CGIAR
Mitigate+: Research for Low-Emission Food Systems

Working paper

Review of Nationally Determined Contributions (NDC) of China from the Perspective of Food Systems

Tek B Sapkota, Bimal Regmi, Apar Paudyal, Regan Sapkota and Rosy Joshi.

CIMMYT
CGIAR

Contents

List of Figures

List of Tables

List of abbreviation

AGFEP	Academy Of Global Food Economics and Policy
BAU	Business As Usual
CH_4	Methane
CO_2eq	Carbondioxide Equivalent
COP	Conference Of the Parties
CSA	Climate-Smart Agriculture
$FFCO_2$	Fossil-Fuel CO_2
FYP	Five-Year Plan
GDP	Gross Domestic Product
GHGs	Greenhouse Gases
GPG	Good Practice Guidance
GT	Giga Ton
IEDA-CAAS	Institute Of Environment and Sustainable Development in Agriculture, Chinese Academy of Agricultural Sciences
IPCC	Intergovernmental Panel on Climate Change
LTS	Long-Term Strategy
LULUCF	Land-Use Change and Forestry
MARA	Ministry Of Agriculture and Rural Affairs
mm	Millimeters
MOA	Ministry Of Agriculture
MRV	Measurement, Reporting, And Verification
Mt	Metric Ton
N_2O	Nitrous Oxide
NDC	Nationally Determined Contribution
NDRC	National Development and Reform Commission
NH_3	Ammonia
SRI	System Of Rice Intensification
TNC	Third National Communication
UNFCCC	United Nations Framework Convention on Climate Change

Summary

China is the largest emitter of greenhouse gases (GHG) and one of the countries most affected by climate change. China's food systems are a major contributor to climate change: in 2018, China's food systems emitted 1.09 billion tons of carbondioxide equivalent (CO_2eq) GHGs, accounting for 8.2% of total national GHG emissions and 2% of global emissions. According to the Third National Communication (TNC) Report, in 2010, GHG emissions from energy, industrial processes, agriculture, and waste accounted for 78.6%, 12.3%, 7.9%, and 1.2% of total emissions, respectively, (excluding emissions from land use, land-use change and forestry (LULUCF). Total GHG emissions from the waste sector in 2010 were 132 Mt CO_2 eq, with municipal solid waste landfills accounting for 56 Mt.

The average temperature in China has risen by 1.1°C over the last century (1908–2007), while nationally averaged precipitation amounts have increased significantly over the last 50 years. The sea level and sea surface temperature have risen by 90 mm and 0.9°C respectively in the last 30 years. A regional climate model predicted an annual mean temperature increase of 1.3–2.1°C by 2020 (2.3–3.3°C by 2050), while another model predicted a 1–1.6°C temperature increase and a 3.3–3.7 percent increase in precipitation between 2011 and 2020, depending on the emissions scenario. By 2030, sea level rise along coastal areas could be 0.01–0.16 meters, increasing the likelihood of flooding and intensified storm surges and causing the degradation of wetlands, mangroves, and coral reefs.

Addressing climate change is a common human cause, and China places a high value on combating climate change. Climate change has been incorporated into national economic and social development plans, with equal emphasis on mitigation and adaptation to climate change, including an updated Nationally Determined Contribution (NDC) in 2021. The following overarching targets are included in China's updated NDC:

- Peaking carbon dioxide emissions “before 2030” and achieving carbon neutrality before 2060
- Lowering carbon intensity by “over 65%” by 2030 from the 2005 level
- Increasing forest stock volume by around 6 billion cubic meters in 2030 from the 2005 level

The targets have come from several commitments made at various events, while China has explained very well the process adopted to produce its third national communication report.

An examination of China's NDC reveals that it has failed to establish quantifiable and measurable targets in the agricultural sectors. According to the analysis of the breakdown of food systems and their inclusion in the NDC, the majority of food system activities are poorly mentioned. China's interventions or ambitions in this sector have received very little attention. The adaptation component is mentioned in the NDC, but is not found to be sector-specific or comprehensive.

A few studies have rated the Chinese NDC as insufficient, one of the reasons being its failure to list the breakdown of each sector's clear pathway to achieving its goals. China's NDC lacks quantified data on food system sub-sectors. Climate Action Trackers' "Insufficient" rating indicates that China's domestic target for 2030 requires significant improvements to be consistent with the Paris Agreement's target of 1.5°C

temperature limit. Some efforts are being made: for example, scientists from the Institute of Environment and Sustainable Development in Agriculture, Chinese Academy of Agricultural Sciences (IEDA-CAAS) have developed methods for calculating GHG emissions from livestock and poultry farmers that have been published as an industrial standard by the Ministry of Agriculture and Rural Affairs, PRC (Prof Hongmin Dong, personal communication) but this still needs to be consolidated and linked to China's NDC.

The updated Nationally Determined Contributions fall short of quantifiable targets in agriculture and food systems as a whole, necessitating clear pathways. China's NDC is found to be heavily focused on a few sectors, including energy, transportation, and urban-rural development. The agricultural sectors' and food systems' targets are vague, and China's agrifood system has a large carbon footprint. As a result, China should focus on managing the food system (production, processing, transportation, and food waste management) to reduce carbon emissions.

Furthermore, China should take additional measures to make its climate actions more comprehensive, quantifiable, and measurable, such as setting ambitious and clear targets for the agriculture sector, including activity-specific GHG-reduction pathways; prioritizing food waste and loss reduction and management; promoting sustainable livestock production and low carbon diets; reducing chemical pollution; minimizing the use of fossil fuel in the agri-system and focusing on developing green jobs, technological advancement and promoting climate-smart agriculture; promoting indigenous practices and locally led adaptation; restoring degraded agricultural soils and enhancing cooperation and private partnership. China should also prepare detailed NDC implementation plans including actions and the GHG reduction from conditional targets. Some specific recommendations include the following:

- **Ambitious and clear targets for the agriculture sector:** The NDC describes multiple ambitions to reduce GHG emissions and reach carbon neutrality by 2060, but the clear and quantified targets of the agriculture sector are largely missing. The agriculture sector only accounts for 7.9% of its overall GHG emissions, thus the Chinese government should focus on enhancing efforts and preparing a holistic action plan and sectoral targets (He, Li & Zhang, 2020). In addition, China should focus on the quantifiable sectoral targets of its NDC.
- **Activity-specific GHG reduction pathways:** The agriculture sector emitted approximately 828 Mt CO_2 eq, from enteric fermentation, manure management, rice cultivation, agriculture soils, and agricultural residues, accounting for 26.2%, 16.6%, 22.1%, 34.1%, and 1.0%, respectively (UNFCCC, 2018). The NDC fails to mention quantifiable ambitions to reduce such emissions from these food-production processes. The trajectories of each activity within a specific frame in the NDC are critical. For example, reducing emissions from a food-related activity until 2030, then reducing emissions by 50% by 2040, and then aiming for a carbon-neutral food system by 2060.
- **Food waste reduction and management:** Reducing food loss and waste relative to the baseline in China would reduce agricultural GHG emissions by 2.0–5.6% by 2030 and 4.0–7.0% by 2060. (AGFEP, 2021). There is thus an opportunity to reduce GHG emissions by around 7% from the food waste sector alone. Reducing food loss and waste would also improve food security, reduce financial losses for farmers and consumers, and have a positive impact on the environment (e.g. on GHG emissions, water consumption, and pesticide/fertilizer pollution) (Government of China, 2022a).
- **Promote sustainable livestock production**: The production of animal-derived

food (ADF) accounts for 19% of global anthropogenic greenhouse gas (GHG) emissions and therefore sustainable livestock production is an important for reducing GHG emissions. These include better animal husbandary practice e.g. better feed management, genetic improvement, management of livestock health. China can reduce GHG emissions from livestock sector by promoting better manure management systems, rangeland and forest protection and sustainable grazing and pasture management.

