated a National Green Factory in 2019.[48]

Key takeaways

- Policy support will play a significant role in driving energy efficiency and emissions reduction efforts in the food processing and manufacturing industry. Initiatives such as green factory certifications, with their corresponding guidelines, economic incentives, and other policy benefits, can encourage companies to adopt sustainable practices and enhance their brand image.
- Enhancing energy efficiency in the production and processing stages can simultaneously reduce energy consumption and operational costs for businesses.

44. YiHai Kerry Group. (2023). The "Zeroing" Code for Carbon Neutrality Factories | Understanding ESG Reports through 6 Stories①. https://yihaikerry.com.cn/new/1406.html
45. Ibid.
46. Wuhan Ecological and Environmental Bureau. (2022). Compilation of Low-Carbon Pilot Cases in Wuhan. http://hbj.wuhan.gov.cn/hjsj/ztzl/dtshalhb/index.shtml#book7/page36-page37
47. Ibid.
48. Wuhan Channel. (2022). Green Manufacturing·Gold and Silver Mountains①: How Manufacturing Factories Achieve Carbon Neutrality. They Did It. http://news.cjn.cn/bsy/dz_20097/202210/t4316867.htm



Case 8: Solving the First Mile – Mobile Cold Storage in the Field

Problems

The development of cold chain transportation for agricultural products can reduce losses and waste of freshly harvested produce that is not preserved in a timely manner. Research shows that, between 2014 and 2018, China saw approximately 350 million tons of food lost and wasted each year, accounting for 27% of total annual food production. Nearly half (45%) of this food loss and waste occurred during the harvesting and storage stages, which is significantly higher than the percentages in developed countries such as the United Kingdom (4.8%) and Japan (10.5%).[49] Therefore, building cold chain infrastructure for the first mile of agricultural product production is essential.

49. Xue, L., Liu, X., Lu, S., Cheng, G., Hu, Y., Liu, J., Dou, Z., Cheng, S., & Liu, G. (2021). China's food loss and waste embodies increasing environmental impacts. Nature Food, 2(7), 519-528.

Approach

Field Cold Storage:

In 2021, Haimen, a district in Nantong City, Jiangsu Province, was designated as part of a county-wide pilot project for the cold storage and preservation of agricultural products. Following its selection, Haimen successively established 20 field cold storage units. As an illustration, Puming Village in Haimen used local investment to construct a cold storage facility with a capacity of 4,600 cubic meters for fruits and vegetables. This facility enables the early harvest and storage of locally grown produce, reducing post-harvest spoilage and preserving fruits and vegetables through refrigeration. The village collective also generates rental income from the use of these cold storage facilities.[50]

FIGURE 8. Mobile cold storage facilities for asparagus

Photo credit: Luo Jiabao from Jiangsu Now

Mobile Cold Storage:

In Lianshui County, Jiangsu Province, which contributes 30% of the country's total asparagus production, the need for maintaining high asparagus freshness is paramount. To counteract post-harvest aging, which is exacerbated by high temperatures, the State Grid Lianshui County Power Supply Company has collaborated with agricultural and rural departments to set up four small mobile cold storage units. These units can be conveniently transported to the fields for the immediate preservation of freshly harvested asparagus.[51] Asparagus, harvested in under 10 minutes, is swiftly placed into the mobile cold storage units, reducing field losses by 20% to 30% and prolonging the freshness period by approximately 3 days.[52] Each mobile cold storage unit covers an area of around 10 square meters and is mounted on all-electric flatbed vehicles powered by a UPS power system. These units receive daily charging via a 200-volt power source for both the vehicles and their batteries.[53]

Key takeaways

- Policy support is crucial for the development of field cold storage. This includes both guiding documents for agricultural cold chain construction and financial support for county-wide initiatives focused on cold storage and preservation in agricultural product storage and logistics facilities.
- Local collaboration between various departments is also beneficial for the development of mobile cold storage. For example, the local power supply company and agricultural and rural departments in Lianshui County, Jiangsu, collaborated to support asparagus preservation efforts by constructing mobile cold storage units.