- **Promote low-carbon diets:** By 2050, the world's dietary trends, if not controlled, will be major contributors to an estimated 80% increase in global agricultural GHG emissions (Zhong et al., 2020). Under the business as usual (BAU) scenario, daily per capita ADF consumption is projected to have increased by 58.5% in 2050 compared to 2018, increasing ADF consumption-related GHG emissions up to 463 Mt CO_2-eq per year by 2050 and posing a challenge to China's "carbon neutrality" (Wang et al., 2022). If the Chinese follow good dietary guidelines, ADF consumption-related GHG emissions can be reduced to 245 Mt CO_2-eq per year, which is 47.1% lower than the BAU scenario in 2050 and comparable to 2018 levels (Wang et al., 2022). Reducing the consumption of unhealthy, unsustainable, carbon-intense diets could reduce GHG emissions by 150 million to 200 million tons by 2030, a reduction of 18–25% (AGFEP, 2021). The reduction in unhealthy diets could contribute to China's aspiration of achieving its carbon neutrality and food security (Government of China, 2022a). A study carried out by Qi et al. (2022) posited that transformation of the nutrient-oriented dietary pattern of China would lead to a 14.9% decrease in the emission of GHGs from the food system. Promoting the consumption of plant-based and alternative protein sources can reduce the demand for livestock products, thus lowering emissions.

- **Reduce chemical pollution**: Pollution from agricultural production plays a crucial role in contributing to GHG emissions. Therefore, several approaches for reducing harmful chemical fertilizers should be promoted: for example, precision agriculture could decrease the utilization rates of fertilizers and pesticides, thereby lowering the total amount of inputs applied and the amount of runoff into the environment (Government of China, 2022a).

- **Minimize the use of fossil fuel in agri-systems**: China's fossil-fuel CO_2 ($FFCO_2$) emissions accounted for approximately 28 % of the global total $FFCO_2$ emissions in 2016. A study shows that total emissions increased from 3.4 (3.0–3.7) in 2000 to 9.8 (9.2–10.4) Giga tons (Gt CO_2 eq) per year in 2016 (Han et al., 2020). Thus, reducing inefficiency and the use of fossil fuels in the agriculture sector is essential to help China increase its overall reduction in GHG emissions. Options could include adoption of reduced tillage and other farm operations, precision water and nutrient management, use renewable energy sources for farm equipment, food storage, and transportation (Government of China, 2022a).

- **Technological advancement and promotion of climate-smart agriculture:** Energy consumption is the primary source of carbon emissions, and China's energy consumption accounts for more than 90% of its carbon emissions. China needs to promote agricultural strategies and approaches that can ensure sustainable food production under predicted climate-change scenarios, e.g., climate-smart agriculture (CSA). Climate-smart agriculture emphasizes improving risk management, enhancing information flows, and promoting local institutions to increase the adaptive capacity of communities to climate change (Campbell et al., 2014). The agriculture sector in China accounts for 7.9% of GHG emissions, thus CSA could contribute to reducing portion of these emissions.

- **Preparation of detailed NDC implementation plans:** With the NDC and other policy instruments in place, China should prioritize the preparation of the NDC implementation plan. The plan should provide clear and quantified short, medium, and long-term low-carbon development pathways in food system management.

Chapter One: Aspects of food included in their NDC target

1.1. Context

China is one of the countries most affected by climate change. Climate change has had a long-term impact on China's ecological environment and socioeconomic development, posing serious threats to the security of its food, water, ecology, energy, and urban operations, as well as to people's safety and property (UNFCCC, 2021). China's food systems are a major contributor to climate change (He, Li & Zhang, 2020). China's food systems emitted 1.09 Gt of CO_2 eq greenhouse gas (GHG) in 2018, accounting for 8.2% of the total national GHG emissions and 2% of global emissions. The primary sources of emissions in food systems are agricultural inputs, particularly fertilizer use. However, following a rapid increase in emissions between 1997 and 2012, food-related emissions have proportionately decreased.

Moreover, as per the Third National Communication Report, GHG emissions in 2010 from energy, industrial processes, agriculture, and waste were 8,283 Mt, 1,301 Mt, 828 Mt, and 132 Mt CO_2 eq. respectively (UNFCCC, 2018). These four sectors accounted for 78.6%, 12.3%, 7.9%, and 1.2% of the total emissions (without LULUCF) respectively, as shown in Figure 1.

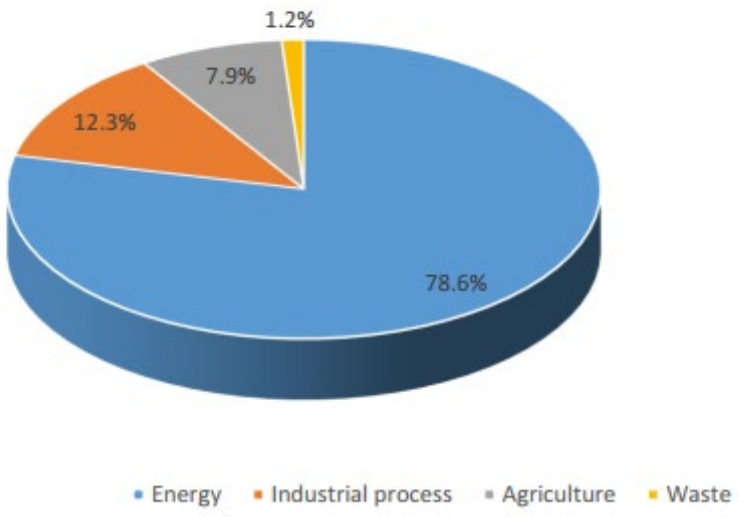

Figure 1: GHG emissions by sectors in China in 2010 (without LULUCF)

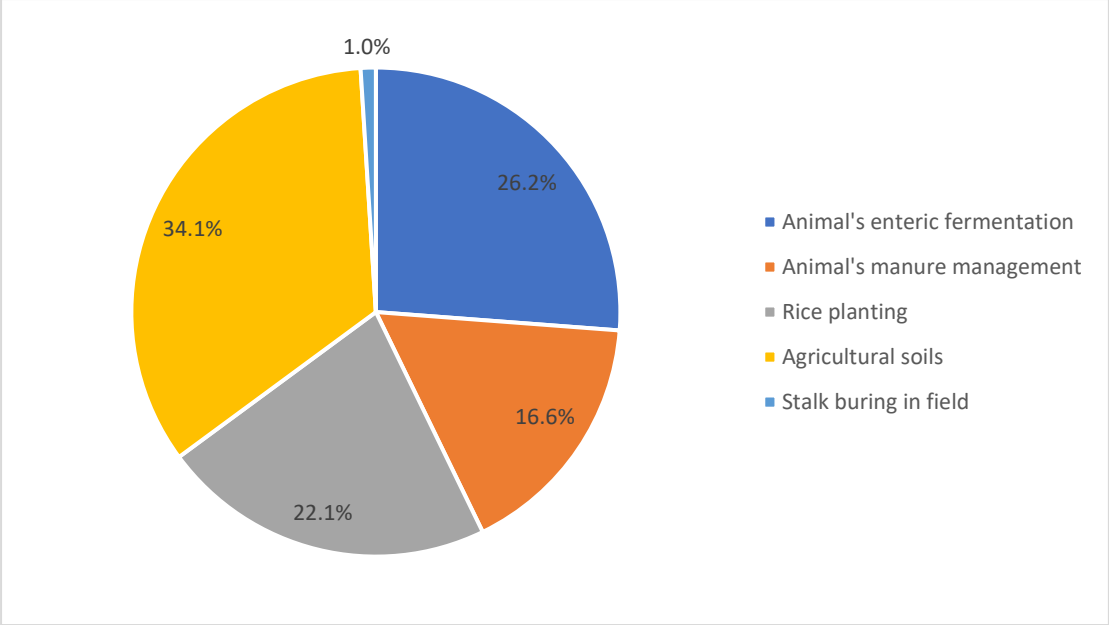

Figure 2: GHG emissions from agriculture by sector in China in 2010

Further, total emissions from the agriculture sector were around 829 Mt CO_2 eq, of which the emissions from enteric fermentation were 217 Mt CO_2 eq, accounting for 26.2%; the emissions from manure management were 137 Mt CO_2 eq, accounting for 16.6%; the emissions from rice cultivation were 183 Mt CO_2 eq, accounting for 22.1%; the emissions from agriculture soils were 283 Mt CO_2 eq, accounting for 34.1%; and the emissions from field burning of agricultural residues were 9 Mt CO_2 eq, accounting for 1.0%, as shown in Figure 2 (UNFCCC, 2018). In total emissions, CH_4 accounted for 56.8%, and N_2O accounted for 43.2% (UNFCCC, 2018).