50. Zhang Zhounan, Xu Chao. (2023). Building "Refrigerators" in the Fields, Doubling the Value of Vegetables. Xinhua Daily. http://www.zgjssw.gov.cn/shixianchuanzhen/nantong/202302/t20230227_7843591.shtml

51. Sun Xin, Jiang Qihui. (2022). Contribution Rate of Agricultural Scientific and Technological Progress Reaches 70.9% in Jiangsu Province. Jiangsu News Network. https://www.js.chinanews.com.cn/news/2022/0830/212317.html

52. Jingchu Net. (2022). "Refrigerators" in the Fields! Asparagus Comes to Market Fresh Despite High Temperatures. http://news.cnhubei.com/content/2022-08/23/content_15000843.html

53. Yangzi Evening News. (2022). Huai'an, Jiangsu: Mobile Cold Storage Arrives in the Fields to Keep Asparagus Fresh. https://rmh.pdnews.cn/Pc/ArtInfoApi/article?id=30629111

Case 9: Carbon Reduction in Food Transportation – Electrification of Light Freight Transport

Problems

As economies grow and living standards improve, the transportation of food over long distances between regions increases, leading to a rise in greenhouse gas emissions. Globally, food miles, or the transportation of food from production sites to consumption areas, contribute nearly 20% of total agricultural and food-systems emissions, totaling approximately 3 billion tons of CO_2e.[54] To mitigate emissions from food transportation, a variety of entities, ranging from large food companies to logistics firms to food delivery services, are exploring solutions.

Approach

Electrification of Logistics:

Nestlé, a multinational food supplier, has laid out its Net-Zero Roadmap, which sets forth ambitious emissions reduction targets. By 2025, they aim to reduce emissions by 20% compared to their 2018 levels. By 2030, the goal is a 50% reduction and, by 2050, they aim to achieve a 100% reduction. To achieve these targets, one crucial strategy involves the adoption of new energy vehicles within their logistics and supply chain operations. This includes promoting more efficient transportation methods, optimizing vehicle loading, introducing biogas-powered trucks, and increasing the use of railway transport.[55] Nestlé has already begun deploying new energy vehicles in cities of all sizes. These vehicles are mostly replacing conventional ones for transportation distances within 150 kilometers, as heavy-duty truck battery range is currently limited.[56]

FIGURE 9. Shared battery sawpping station for two-wheel electric vehicles in Beijing

Photo credit: iGDP

Prominent logistics companies, including SF Express, Cainiao, and JD Logistics, are embracing new energy vehicles in their operations. In 2018, SF Express initiated a nationwide shift toward electric logistics vehicles for last-mile deliveries, especially through the introduction of fully electric compact vans.[57] By 2022, JD Logistics had rolled out a novel battery-swapping solution for its new energy vehicles. This strategic move is projected to significantly boost energy storage utilization at JD Logistics' facilities by over 25%, reduce the number of deployed vehicles by more than 20%, and further enhance the carbon emissions reduction achieved per vehicle by more than 15%. In total, it aims to deliver a comprehensive carbon emissions reduction rate exceeding 35%.[58]

54. Li, M., Jia, N., Lenzen, M. et al.(2022). Global food-miles account for nearly 20% of total food-systems emissions. Nature Food (3), 445–453.

55. Nestle Group. (2020). Accelerate, Transform, Regenerate: Nestle's Net Zero Carbon Emission Roadmap. https://www.nestle.com/sites/default/files/2020-12/nestle-net-zero-roadmap-cn.pdf

56. Shan Yi. (2023). Nestle: Sustainable Supply Chain Practices for the Future. https://new.qq.com/rain/a/20230603A07BXS00?no-redirect=1

57. Jiangxi Network Radio and Television Station. (2020). KSTAR Partners with SF Express to Create a New Benchmark for Green Urban Distribution. China Daily. https://cn.chinadaily.com.cn/a/202001/17/WS5e216c87a3107bb6b579a8ea.html

58. EVHui.COM (2022). JD Logistics' First Batch of Battery-Swapping Electric Cars Put into Operation, Plans to Deploy 1,000 Battery-Swapping Light Trucks by the End of the Year. Sina Technology. https://finance.sina.com.cn/tech/roll/2022-08-16/doc-imizmscv6422316.shtml?finpagefr=p_114

In addition, nearly all delivery riders in urban areas have switched to two-wheel electric vehicles for order deliveries. However, the limited battery range of these electric scooters has encouraged energy and internet companies to promote battery swapping services. For instance, Alibaba's "Xiaoha Battery Swapping" has set up battery swapping stations in several cities across the nation. Delivery riders can access these stations using the "Xiaoha Battery Swapping" mini-program within the Ha Luo app or Alipay to conveniently scan and exchange batteries. According to data published by "Xiaoha Battery Swapping," its service in Shenzhen has collectively recorded over 120 million kilometers ridden using the battery-swapping method, resulting in emissions reductions equivalent to 6,000 tons.[59]

Food suppliers, logistics firms, and internet companies are exploring and experimenting with the electrification of food transportation. However, it is important to note that success in achieving a significant reduction in carbon emissions depends on the availability of clean energy.

Key takeaways

- The widespread adoption of new energy vehicles provides a foundation for the electrification of food transportation, especially in short-distance intercity delivery. Future advancements in heavy-duty electric freight vehicles and battery storage could drive further electrification in long-distance cargo transport.
- Electric bicycles lack uniformity in battery size and interface standards, which can cause problems with interoperability in battery swapping systems. Therefore, the implementation of unified technical standards[60] for electric bicycle battery swapping is essential for the successful promotion of battery sharing services.

59. Dai Xiaorong. (2022). Shenzhen Releases the First Report on the New Trend of Two-Wheel Electric Shared Energy: Citizens Replace Charging, Reducing Carbon Emissions by Nearly 6,000 Tons. Shenzhen Special Zone Daily. https://finance.sina.com.cn/jjxw/2022-09-23/doc-imqmmtha8453823.shtml

60. Yu Haijun. (2023). Smart Battery Swap Cabinets: "Standards" Should Not Fall Behind. Minseng Weekly. http://paper.people.com.cn/mszk/html/2023-06/12/content_25999435.htm

Case 10: A New Dawn for Surplus Food – Innovating Business Practices to Reduce Food Waste

Problems

Within the food industry, there is a concept of food having a shelf life, and "near-expired" products are items that are approaching their expiry date but have not yet passed it. In principle, food is still of good quality as long as it is within its shelf life. However, selling near-expired food still remains a challenge in society. Food waste not only represents a loss of food; it also signals that resources (i.e. water, soil, and energy) are being inefficiently used to produce such food. Many companies and supermarkets are increasingly adopting sustainable consumption practices, and actively reducing food waste by minimizing the disposal of near-expired food.

Approach

Selling Near-Expired Food:

There have been news reports that HotMaxx served over 13 million customers in 2021 across its 400+ stores nationwide. It circulated over 300 million items, and directly reduced food waste by over 70,000 tons, cutting approximately 140,000 tons

of carbon emissions.[61] In August and September 2022, HotMaxx conducted its "Zero Food Waste" campaign as part of a "Waste-Free Month" initiative. According to HotMaxx data, some 100,000 people participated both online and offline in this campaign. They saved over 122 tons of food from being wasted, and this lead to a reduction of approximately 243.8 tons of greenhouse gas emissions.[62]

In 2021, China launched a pioneering scheme called the "Food-Saving Magic Bag" to curb food waste. It connected businesses and consumers, and provided solutions for handling surplus food products. The "Food-Saving Magic Bag" involved baked goods, light meals, and a limited selection of fruits, vegetables, and beverages. It was carried out in over 30 cities nationwide and has partnered with more than 200 food brands.[63] Approximately 4,000 stores nationwide have now joined the "Food-Saving Magic Bag" scheme, and on average, they collectively reduce food waste by five tons daily. That equates to around 12.5 tons of reduced carbon emissions.[64]

FIGURE 10. Main page of "Food-Saving Magic Bag" mini program and a detailed page about food products

Photo credit: iGDP

Many supermarkets and retail stores have adopted the practice of offering discounts on near-expired food. In October 2021, Hema Fresh opened a "Fresh Outlet" store in Shanghai, which was primarily focused on offering perishable items and near-expired food products. Suning subsequently established its first discount supermarket in Ma'anshan, and has plans to expand into Jiangsu, Zhejiang, and Shanghai in the near future.[65]

According to iiMedia Research, the close-to-expiry goods market is poised to grow from a niche demand into a booming industry.[66] However, the emerging market for near-expired food also necessitates strict food safety standards and regulatory oversight.