Table 1: China's GHG emissions and removals in 2010 (Mt CO_2 eq)

Sector	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total
Agriculture		471	358				829
Waste	8	92	31				132
Total (without LULUCF)	8,707	1,127	547	132	10	21	10,544

Similarly, in 2010, the total GHG emissions from the waste sector were 132 Mt CO_2 eq (Table 1), of which 56 Mt were from municipal solid waste landfills, accounting for 42.7%; and 76 Mt were from wastewater handling, accounting for 57.3%. The proportions of CO_2, CH_4, and N_2O emissions were respectively 6.4%, 69.9%, and 23.7% (UNFCCC, 2018).

Further, China's agrifood system generated 1.09 GT of CO_2 eq in 2018, the (AGFEP, 2021, Government of China, 2022a). This amount represents 12% of the 13 billion tons of CO_2 eq emitted by China that year, a substantial increase from the 1997 level of 0.94 billion tons of CO_2 eq (Government of China, 2022a). While GHG emissions from the country's agrifood system span multiple sectors, the majority come from food production activities (Figure 4) (Government of China, 2022a).

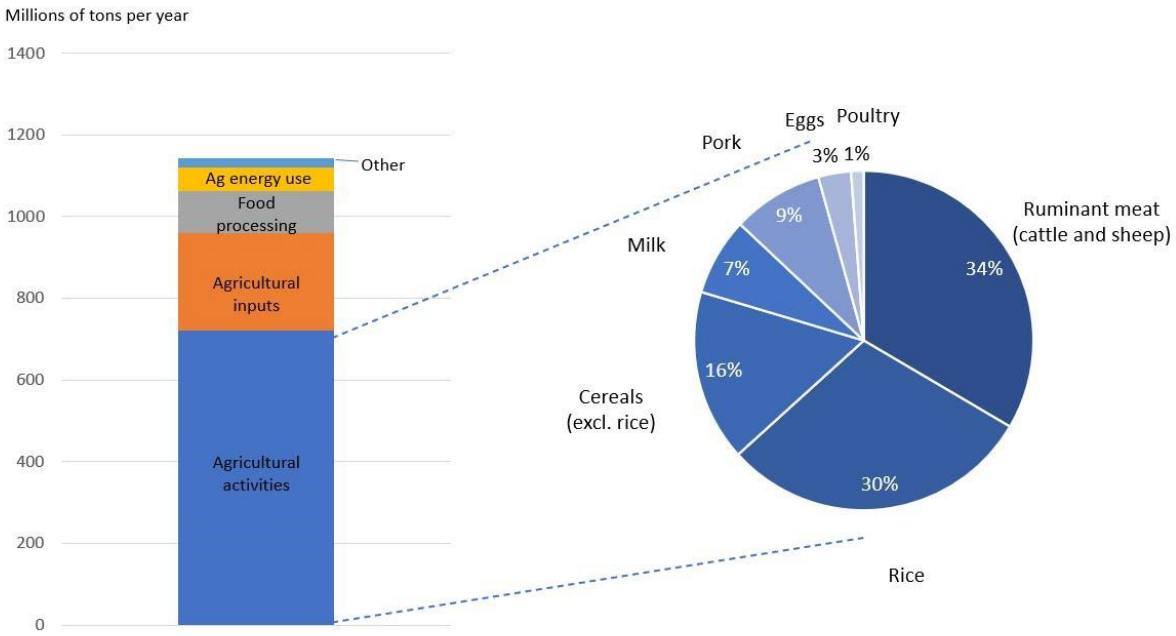

Figure 3: Greenhouse gas emissions from China's agrifood system (2017)

Source: AGFEP, CARD, CIFAE, IAED, and IFPRI. 2021. China and Global Food Policy Report. (Government of China, 2022a).

Similarly, a study carried out by the Government of China, (Government of China, 2022a) shows the potential for reducing GHG emissions under BAU, low, medium, and high emissions reduction scenarios:

- Under BAU, GHG emissions from agrifood systems will reach 1.17 GT in 2030, an increase of 7.7%, compared with 2020, and then they decline again to 1.09 billion tons in 2060, returning to their 2018 level.
- In the low, medium, and high emission reduction scenarios, GHG emissions from agrifood systems in 2060 are 17–63% lower than under BAU and 19–63% lower than in 2020.
- The medium-level scenario would contribute to a reduction of 47% of GHG emissions in agrifood systems in 2060, compared with 2020.

1.2. The country's climate change scenarios

China is the largest emitter of GHGs, a triggering factor for human-caused climate change. The climatic system of China has also been changing and making China vulnerable to the adverse impacts of climate change (JGRI & BMI, 2009). The changes include the following:

- Over the past century (1908 to 2007), the average temperature in China has risen by 1.1 degree Celsius
- Although no significant trend was observed in nationally averaged precipitation amounts over the past 50 years, a drying trend was observed in the Yellow River Basin and North China Plain
- Over the past 30 years, the sea level and sea surface temperature have increased by 90 millimeters (mm) and 0.9°C, respectively

- China has experienced more extreme events (floods, droughts, storms) in recent years than ever before. The extreme weather events cause direct economic losses of US$ 25 to 37.5 billion in China per year.

A regional climate model projected a country-averaged annual mean temperature increase of 1.3–2.1°C by 2020 (2.3–3.3°C by 2050); another regional climate model projected a 1–1.6°C temperature increase and a 3.3–3.7 percent precipitation increase between 2011 and 2020, depending on the emissions scenario. By 2030, the rise in sea level along coastal areas could be 0.01–0.16 meters, increasing the possibility of flooding and intensified storm surges, leading to the degradation of wetlands, mangroves, and coral reefs (JGRI & BMI, 2009).

1.3. Mitigation Priorities and actions for the agriculture, food, and LULUCF sectors

China has formally submitted its updated NDC to the United Nations Framework Convention on Climate change (UNFCCC), updating its four separate NDC targets and adding a fifth target aimed at increasing capacity in renewable energy. Similarly, on October 20 2021, China submitted to the UNFCCC its Mid-Century Long-Term Low Greenhouse Gas Emission Development Strategy (Government of China, 2021), which includes the country's commitment to achieving "carbon neutrality before 2060." (CAT, 2021). China's NDC is intended to be the primary vehicle for transitioning to the new normal and moving forward on the path of innovative development. Given continued economic growth, China's NDC and 2030 peak emissions can only be met by accelerating structural change and lowering energy and carbon intensity (PMR & NCCCSIC, 2016).