Key takeaways

- Social media and online platforms are essential channels for promoting close-to-expiration foods. By leveraging these platforms effectively, businesses can significantly boost their consumer engagement and promote thriftiness.
- Some blind-box food items, like in-house packaged bread, might lack ingredient details and production dates, which could pose certain food safety concerns. Clear policies and regulations are needed to address this issue.
- Traditional supermarkets and food retailers often have sections dedicated to near-expiration products. However, there are often insufficient communication channels on this for consumers. Retailers should consider providing information about their near-expiration foods, or create a section for it on their online platforms to better engage with customers.

61. Qilu Evening News. (2022). HotMaxx Leads Low-Carbon Consumption, Creating a Beautiful Life. https://k.sina.cn/article_5328858693_13d9fee4500101kl45.html?from=tech&subch=internet
62. Qilu Evening News. (2022). HotMaxx's Low-Carbon Activities, "Star" Series Green Life. https://k.sina.cn/article_5328858693_13d9fee4500101l5fg.html?from=news
63. Insight. (2023). Small "Magic Bags," Green, Low-Carbon, and Cost-Effective! https://www.sohu.com/a/672780375_426502
64. Xie Longfei. (2023). Why Are "Leftover Box" Meals Popular Among Young People? What's Inside? China News Network. http://www.jwview.com/jingwei/html/06-29/546797.shtml
65. DoNews. Wang Huiying. (2022). Why Don't Young People Like Near-Expired Food Anymore? DoNews. https://www.donews.com/article/detail/5093/45579.html
66. Wang Xiaoyue. (2023). "Leftover Box" Opens Up New Ideas for Combating Food Waste. China Consumer News. https://news.cctv.com/2023/06/09/ARTIIBAnHEUbei8I6uxRGqdJ230609.shtml

Case 11: Reducing Food Packaging to Cut Down on Plastics

Problems

Plastic is commonly used in food packaging and takeaway containers because it is lightweight and waterproof. However, the plastic economy is currently very linear: plastic is produced, used, and then disposed of. Ninety-five percent of the value of plastic packaging is wasted worldwide, meaning annual economic losses of US $800-1,200 billion.[67] Significant amounts of greenhouse gases are also emitted during each stage of the plastic lifecycle: from extracting and transporting fossil fuels to refining and producing plastic, to managing and disposing of plastic waste.

Approach

Reducing Plastic Sources:

FIGURE 11. A comparison between PS Youyi C packaging and PP Light Bottle Youyi C packaging (left), along with a promotional poster for "Light Bottle Youyi C"

Photo credit: Institute of Carbon Neutrality and Circular Economy

According to the Qinghe Circular Economy and Carbon Neutrality Research Institute, in 2022, Mengniu introduced "Light Bottle Youyi C" materials (see Figure 3). These reduced the weight of the company's bottles from 7g to 6.5g, and meant an annual reduction of 270 tons of plastic. Mengniu also got rid of bottle labels; instead, they have engraved product information on its bottle, which reduced plastic by a further 523.8 tons per year. The thickness of the aluminum foil seals on bottles was also reduced from 40um to 30um, meaning 21.6 tons of aluminum foil were saved annually. Additionally, the technology used to engrave product information directly onto bottles, instead of using labels, meant that steam consumption was reduced by 85 tons per year. As a result of innovative packaging, each pack of Youyi C (containing five bottles, each 100g) meant reduced carbon emissions of 84.31g of CO_2e per pack, or 46.62% compared to the original packaging.

By the end of 2021, China had 544 million online users of food delivery services.[68] In order to address the significant amount of single-use plastics being wasted, a company named Shuangti developed a dedicated online food delivery platform for both on- and off-campus use. Shuangti collects, cleans, and reuses food containers, preventing the mass-production of disposable meal boxes. As of December 2021, Shuangti's reusable meal boxes have been used 63 times on average. Every time a reusable meal box is used, 91g of CO_2e emissions are reduced, and 2 terajoules of primary energy resources are saved.[69] Shuangti estimates that every reusable meal box can be used at least 150 times.[70]

67. Ellen MacArthur Foundation, Tsinghua University. (2022). Strategic Research Report on the Circular Economy Development of China's Plastic Packaging Industry. https://ellenmacarthurfoundation.org.cn/towards-a-circular-economy-for-plastics-in-china

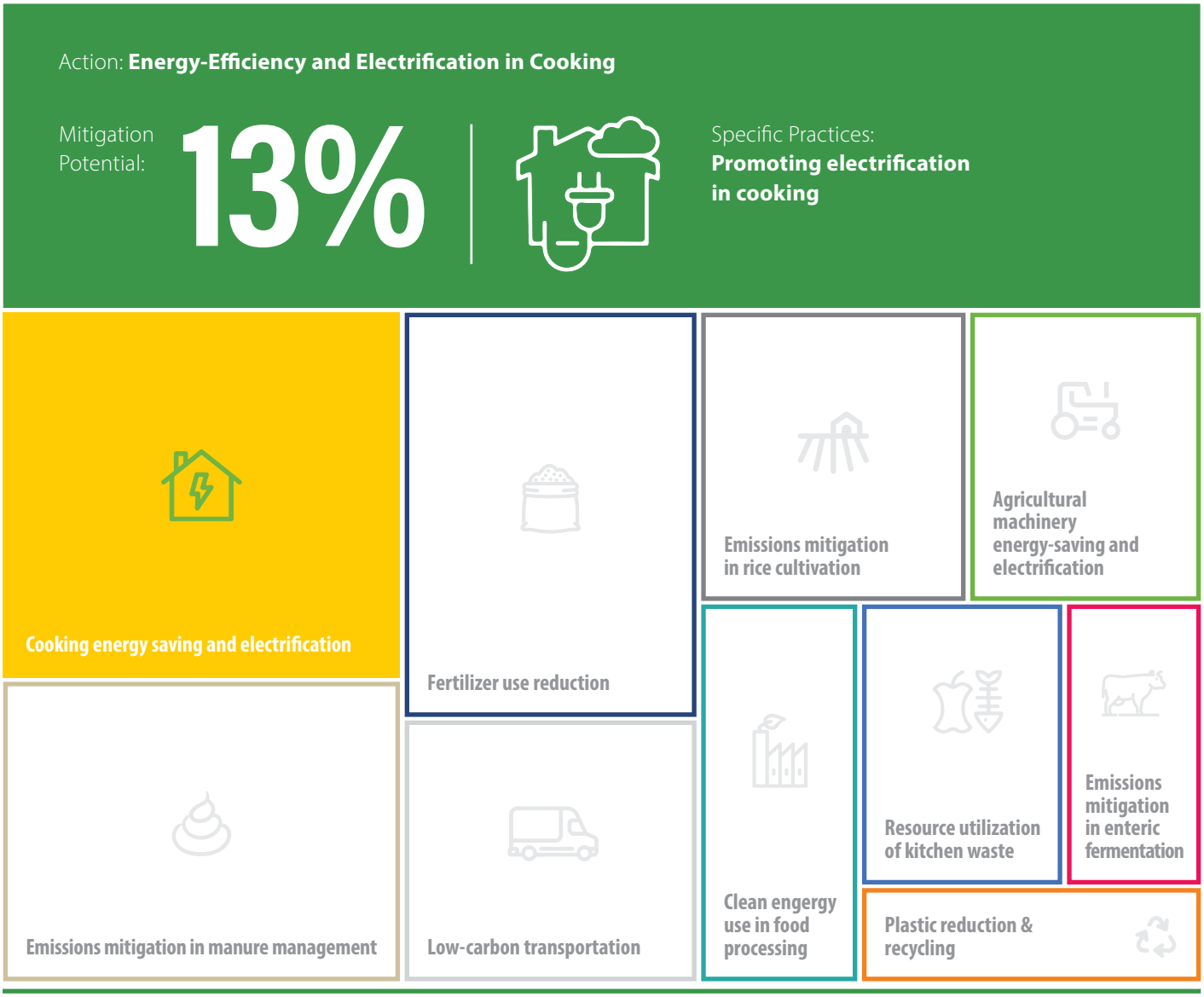
68. GONYN.COM. (2023). Analysis of the Scale of China's Takeout Users, Market Size, and Major Platforms in 2022. https://www.sohu.com/a/652286798_121388108

69. plasticfreechn.org.cn. (2022). Research Report on the Economic and Environmental Benefits of Takeout Circular Lunch Boxes. http://www.plasticfreechn.org.cn/upload/ueditor/20220511/202205111144068741.pdf

70. Lin Fangzhou, Huang Jiayu. (2022). The Challenge of Reducing Plastic in Takeout: Discoveries in 35 Million Takeout Orders. Southern Weekend. https://new.qq.com/rain/a/20220602A0857A00

Key takeaways

- Businesses should strive to minimize unnecessary packaging and explore designs that support reusability. They should ensure that packaging materials and designs are recyclable.
- Local governments could encourage more coordination and standardization along the supply chain. They could promote ecological design principles, and establish certification and labeling systems for recyclable packaging. These measures could help more companies adopt low-carbon practices.
- Collecting plastic waste from consumers is a complex challenge due to their widespread distribution, and the diverse range of materials used in plastic packaging. It is also challenging to collect and sort plastic waste. Reusable food containers are suitable options for closed environments e.g. campuses, business parks, hospitals, and government facilities, but there are logistical challenges extending their use to more open environments such as residential areas.