Table 2: Major GHG reduction targets of China

CHINA — Main climate targets	
2030 NDC target	
Formulation of a target in NDC	China’s updated NDC contains five overarching targets: 1. Peaking carbon dioxide emissions “before 2030” (up from the previous “around 2030 and making efforts to peak earlier”) and achieving carbon neutrality before 2060. 2. Lower carbon intensity by “over 65%” in 2030 from the 2005 level, (up from the previous “by 60–65%”). 3. Share of non-fossil fuels in primary energy consumption to “around 25%” in 2030, (up from “around 20%”). 4. Increase forest stock volume by around 6 billion cubic meters in 2030 from the 2005 level, (previously 4.5 billion cubic meters). 5. Increase the installed capacity of wind and solar power to over 1,200 GW by 2030 (new target).
Net zero & other long-term targets	

Formulation of target	China will strive to reach a CO_2 emissions peak before 2030 and achieve carbon neutrality before 2060

Furthermore, China's Long-Term Strategy (LTS) 2021 accelerates the promotion of nature-based solutions; integrates the sustainable use of natural resources into the policy and action framework for addressing climate change; maximizes nature's mitigation effect in forestry, agriculture, oceans, water resources, ecosystems, and other fields; and comprehensively improves resilience in addressing climate change (Government of China, 2021). The LTS also incorporates the following targets to promote agriculture's green and low-carbon development:

- Change the development orientation of agriculture from increasing production to improving quality and efficiency, and develop green, low-carbon circular agriculture
- Promote the resource-saving and recycling-oriented development of agriculture, focusing on saving land, water, fertilizer, medicine, energy, and labor, effectively reducing material consumption and resource inputs in agricultural production including breeding for resources-use-efficiency thereby improving agricultural production efficiency and comprehensive benefits.
- Introduce a mechanism and formulate and implement policies for the comprehensive utilization of agricultural waste, optimize the industrial structure and improve the quality and efficiency of the comprehensive utilization of agricultural waste,
- Promote the recycling of waste from straw, livestock, and poultry breeding, protect and improve the quality of cultivated land, and achieve healthy and sustainable development
- China will strictly control the consumption of fossil energy, and vigorously accelerate the development of non-fossil energy (Government of China, 2021). By 2030, the proportion of non-fossil energy in energy consumption will reach about 25%, and total installed wind and solar power capacity will reach over 1.2 billion kilowatts

China's food systems are critical to both the country's economy and the world's food supply. China and its food systems feed 1.4 billion people, accounting for nearly one-fifth of the world's population. China is the world's largest producer of food (Fan et al., 2021). In 2014, China produced 50% of the world's vegetables, 29% of its meat, 70% of its fish, 30% of its rice, 17% of its corn, and 15% of its wheat (Ghose, 2014). Agriculture, agribusiness, food processing, packaging, transportation, wholesale and retail trade, food services, finance, insurance, advertising, and input supplies account for 23% of China's GDP and employ 30% of its workforce (Fan et al., 2023). China's food systems are major contributors to climate change (He, Li & Zhang, 2020). However, various advancements can be made to achieve low-carbon development of the food systems.

Table 3: Technologies and practices to reduce GHG emissions from food production

GHG emissions source	**Annual emissions ($MtCO_2eq$)**	**Technologies and practices that can reduce emissions**

Ruminant enteric fermentation (meat and milk)	180	• Utilize enteric methane inhibitor feed additives (eg. 3-NOP, seaweeds) • Improve ruminant breeding for better feed conversion efficiency
Livestock manure	140	• Separate solids from liquids and manage dry solids (reducing emissions in animal housing) • Acidify manure or use other options for improved liquid manure management (reducing losses during manure storage) • Utilize digesters in warm locations with large lagoons and use the CH_4 as biogas (at large-scale locations like communities or larger farms)
Livestock: crosscutting (enteric fermentation, manure management)		• Boost ruminant livestock productivity and efficiency—reducing methane emissions per kg of meat and milk or per hectare of pasture—through improvements in: – Feed quality – Animal breeds – Veterinary care • Improve pasture and grazing management (eg. rotational grazing, better grass mixes)
Rice cultivation	150	• Promote a System of Rice Intensification (SRI) • Accelerate yield gains to reduce the flooded paddy area needed • Breed lower-methane-emitting rice. • Sustainable rice straw management for nutrient recycling and emission reduction • Reduce flooding periods (e.g., alternate wetting and drying, single mid-season water drainage, dry seeding) • Use biodegradable plastic film for rice cultivation
Crops: crosscutting	120	• Boost crop yields per hectare (thereby reducing cropland needs per given amount of crop production, reducing emissions per hectare, and liberating land for restoration)
Fertilizers	160	• Reduce overapplication of fertilizers (e.g., (Government of China, 2022a) “4R management” = right amount, right type, right time, and right place) • Increase plant absorption of fertilizers (nitrogen use efficiency) through management changes, nitrification

		inhibitors, and/or • breeding for biological nitrification inhibition into crops • Boost crop yields via better breeding and varieties (thus reducing the need for more fertilizers) • Use nitrogen-fixing legumes in crop rotations and inter-cropping
Food processing and packaging	110	• Improve energy efficiency. • Shift to renewable energy sources. • Reduce food packaging
Direct agriculture energy use	120	• Improve the energy efficiency of farm equipment. • Shift to renewable energy sources for farm equipment. • Electrify farm equipment
Indirect agriculture energy use		• Reduce NH_3 and N_20 emissions during fertilizer manufacturing. • Improve energy use efficiency during fertilizer, film, and pesticide production
Total	980 $MtCO_2eq$	

1.4. Adaptation Targets or ambitions reflected in NDC

China has developed the National Strategy for Climate Change Adaptation, 2035, to fulfill the NDC commitments in the new situation. The national strategy strengthens the integration of adaptation actions with economic and social development goals, as well as developing a work plan for climate change adaptation over the next 15 years. To build a climate-resilient and climate-smart society, China will vigorously improve the national guaranteed capacity for climate security and comprehensively enhance climate resilience in natural ecological, economic, and social fields. Table 4 shows the National Climate Change Adaptation Strategy highlights.

Table 4: Adaptation Targets in National Climate Change Adaptation Strategy, 2035

Area	Adaptation Targets
Establishment of a climate-change-adapted food security assurance system	• Implement the strategy of preserving farmland and improving agricultural technology, • Construct agricultural infrastructure based on the distribution of climate and climate-related disasters, • Establish and improve monitoring, forecasting, supply and demand, and risk-estimation systems, • Strengthen arable land protection, quality improvement,

	and land use controls • Promote the construction of high-standard farmland, achieving 177 million acres of such land by 2025, • Vigorously develop climate-smart agriculture. • For agricultural climate-change adaptation, technological innovation will be strengthened and demonstrated • Improve the agricultural weather service system and risk-sharing mechanisms, gradually promote weather index-based insurance, and explore agricultural catastrophe insurance mechanisms (Government of China, 2022b).
Carry out demonstrations of climate change adaptation technologies for agriculture	• By 2025, coupled with the construction of national agricultural high-tech industry demonstration zones and national modern agricultural science and technology demonstration zones, carry out climate change adaptation technology demonstrations in typical sensitive and vulnerable areas affected by climate change and build national-level demonstration bases. • By 2035, coupled with the construction of national agricultural science and technology parks and modern agricultural science and technology demonstration bases, several national-level demonstration bases for climate change adaptation technologies in agriculture, forestry, animal husbandry, fisheries, and aquaculture will be established (Government of China, 2022b).
Conduct climate-smart agriculture pilot demonstrations	• By 2025, build a climate-smart crop planting technology system, • Establish several experimental demonstration bases in the main grain-producing areas of north and northeast China. • By 2035, a perfected climate-smart agriculture (CSA) technology system will be constructed and promoted in well-positioned agricultural areas (Government of China, 2022b).
Carry out certification of climate-friendly, low-carbon agricultural products	By 2025: • Climate-friendly, low-carbon agricultural product certification standards will be drawn, • Synergies between adaptation and mitigation will be fully reflected, • High-value-added economic crops will be selected to carry out climate-friendly, low-carbon quality agricultural product certification pilots, • Quality climate-friendly, low-carbon agricultural product brands with local characteristics will be launched in key agricultural counties and cities, • By 2035, certification of climate-friendly, low-carbon agricultural products will be fully promoted (Government of China, 2022b).