Case 12: Electrification Empowers Low-Carbon and Safe Chinese Cooking

Problems

Carbon emissions linked to food consumption can be subdivided into three parts: direct food carbon emissions, indirect carbon emissions from households, and indirect carbon emissions from industry. Direct food carbon emissions refer to the carbon emissions from the food itself, while indirect carbon emissions from households refer to the carbon emissions from cooking and storing food. Indirect carbon emissions from industry refer to the carbon emissions generated by different links in the food consumption process, such as production, processing, and distribution, as well as transfers between different industries. Research shows that per capita indirect carbon emissions in 30 provinces (including autonomous regions, and centrally-administered municipalities) in China have been rising from 1990 to 2018.[71]

71. Huang Heping, Li Yaili & Yang Siling. (2021) Spatio-Temporal Evolution Characteristics of Carbon Emissions from ood Consumption of Urban Residents in China. Chinese Journal of Environmental Management, 13(1), 112-120.

Approach

Electrification in Dining Establishments:

As more urban residents choose to dine out, energy consumption for cooking has shifted from residential areas to public buildings.[72] Therefore, promoting cooking electrification in dining establishments and other businesses is a more effective way to reduce emissions. In June 2021, Jiangsu Province released the first provincial-level policy supporting the "switch from bottled gas to electricity" for dining establishments. By the end of 2021, Jiangsu had established 4,023 commercial-grade "all-electric kitchens" across various cities and counties in the province. These kitchens can significantly improve kitchen safety and reduce energy costs by 20% to 45%. On average, they can reduce carbon emissions by over 30%.[73]

FIGURE 12. Electrified kitchen in a primary school in Jianhu county, Jiangsu Province

Photo credit: Jianghu county people's government

Residential Electrification:

A study by the Xiamen Construction Bureau found that, for residential units smaller than 168 square meters, the construction cost and annual operating cost of electric stoves are lower than those of gas stoves. At present, Xiamen has already implemented residential building electrification at the Haicang Ecological Garden residential project. This project consists of high-rise residential buildings and, due to fire safety concerns, traditional natural gas service is not provided to households. Instead, the developer has equipped each household with electric induction stoves, achieving a fully electrified kitchen. By using clean electrical energy, electric cooking appliances reduce carbon emissions to zero.[74]

Key takeaways

- The slow transition to electrical cooking is partly due to the long-standing tradition of cooking over an open flame. Nevertheless, modern kitchen appliances are fully capable of satisfying traditional cooking requirements, necessitating increased promotion and awareness.
- Research shows[75] that relevant policies and funding incentives[76] are essential for driving the adoption of electrification in public buildings, especially for cooking purposes.

72. Hao Bin, Li Yemao, Feng Wei, Xu Xiaolong, Peng Chen, Lu Yuanyuan, Li Yutong, Pan Wenyu, & Kang Jing. (2020). Summary of the Report on the Urban Energy Transition Path Driven by Building Electrification. Energy Foundation (China) & Shenzhen Institute of Building Science Co., Ltd.

73. Dong Ying, Sun Mengru. (2022). Jiangsu Promotes "Green Transformation" of Back Kitchens with Over 4000 "All-Electric Kitchens." Yangzi Evening News. https://k.sina.cn/article_1653603955_628ffe73020018knv.html?from=news&subch=onews

74. Yuan Shuqi. (2021). Continuing to Select Newly Built Residential Areas as Pilot Projects for Electrification, Xiamen Will Have More Communities Cooking and Stir-Frying with Electricity. Xiamen Daily. http://m.news.cn/fj/2021-11/22/c_1128087092.htm