1.5 Policy measures on mitigation and adaptation reflected in the NDC of China

As the world's largest emitter of GHGs, China has increased its efforts in recent years to promote low-carbon development by effectively mitigating GHG emissions, proactively enhancing climate resilience, and continuously improving systems and mechanisms. China has taken several policy measures and made national, regional, and international commitments to achieve carbon neutrality, including a recently published (July 1 2022) action plan aimed at reducing carbon emissions in agriculture and rural areas jointly released by the National Development and Reform Commission (NDRC) and the Ministry of Agriculture and Rural Affairs (MARA). Other initiatives include:

- China's goal of establishing an "Ecological Civilization" (MARA, 2021; The State Council, 2021). "Decreasing GHG emissions and increasing the carbon sink of agriculture and rural areas are critical measures for achieving carbon peaking before 2030 and carbon neutrality before 2060," President Xi Jinping stated (Government of China, 2022a)
- Furthermore, at the Climate Ambition Summit in December 2020, President Xi Jinping announced some additional commitments for 2030: China will reduce its CO_2 emissions per unit of gross domestic product (GDP) by increasing its total installed capacity of wind and solar power to over 1.2 billion kW (UNFCCC, 2021)
- China has also officially submitted its long-term, low-greenhouse-gas emission development strategy for the mid-century. China's targets are supported by the 14th Five-Year Plan (FYP), as well as its action plan for carbon dioxide peaking before 2030 and working guidance for carbon dioxide peaking and carbon neutrality (FYP)
- China has stated that it will strictly control coal consumption during the 14th FYP (2021–2025) and phase out coal consumption during the 15th FYP
- China has decided to accept the Kigali Amendment to the Montreal Protocol and tighten regulations on non-carbon dioxide emissions through the 14th Five-Year Plan. Non-CO_2 GHG reduction in agri-food systemsfeatures predominantly in China’s 2021–2025 five-year plan, National Determined Contributions (UNFCCC, 2021), 2060 climate goals, and other policies as a contributor to national priorities such as food security, climate neutrality, common prosperity, and public health (Government of China, 2022a).

Chapter Two: Scientific basis, data, and analytics behind NDC targets

In recent years, China has stepped up efforts to promote low-carbon development by effectively mitigating GHG emissions, proactively enhancing climate resilience, and continuously improving systems and mechanisms. China has also played a constructive role in the finalizing of the Paris Agreement and its rapid entry into force.

2.1. The process adopted

China has prepared the Nationally Determined Contributions as an update to the Enhanced Actions on Climate Change following paragraph 24 of Decision 1/CP.21 of the Conference of the Parties (COP) to the UNFCCC and the relevant requirements of the Paris Agreement. This includes policies and measures adopted and results achieved by China about NDCs, new goals and measures for enhanced climate-change action, and active efforts in international climate change cooperation. The goals are the result of several pledges made at various events. In April 2020, President Xi Jinping stated that "food security is an important foundation for national security" (Xinhuanet, 2020; Government of China, 2022a). In addition, China established a leading group on carbon peaking and carbon neutrality in May 2021 to strengthen overall planning, coordination, and promotion of the work to achieve carbon peaking and carbon neutrality (Government of China, 2021).

2.2. Scientific basis and data used

China's NDC fails to explain the scientific basis, data, and methodologies used in setting the various ambitions and targets. The targets, however, are the result of several commitments made at various events.

China, on the other hand, has clearly described the procedure used to create its third national communication report via the GHG Inventory, 2010. The 2010 agricultural inventory includes CH_4 emissions from livestock enteric fermentation, CH_4 and N_2O emissions from manure management, CH_4 emissions from rice cultivation, N_2O emissions from agricultural soils, and CH_4 and N_2O emissions from field burning of agricultural residues. The enteric fermentation inventory tracks CH_4 emissions from 12 different livestock species, including beef cattle, dairy cows, goats, and sheep (UNFCCC, 2018).

The CH_4 emissions from beef cattle, dairy cows, buffalo, yak, and other types of cattle, sheep, goats, and pigs were calculated using the Tier 2 method of the Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines, while those from other sources were calculated using the Tier 1 method. In manure management, the CH_4 emissions from pigs, beef cattle, dairy cows, poultry, buffalo, and goats were calculated using the Revised 1996 IPCC Guidelines Tier 2 method, while those from other sources were calculated using the Tier 1 method. CH_4 emissions from rice paddies were again estimated using China's rice paddy methane model (CH_4 MOD) that was developed using the methods of the Revised 1996 IPCC Guidelines and Chinese statistical data.

According to the Revised 1996 IPCC Guidelines, the model (CH_4 MOD) is a Tier 3 method. The N_2O emissions from farmland were calculated by adding the emissions from different provincial and regional farmlands using the regional nitrogen-cycling model (IAP-N) that was rated as a Tier 2 method in the 2006 IPCC Guidelines. The CH_4 and N_2O emissions from agricultural residue field burning were calculated using Tier 1 of the Revised 1996 IPCC Guidelines (UNFCCC, 2018). Further, the activity

data of enteric fermentation, manure management, rice paddies, and farmland were mainly from the China Statistical Yearbook-2011, China Animal Husbandry Yearbook 2011 and 3rd agricultural census results, and the Department of Animal Husbandry, Ministry of Agriculture (MOA) (UNFCCC, 2018).

The CH_4 MOD was used to calculate the factors of CH_4 emissions from rice paddies. The empirical formula was used to calculate the factors of CH_4 emissions from a flooded paddy field during the non-rice growing season. The emission factors of direct N_2O emissions from farmland were calculated using statistical analysis of nearly 30 years of observational data from various farmland categories. The emission factors for N_2O emissions from grazing were the Revised 1996 IPCC Guidelines default values. The direct emission factors of farmland were the emission factors of direct N_2O emissions from atmospheric nitrogen deposited into farmland. The factors of direct N_2O emissions caused by atmospheric nitrogen deposited outside farmland, as well as nitrogen leaching and runoff, were all set to default values of the 2006 IPCC Guidelines (UNFCCC, 2018).

Similarly, the inventory of Chinese GHGs from the waste sector in 2010 includes CO_2, CH_4, and N_2O emissions from municipal solid waste (MSW) treatment, as well as CH_4 and N_2O emissions from domestic, commercial, and industrial wastewater treatment. The solid waste sector inventory reports GHG emissions from municipal solid waste landfills, incineration, and biological treatment (UNFCCC, 2018).

GHG emissions from municipal solid waste landfills were calculated using the first order decay (FOD) model from the 2006 IPCC Guidelines (Tier 2), while emissions from incineration and biological treatment were calculated using the Revised 1996 Guidelines and IPCC Good Practice Guidance (GPG) 2000. GHG emissions from wastewater treatment were calculated using the Revised 1996 Guidelines, IPCC GPG 2000, and the 2006 IPCC Guidelines (UNFCCC, 2018). The MSW landfill activity data (AD) were obtained from the China Urban-Rural Construction Statistical Yearbook and the China Population & Employment Statistical Yearbook (UNFCCC, 2018).

The CH_4 emission factors from municipal solid waste landfills were country-specific values. In the inventory year, the emission factors for CH_4 and N_2O emissions from industrial, domestic, and commercial wastewater treatment were country-specific values. The emission factors for CH_4 and N_2O emissions from biological waste treatment were the IPCC GPG 2000 default values. The emission factors for CO_2, CH_4, and N_2O emissions from waste incineration were determined using the scope of default values in the IPCC GPG 2000 and 2006 IPCC Guidelines to select emission factors that were appropriate for China's actual circumstances (UNFCCC, 2018).