75. Tian Jin, Huang Peikun, Zhou Yan, et al. (2022). Research Report on Low-Carbon Action Guidelines for Catering Businesses. China Environmental Protection Foundation. http://www.cepf.org.cn/jjhdt/202211/W020221108493004865079.pdf

76. Ding Xixi. (2021). "All-Electric Kitchen": The Green and Low-Carbon New Trend in the Rise of the Jiangsu Catering Industry. Jiangnan Times. http://www.jntimes.cn/ttxw/202106/t20210617_7126970.shtml

Case 13: Leftover Food – A Hot Commodity in Terms of Power and Compost

Problems

As China has urbanized and industrialized, greenhouse gas emissions from municipal solid waste systems have increased steadily, harming the environment. In 2020, the volume of urban waste collected in China reached 235 million tons,[77] an increase of nearly 49% since 2010. Kitchen waste makes up a significant portion of urban waste in China. More effective kitchen waste management can mean more valuable products, more fuel, and more energy.

Approach

Utilizing Kitchen Waste Resources:

In December 2018, the city of Xi'an in Shaanxi Province launched the first phase of a project to harmlessly treat and utilize

77.

kitchen waste. Xi'an established a facility that became the city's first kitchen waste processing plant. It had capacity to handle 200 tons of kitchen waste and 20 tons of used cooking oil per day. The project was built, owned, and operated (BOO) under a 30-year franchise period. The total investment of the project was 192 million yuan. Under the franchise agreement, the local government paid for kitchen waste collection and set a processing fee at 274 yuan per ton.

Since its trial phase, this project has consistently been operational, processing more than 200 tons of kitchen waste per day; some days this figure exceeds 250 tons. More than 80,000 tons of kitchen waste are processed in total per year. Operational data linked to the project indicates that one ton of kitchen waste can produce about 80 cubic meters of biogas, 50 kilograms of waste cooking oil, or generate 160 kWh of electricity. Plans are in place to integrate the electricity generated into the grid; it will also be used to further the project's own needs. The effluent generated meets the discharge standards for Class II water bodies in the Yellow River Basin, and so once it is processed, solid residue will be transported to a landfill for disposal.

FIGURE 13. Kitchen waste treatment equipment in Xi'an city, Shaanxi Province

Photo credit: iGDP

The kitchen waste treatment project in Taiyuan, Shanxi Province, has overall capacity to treat 500 tons per day and it was constructed in two phases. The first phase, which began trial operations in 2017, has a kitchen waste processing capacity of 200 tons per day. It covers the six urban districts of Taiyuan and Qingxu County. This project was built, operated, and transferred (BOT) under a 30-year franchise period. The total invested in the project was 311 million yuan. Under the franchise agreement, the local government pays a fee of 309 yuan per ton to collect and process kitchen waste.

This project is now operating smoothly, and over 200 tons of kitchen waste are processed per day. More than six million cubic meters of biogas are produced annually, and there are plans to purify this and turn it into biomethane. Additionally, measures to separate oil and water result in a significant amount of crude oil as a primary byproduct. The digestate generated from kitchen waste is transported to a wastewater treatment plant, while residue is taken to an on-site incineration plant within the park, meaning transportation costs are effectively reduced.

Key takeaways

- Effective planning and coordination are essential when it comes to kitchen waste treatment projects. Money can be saved on transportation, meaning projects are more economically viable.
- Kitchen waste has a complex composition; after processing, it contains high concentrations of organic contaminants, grease, and inorganic salts. The resulting digestate is typically transported to wastewater treatment facilities. However, projects are advised to explore different chemical agents that might mean more efficient treatment outcomes.
- Different technologies might be required to treat kitchen waste. Local authorities should consider the quality of waste materials, and the technical and economic feasibility when treating them. They should also factor in any unique circumstances when selecting the most suitable treatment methods.

Action: **Dietary Shift and Behavioral Change**

Mitigation Potential: **

Specific Practices:
Promoting environmentally-friendly dietary habits

Case 14: Advocating Environmentally-Friendly Diets in the Pearl River Delta Region – How Restaurant Orders Can Reduce Food Emissions

Problems

Encouraging the adjustment of consumer diets is an important and effective way of reducing emissions.[78] There is potential to transform dietary structures, reduce food waste, and enhance food education, all of which are effective intervention strategies. A scientific approach could be applied; the carbon emissions associated with different food items (as part of their lifecycle) could be calculated, and then displayed on a menu. This would not only raise awareness about the environmental impact of consumers' dietary choices, it would also help individuals who prefer low-carbon consumption to make informed decisions. Research[79] has shown that frequent reminders can influence people to choose more "environmentally-friendly" consumption options.

Approach

"Climate Menu":

The PDT Food Collective (PDT) is an organization dedicated to promoting the transition to sustainable food systems. The PDT has conducted field visits and research at 20 restaurants in the Pearl River Delta region. It has assessed the operational status of these establishments, their understandings of sustainable dining, and the feasibility of taking action. PDT is collaborating with five restaurants that have already made attempts to switch towards more sustainable dining. PDT has selected one item off the menu at each restaurant, and has "re-engineered" it to make it more environmentally-friendly. Methods have included increasing the proportion of vegetables over meat (e.g. substituting leeks for pork in "Hakka Stuffed Tofu"), using locally sourced ingredients (e.g. locally-caught fish instead of high-carbon meats), and reducing the amount of heavily processed foods by substituting wholegrains for refined ones. PDT assessed relevant carbon emissions data before and after transforming these dishes and found that emissions were reduced 15% to 88%. During the "Guangdong Dining, Low Carbon" campaign on Earth Day, 3,061 servings of these revamped dishes were sold. These dishes resulted in a reduction of 2964 kg of CO_2e.[80]

In order to promote the guiding principles of "Environmentally-Friendly Dining" to Pearl River Delta consumers, PDT introduced professional terminology into texts that resonated with the local culture of the region. For example, it used the promotional slogan "不时不食" ("eat in season" or "seasonal eating") to encourage consumers to explore seasonal local ingredients. The slogan helped strengthen the connection between local culture and low-carbon food.

78. Valentine Graveleau. (2022). On the menu at a UK restaurant: carbon footprint . https://phys.org/news/2022-08-menu-uk-restaurant-carbon-footprint.html

79. Isabelle Gerretsen. (2022). The menu tweaks that lower diners' emissions. https://www.bbc.com/future/article/20221121-the-menu-tweaks-that-lower-diners-emissions

80. Data and information were provided by the interviewees.

FIGURE 15. Posters designed by PDT to promote the guiding principles of "Environmentally-Friendly Dining" to Pearl River Delta consumers

Photo credit: PDT

PDT's "foodservice transformation program," which was originally a pilot, assessed the reasons the industry might be motivated to change, and looked at companies' business feasibility to do so, and their brand images. The PDT also collaborated with media to promote businesses and green dishes within the foodservice alliance. These activities helped improve businesses' understanding of environmentally-friendly dining and raised awareness of the benefits of participating in an environmental scheme. Some restaurants have responded by saying: "When we update our menus now, we consider carbon emissions, and choose more seasonal ingredients."

Key takeaways

- When proposing solutions, it's crucial to listen to businesses' feedback, consider the cost-effectiveness of carbon reduction measures, and assess how consumers might respond so as to ensure their sustainability in the business context.
- Recognize and play to local experiences and wisdom. For restaurant and consumer education, highlight and preserve existing sustainable culinary traditions and practices, and avoiding simply importing foreign concepts.
- Empower frontline staff in the food industry, including chefs, waitressing staff, and restaurant managers. Place a strong emphasis on cultivating a mindset shift among service personnel who directly interact with consumers.
- Given China's vast geography and varying restaurant locations, brand identities, and customer demographics, the increased interest in sustainable dining opens the door for more non-profit organizations and associations to participate. They can offer tailored guidance to restaurants as they transform.

ABOUT iGDP

The Institute for Global Decarbonization Progress (iGDP) is an international non-profit think tank focusing on green and low-carbon development with offices in China and Europe. Established in Beijing in 2014, iGDP is dedicated to supporting China's green and low-carbon practices, contributing to the global effort to address climate change, and providing decision-makers, investors and local communities with forward-thinking solutions. Through interdisciplinary, systematic, and empirical policy research, iGDP promotes robust energy and climate solutions with high implementation and investment feasibility. iGDP works with its partners to promote a zero emissions future and tell the story of China's green and low-carbon development.

www.igdp.cn

iGDP

6-2-62, Jianguomenwai Diplomatic Residence
Compound, 1 Xiushui Street, Chaoyang District,
Beijing, 100600 P.R. China

Email: igdpoffice@igdp.cn
Tel: 86-10-8532-3096