2.3. Analytics behind NDC targets (Adequacy and feasibility)

China is the world’s largest food producer (He, Li & Zhang, 2020). According to 2014 figures, China produces 50% of the world's vegetables, 29% of the world's meat, 70% of the world's fish, 30% of the world's rice, 17% of the world's corn, and 15% of the world's wheat (Ghose, 2014). Agriculture, agribusiness, food processing, packaging, transportation, wholesale and retail trade, food services, finance, insurance, advertising, and input supplies account for 23% of China’s GDP and employ 30% of its workforce (Fan et al., 2023). Overall, China's NDC has failed to set quantifiable and measurable targets in the agricultural sectors, as shown in the analysis breakdown as shown in Table 5.

Table 5: Current GHG emissions and reduction targets

Categories	GHG Emission in 2010 (Mt CO_2 eq)	Broad targets for GHG reduction
Agriculture	828	• NDC fails to mention quantified targets
Waste	132	• NDC fails to mention quantified targets
LULUCF	-993	• BY 2030 forest stock volume will increase 6 billion cubic meters over the 2005 level (Government of China, 2021).
Overall		• CO_2 emissions peak before 2030 and achieve carbon neutrality before 2060 (UNFCCC, 2021). • By 2030, the proportion of non-fossil energy in energy consumption will reach about 25%, and the total installed wind and solar power capacity will reach over 1.2 billion kilowatts (Government of China, 2021). • By 2060, China will have fully established a clean, low-carbon, safe, and efficient energy system, reached energy efficiency at international advanced levels and improved the proportion of non-fossil fuels in energy consumption up to over 80% (Government of China, 2021).

The NDC specifically mentions productive and regenerative agriculture, a healthy and productive ocean, stronger and better-adapted rural livelihoods, and decreased food loss/waste. However, it fails to provide the specific pathways that China will take in achieving this, making it difficult to understand China's targets of carbon neutrality by 2060. In addition, issues such as sustainable healthy diets, digitalized and efficient food and land use systems, and gender and equal access are largely absent from China's NDC.

Further, the analysis of the breakdown of food systems and its inclusion in the NDC revealed that most activities of food systems are poorly mentioned. Specifically, the activities related to food production have very little or zero mention. The Chinese government aims to increase the forest stock volume by 6 billion m^3 from the 2005 level by 2030. The targets seem ambitious as it has not been able to reflect clear pathways to achieve them. Another component of the food system, i.e. marketing and consumption, has no specific information or targets in the NDC. Lastly, reducing food loss and waste management was mentioned in the NDC without having specific targets.

Table 6: Qualitative assessment of the food systems inclusion in NDC

Systems	**What is included**	**Adequacy of the NDC (High, Medium, Low)**
Production activities	No specific information on food production activities. However, the NDC touched slightly upon the adaptation/mitigation activities that China has carried out recently.	NDC does not mention any specific information on policy interventions for the critical transition. **Overall Rating: Low**
Transportation	China will accelerate the construction of a comprehensive transportation network, channel energy into multi-modal transportation, and increase the share of railways and waterways in integrated transportation, constantly reducing the energy consumption and carbon intensity of transportation	China's NDC has prioritized the transportation sector. However, it has not been specific as to transportation sector enhancement related to the food system. **Overall Rating: Medium**
LULUCF	NDC aims to increase the forest stock volume by 6 billion m^3 from the 2005 level. China's forest stock volume has increased by 2.423 billion m3 and the forest coverage rate has increased from 21.63% to 22.96%. The National Forest Fire Prevention Plan (2016–2025) was issued and implemented to strengthen forest disaster prevention and control.	China has prioritized the increment of the carbon sink potential. However, it has not set specific quantified pathways to achieve such a target. **Overall Rating: Medium**
Marketing and consumption	No specific information on food production activities	NDC does not mention any specific information on policy interventions for the critical transition. **Overall Rating: Low**
Reducing food loss and waste management	The NDC mentions the release of the Code of Conduct for Environmental Protection (Trial) to encourage the public across the country to practice low-carbon lifestyles through measures such as energy conservation and green consumption. Public attention has been especially drawn to food security, and the "empty-plate" campaign has been launched nationwide to reduce food waste.	NDC has not set specific targets for reducing food loss and waste management, however, it has touched upon the promotion of activities like minimizing food waste and waste to energy. **Overall Rating: Medium**

Note: High: Highly sufficient and highly adequate interventions proposed; Medium: adequate and sufficient; Low: inadequate and insufficient

Adequacy and feasibility of adaptation targets

Overall, the adequacy of China's adaptation targets in the NDC was found to be low, given the country's global contribution to GHG emissions, vulnerability, and risks. Future climate risk and vulnerability in agriculture were found to be very high, whereas the Chinese government's adaptation activities and targets were found to be relatively low. The adaptation component is mentioned fairly in the NDC but was not found to be sector-specific or comprehensive.

Table 7: Adaptation adequacy rating of Chinese NDC

Category	**Overall Rating**
A. Future Climate Risk and Vulnerability in the Agriculture Sector	**Overall Rating: Very High (5)** Agricultural growing seasons will lengthen and the risk of extreme heat episodes will increase. Storms may intensify, but warming temperatures are likely to enhance drying in already-dry areas, so both droughts and floods may increase (JGRI & BMI, 2009). Overall, climate change will reduce food production, raise prices, increase net imports of most food, and lower China's overall food self-sufficiency. Considering the impact of temperature and precipitation on grain yield, climate change will certainly have an impact on China's food security (Xie et al., 2019).
B. Adaptation activities and targets	**Overall Efforts rating: Medium (3)** The NDC mentions the preparation of the National Strategy on Climate Change Adaptation. It also mentions the adaptation practices that China has been taking in key areas including agriculture.
Differences in the degree of risk and level of adaptation efforts = Gap	**Overall Gap rating: Low (2)**

Rating: Very high (5), high (4), moderate (3), low (2), very low (1)

Chapter Three: Missing data gaps

A few studies have rated the Chinese NDC as insufficient, one of the reasons being its failure to give the breakdown of each sector's clear pathways for achieving its goals. Furthermore, China's NDC submitted an unconditional NDC target but did not specify the level of emissions achievable with international assistance (a conditional target) (CAT, 2021). China's NDC lacks quantified data on food system sub-sectors. The emissions and thus the potential reduction trajectories of important components of food systems such as production activities, food processing, transportation, marketing, consumption, and food loss & waste are largely absent from documents submitted to the UNFCCC (i.e. both NDC and Third National Communication). As a result, the NDC fails to set any quantifiable targets for those sub-sectors. Although China is one of the major global importers of food, both the NDC and the TNC fail to account for the emissions associated with food imports. Table 8 shows the adequacy and the missing context/gaps in China's NDC and other relevant documents.

On the other hand, the Chinese government has taken several initiatives to strengthen the data collection system for climate change. They have established a national system for the preparation and reporting of National Communications on Climate Change since the Initial National Communication on Climate Change and formed a team for the preparation of National Greenhouse Gas Inventories and Biennial Update Reports. China continues to provide update reports in the form of Biennial Update Reports (BUR) as a form of communication material. In 2016, appropriate accounting and reporting methods were established, as well as assessments of each province's implementation of target tasks.

Developing countries must build national capacity for measurement, reporting, and verification (MRV) to effectively address climate change. The Chinese government places a high value on basic climate change work and capacity building. The "Twelfth Five-Year Plan" Greenhouse Gas Emissions Control Work Plan was issued by the State Council of China in November 2011, requiring the establishment of a national, local, and corporate three-level basic statistics and accounting system for greenhouse gas emissions, as well as strengthening monitoring, evaluation, and assessment. The National Development and Reform Commission and the National Bureau of Statistics issued "Opinions on Strengthening Statistical Work on Climate Change" in May 2013, requiring all regions and departments to prioritize statistical work on climate change.

The National Development and Reform Commission issued the "Notice on Organizing and Carrying Out the Reporting of Greenhouse Gas Emissions of Key Enterprises (Institutions)" and the "Responsibility Assessment Measures for Reducing Carbon Dioxide Emissions per Unit of GDP" in 2014. Scientists from the IEDA-CAAS have developed methods for calculating GHG emissions from livestock and poultry farmers, which have been published as an industrial standard by the Ministry of Agriculture and Rural Affairs, PRC (Prof Hongmin Dong, personal communication). All of these initiatives help to promote data retention and thus MRV systems. Despite the presence of these instruments, the documents submitted by China to the UNFCCC appear to be unquantifiable, unmeasurable, and not disaggregated. In China's NDC, a proper breakdown of the system and timewise target trends and scenarios is largely missing, necessitating updates.

On July 1 2022, the National Development and Reform Commission (NDRC) and the Ministry of Agriculture and Rural Affairs (MARA) jointly released an action plan aimed at reducing carbon emissions in agriculture and rural areas. The plan proposes ten

major actions in these areas in crop, livestock and fisheries production as well as means of increasing carbon sequestration and improving energy-efficiency in production. This is not only highly significant for China's climate mitigation and adaptation efforts, but also for the acceleration of agricultural modernization, rural revitalization, and the promotion of a rural ecological civilization and the targets in this plan should be included in China's NDC.

Table 6: Analysis of the data and information reflected in the NDC

Data and information management	Focus of NDC
Availability of information on the mitigation targets	The NDC of China has set overall mitigation targets in its updated NDC, but it fails to provide data, the basic, present context and the targeted scenarios.
Availability of information on emissions	The TNC of China gave sufficient information on the data and the methods used to generate GHG emission levels.
Availability of information on GHG reduction	The NDC has broadly mentioned the overall reduction of GHGs and aims to be carbon neutral by 2060. However, the NDC has not provided clear, sector-specific and disaggregated emission reduction models or trajectories.
Submission of other required information to UNFCCC	Besides the NDC, China has submitted various other requirements of UNFCCC. These include the third national communication report and GHG inventories in 2018, the second BUR in 2018, and the Mid-Century Long-Term Low Greenhouse Gas Emission Development Strategy in 2020. However, these documents also failed to provide quantified targets.
Carbon accounting system	The NDC states that China will press on with the capacity-building of carbon emission statistical accounting and accelerate the construction of a unified and standardized statistical accounting system for carbon emissions. The working mechanism for national and local GHG emission inventories will be improved, and a compliance reporting system with the full participation of all sectors will be established. However, the quantified ambitions or the targets are missing.
Strengthen the Supporting and Safeguard Systems	The NDC states that China will comprehensively clear existing laws and regulations that are incompatible with the work of carbon peaking and carbon neutrality, fortify the coherence of laws and regulations, research the formulation of special laws on carbon neutrality, expedite the formulation of an energy conservation law, electricity law, coal industry law, renewable energy law, circular economy promotion law, etc., and strengthen the pertinence and effectiveness of relevant laws and regulations.
Technological advancement	The NDC mentions harnessing next-generation information technology to provide more support for climate change monitoring, impact, and evaluation, and states that a dynamic and systematic climate change monitoring and evaluation system will be established.

Chapter Four: Additional mitigation options and their abatement potential for the possible update of NDC

China's domestic target for 2030 needs substantial improvements in ambition to be consistent with the 1.5°C temperature limit. If all countries were to follow China's approach, warming would reach above 2°C and up to 3°C. This rating takes into account that the part of China's domestic target consistent with the 1.5-degree limit would need international support (CAT, 2021).

4.1. General recommendations

Food system management: Food systems are responsible for a third of global anthropogenic greenhouse gas (GHG) emissions (Xu et al., 2021). The carbon footprint of China's agrifood system is high as it also includes GHG emissions from imported food used for domestic processing and/or consumption. Therefore, China should focus on the management of the food system (production, processing, transportation, and food waste management) to make it low-carbon emitting. China should pursue a program to ensure that the food it imports is low carbon, thereby helping reduce food supply GHG emissions (Government of China, 2022a).

Formulation of research-based plans: The NDC of China is lacking in accounts of how the commitments are set. There are key data gaps in the agriculture and food systems sector. Therefore, the government needs to invest in generating data and information on the analysis of GHG trends and scenarios and mitigation potentials in the sub-sectors of food systems, including the existing cropping systems and the use of technology and practices.

4.2. Recommendation for adopting additional mitigation options

Ambitious and clear targets for the agriculture sector: The NDC describes multiple ambitions to reduce GHG emissions and reach carbon neutrality by 2060, but clear and quantified targets of the agriculture sector are largely missing. The agriculture sector only accounts for 7.9% of its overall GHG emissions, thus the Chinese government should focus on enhancing efforts and preparing a holistic action plan and sectoral targets (He, Li & Zhang, 2020). China should also focus on the quantifiable sectoral targets of its NDC.

Activity-specific GHG reduction pathways: The agriculture sector emitted approximately 828 Mt CO_2 eq, from enteric fermentation, manure management, rice cultivation, agriculture soils, and agricultural residues, accounting for 26.2%, 16.6%, 22.1%, 34.1%, and 1.0%, respectively (UNFCCC, 2018). The NDC fails to mention quantifiable ambitions to reduce such emissions from the these food production processes. The trajectories of each activity within a specific frame within NDC are critical. For example, reducing emissions from food production-related activities until 2030, then reducing emissions by 50% in 2040, and then aiming for a carbon-neutral food system by 2060.

Food waste reduction and management: Reducing China's food loss and waste relative to the baseline would reduce agricultural GHG emissions by 2.0–5.6% by 2030 and 4.0–7.0% by 2060. (AGFEP, 2021). There is opportunity to reduce GHG emissions by around 7% from the food waste sector alone. Reducing food loss and waste would also improve food security, reduce financial losses for farmers and consumers, and

have a positive impact on the environment (e.g., GHG emissions, water consumption, pesticide/fertilizer pollution) (Government of China, 2022a).

Promote sustainable livestock production: The production of animal-derived food (ADF) accounts for 19% of global anthropogenic greenhouse gas (GHG) emissions and therefore sustainable livestock production is an important for reducing GHG emissions. China should promote better animal husbandary practice e.g. better feed management, genetic improvement, management of livestock health and quantify their mitigation potential to include them in its updated NDC. China should also include GHG emissions reduction by promoting better manure management systems, rangeland and forest protection and sustainable grazing and pasture management in its NDC.

Promote low-carbon diets: By 2050, the world's dietary trends, if not controlled, will be a major contributor to an estimated 80% increase in global agricultural GHG emissions (Zhong et al., 2020). Reducing the consumption of unhealthy, unsustainable, carbon-intense diets could reduce GHG emissions by 150 million to 200 million metric tons by 2030, a reduction of 18–25% (AGFEP, 2021). A reduction in unhealthy diets could contribute to China's aspiration of achieving its carbon neutrality and food security (Government of China, 2022a). A study carried out by Qi et al. (2022), posited that transformation of the nutrient-oriented dietary pattern of China would lead to a 14.9% decrease in GHG emissions from the food system that can be included in its updated NDC.

Fertilizer-induced emission reduction:

China has implemented zero fertilizer growth policy, an initiative aimed at reducing excessive use of chemical fertilizers in agricultures to address environmental concerns including GHG emissions. Fertilizer consumption has decreased since the implementation of this policy. GHG emissions reduction of such policy should be quantified and included in its updated NDC.

Minimize the use of fossil fuels in the agri-system: China's fossil-fuel CO_2 ($FFCO_2$) emissions accounted for approximately 28 % of the global total $FFCO_2$ in 2016. A study by Han et al. (2020) shows that total emissions increased from 3.4 (3.0–3.7) in 2000 to 9.8 (9.2–10.4) Gt CO_2 per year in 2016. Thus, reducing inefficiency and the use of fossil fuels in the agriculture sector is essential to help China reduce its overall reduction in GHG emissions. Options could include renewable energy sources for farm equipment, food storage, and transportation (Government of China, 2022a).

Technological advancement and promotion of climate-smart agriculture: Energy consumption is the primary source of carbon emissions. China's energy consumption accounts for more than 90% of its carbon emissions. China needs to quantify systematic approaches and agricultural strategies that can ensure sustainable food production under predicted climate change scenarios, e.g., climate-smart agriculture. Climate-smart agriculture emphasizes improving risk management, enhancing information flows, and promoting local institutions to increase the adaptive capacity of communities to climate change (Campbell et al. 2014). The agriculture sector in China accounts for 7.9% of GHG emissions, thus CSA could contribute to reducing the emissions.

Promote Green Financing: by establishing a clear framework for green financing within the agricultural sector, making it easier for farmers and agricultural businesses to access funding for adaptation and mitigation options within food systems. This can be done by encouraging financial institutions to offer preferential loans for regenerative

agricultural practices that have lower GHG emissions and promote C sequestion, by promting partnerships between financial institutions, agricultural stakeholders and government agencies to develop innovative financial products tailored to low-emission food sytems

Repurposing Agricultural Subsidies: to ensure that agricultural subsides are aligned with low-emission pathways. This may involve reducing subsidies to practices that are environmentally harmful (e.g. intensive tillage, irrigation, fertilization etc) and increasing support for regenerative practices such as conservation agriculture, residue recycling, energy-efficient machinery, precision nutrient/water management etc. The government could also introduce tax incentives for farmers and businesses that follow such regenerative and low-emission systems.

Enhance Data Collection and Monitoring: Develop robust data collection and monitoring systems to track emissions from the food systems accurately. This will enable evidence-based decision-making and the adjustment of policies as needed.

Preparation of detailed NDC implementation plans: With the NDC and other policy instruments in place, China should aim to prioritize the preparation of the NDC implementation plan. The plan should provide clear and quantified short, medium, and long-term low-carbon development pathways in the food system management.

References

Academy of Global Food Economics and Policy (AGFEP). 2022. Reforming agricultural support policies to transform agrifood systems. http://agfep.cau.edu.cn/art/2022/5/24/art_39031_861011.html

Campbell, B.M., Thornton, P., Zougmoré, R., Van Asten, P. and Lipper, L., 2014. Sustainable intensification: What is its role in climate smart agriculture?. *Current Opinion in Environmental Sustainability*, *8*, pp.39-43.

Climate Action Tracker (CAT). 2021. *Climate Action Tracker Data Portal*.

Fan, S., Huang, J., Zhang, F., Zhao, W., Song, H., Nie, F., Sheng, Y., Wang, J., Bi, J. and Cong, W., 2023. Transforming Chinese food systems for both human and planetary health. *Science and Innovations for Food Systems Transformation*, p.779.

Ghose, B., 2014. Food security and food self-sufficiency in China: from past to 2050. *Food and Energy Security*, *3*(2), pp.86-95.

Government of China. 2021. Mid-century long-term low greenhouse gas emission development strategy.

Government of China. 2022a. Sustainable Agrifood Systems: Meeting China's Food and Climate Security Goals. China Council for International Cooperation on Environment and Development (CCICED) Special Policy Study

Government of China. 2022b. National Climate Change Adaptation Strategy 2035.

Han, P., Zeng, N., Oda, T., Lin, X., Crippa, M., Guan, D., Janssens-Maenhout, G., Ma, X., Liu, Z., Shan, Y. and Tao, S., 2020. Evaluating China's fossil-fuel CO 2 emissions from a comprehensive dataset of nine inventories. *Atmospheric Chemistry and Physics*, *20*(19), pp.11371-11385.

He, J., Li, Z., & Zhang, X. 2020. China's Long-term Low-carbon Development Strategies and Pathways. *Beijing: Tsinghua University*.

Joint Global Change Research Institute and Battelle Memorial Institute. 2009. China: The Impact of Climate Change to 2030: A Commissioned Research Report.

Ma, J., Zadek, S., Sun, T. Y., Zhu, S. Q., Cheng, L., Eis, J., ... & Stumhofer, T. 2019. Decarbonizing the Belt and Road: A green finance roadmap. Tsinghua University Center for Finance and Development, Vivid Economics, and the Climate works Foundation. www. climateworks. org/wp-content/uploads/2019/09/Decarbonizing-the-Belt-and-Road_report_final_lo-res. pdf.

Ministry of Agriculture and Rural Affairs (MARA). 2021. Notice on Printing and Distributing the 14th Five-Year National Agriculture Green Development Plan. http://www.moa.gov.cn/nybgb/2021/202109/202112/t20211207_6384020.html

Partnership for Market Readiness, & National Center for Climate Change Strategy and International Cooperation. 2016. *Pursuing an Innovative Development Pathway: Understanding China's NDC*. World Bank.

Qi, X., Huang, X., Feng, K., Yang, H., Zhong, T., Thompson, J. and Scott, S., 2022. Cutting carbon emissions from China's food system by supply-demand coordination and optimizing spatial allocation of production.

The State Council. 2021. Action Plan for Carbon Dioxide Peaking Before 2030. http://english.scio.gov.cn/topnews/2021-10/27/content_77835815.htm

UNFCCC. 2018. The People's Republic of China Third National Communication on Climate Change. Government of China.

UNFCCC. 2021. China's Achievements, New Goals, and New Measures for Nationally Determined Contributions. Government of China.

Wang, R., Bai, Z., Chang, J., Li, Q., Hristov, A.N., Smith, P., Yin, Y., Tan, Z. and Wang, M., 2022. China's low-emission pathways toward climate-neutral livestock production for animal-derived foods. *The Innovation*, *3*(2).

Xie Wei, Wei Wei, & Cui Qi. 2019. Bibliometric meta-analysis of the impact of climate change on the unit yield of major grain crops in China China's population, resources, and environment, 29 (01), 82-88

Xinhuanet. 2020. Why did this matter become an "eternal topic" in the mind of the General Secretary. https://news.china.com/zw/news/13000776/20200723/38531294.html

Xu, X., Sharma, P., Shu, S., Lin, T.S., Ciais, P., Tubiello, F.N., Smith, P., Campbell, N. and Jain, A.K., 2021. Global greenhouse gas emissions from animal-based foods are twice those of plant-based foods. *Nature Food*, *2*(9), pp.724-732.

Zhong, V.W., Van Horn, L., Greenland, P., Carnethon, M.R., Ning, H., Wilkins, J.T., Lloyd-Jones, D.M. and Allen, N.B., 2020. Associations of processed meat, unprocessed red meat, poultry, or fish intake with incident cardiovascular disease and all-cause mortality. *JAMA internal medicine*, *180*(4), pp.503-512

Mitigate+: Research for Low-Emission Food Systems

CGIAR

AUTHORS
Tek B Sapkota, Bimal Regmi, Apar Paudyal, Regan Sapkota and Rosy Joshi. International Maize and Wheat Improvement Center (CIMMYT)

ACKNOWLEDGEMENTS
We would like to thank all funders who supported this research through their contributions to the CGIAR Trust Fund: https://www.cgiar.org/funders/

To learn more, contact: t.sapkota@cgiar.org

To learn more about Low Emission Food Systems, please contact:
l.verchot@cgiar.org; w.zhang@cgiar.org

ABOUT Research on Low-Emission Food Systems

Supports co-creation of knowledge, information, and tools needed to make robust evidence-based decisions for food system transformation toward low-emission pathways.

ABOUT CGIAR

CGIAR is a global research partnership for a food secure future. Visit https://www.cgiar.org/research/cgiar-portfolio to learn more about the initiatives in the CGIAR research portfolio

DISCLAIMER