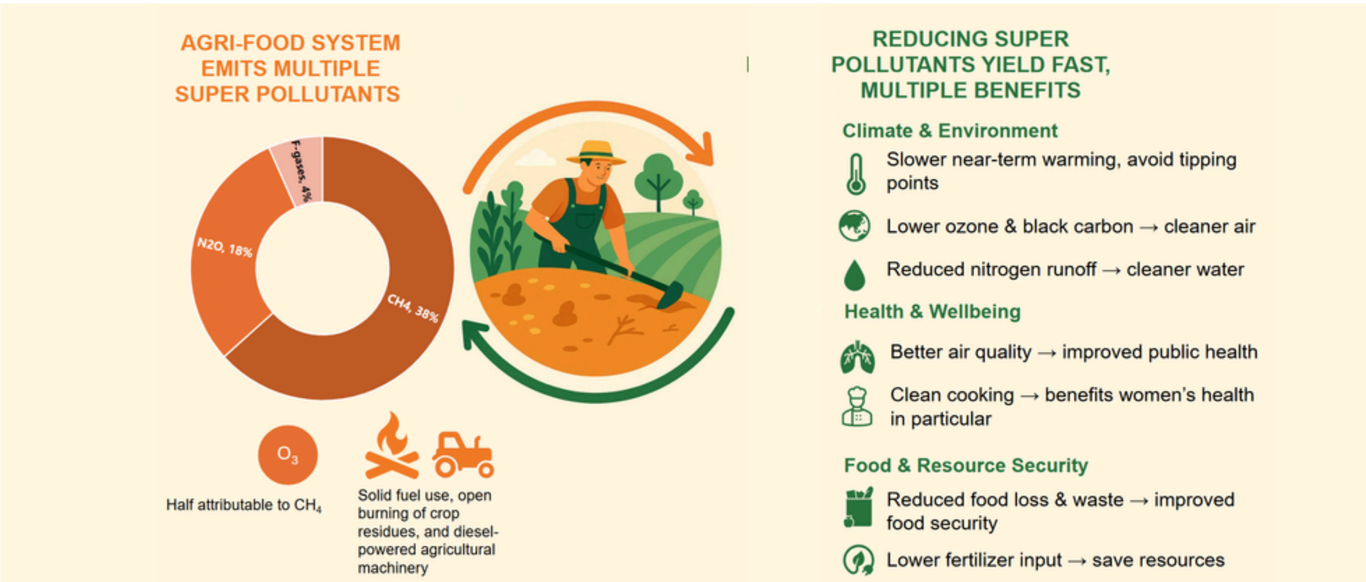
Agri-Food Super Pollutants Reduction in China: Accelerating a Green and Low-Carbon Transition to Unlock Co-benefits

Super pollutants—including methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), black carbon, and ground-level ozone (O_3)—are responsible for nearly **45% of global warming effects**[1]. Agri-food systems are a major source, generating **16.2 billion tons of CO_2e** in 2022, including 38% from methane, **18%** from N_2O, and **4%** from fluorinated gases[2]. Methane is also a key precursor of ground-level ozone, contributing to about half of its global increase. Both methane and ground-level ozone harms crops, respiratory health and food security[3].

Agri-food systems are also closely associated with black carbon emissions, primarily from solid fuel use, open burning of crop residues, and diesel-powered agricultural machinery. These emissions harm crops and reduce yields by depositing particles on plant surfaces[4]. Millions of deaths each year around the globe are attributed to air pollution from the incomplete combustion of solid fuels used for cooking, with women and children disproportionately affected[5].

Cutting super pollutants from agri-food systems delivers climate, health, and economic co-benefits: slowing warming, improving air quality, reducing food loss and waste, and protecting water resources.

Figure 1. The Agri-food System and Super Pollutants — A Cycle of Emissions and Co-benefits



Source: iGDP

This policy brief focuses on three priority areas where super pollutants are closely linked to China's agri-food system and examines how advancing super pollutant reduction can unlock significant climate, health and economic co-benefits:

1. **Nitrogen fertilizer use and nitrous oxide (N_2O) emissions**
2. **Food loss and waste (FLW) and methane emissions**
3. **Rural energy and black carbon (BC) emissions**

Nitrogen Fertilizer Use & Nitrous Oxide Emissions

Problem:

While nitrogen fertilizer plays a vital role in boosting crop yields and agricultural income, excessive application has led to significant environmental challenges. In China, **nitrous oxide (N_2O) emissions from fertilizer production and use account for 33%** of national totals.[6] Despite recent policies to reduce fertilizer use, application intensity remains far above the internationally recognized safe threshold[7] (293 kg per hectare vs. 225 kg per hectare). Fertilizer runoff is the main source of nitrate contamination in surface water (**26.9%**), posing health risks in the Hai and Yellow River basins, where children's safety limits are exceeded in **12%** and **46%** of cases.[8] Over-application also causes direct economic losses of **RMB 15.55 billion**.[9]

Solution: Scientific use of nitrogen fertilizer

Ensuring food security and farmer income remains a priority, but reducing and improving nitrogen fertilizer use is critical. Solutions include **improved fertilizers** (slow-release, nitrification inhibitors, organic) and **precision practices** such as soil testing, crop nutrient planning, and integrated water–fertilizer systems. Research suggests these measures could cut China's chemical nitrogen demand by up to **25%** from 2023 levels.[10]

Benefits:

- Direct N_2O emissions from Chinese farmland in 2022 were **17%** lower than in 2015.[11]
- Incorporating organic amendments into chemical fertilizers can improve soil quality by **17.6%-26.3%** .[12]

- Adopting technologies in crops and livestock production to reduce ammonia volatilization could prevent. approximately **74,300** premature deaths attributed to PM2.5 exposure.[13]

- Nitrification inhibitors can increase staple crop yields by about **9%** .[14]
- Soil testing for wheat and rice can boost farmers' income by **RMB 531.64/ha** and **RMB 492.15 /ha** , respectively.[15]

Food Loss and Waste & Methane Emissions

Problem:

Food loss and waste (FLW) in agri-food systems not only worsen global food security but also impose severe environmental and economic costs. In 2022, China generated **460 million tons of food loss and waste**, with post-harvest and storage stage accounting for **41.6% of its total food production**—far higher than the UK (4.8%) and Japan (10.5%)[16]. This wasted food, equal to **22.3% of agricultural output value**, could meet the annual nutritional needs of **190 million people**[17]. Additionally, FLW is a significant source of GHG emissions and air pollutants. In China, FLW contributed to **3.7% of GHG emissions**[18] and released **161,000 tons of ammonia, 24,000 tons of PM2.5**, and **56,000 tons of NOx**[19] into the atmosphere in 2023.

Solution: Sustainable food cold chain

The lack of an effective cold chain system is a major driver of food loss, directly affecting food quality, nutritional value, and safety—ultimately impacting public health[20]. Developing sustainable cold chain logistics is essential to reduce post-harvest losses, curb food waste, increase farmer incomes and support rural revitalization. Currently, China's cold chain transport rates for fruits and vegetables, meat, and aquatic products are **35%, 57%, and 69%**, respectively—far below the **90%+ average in developed countries**[21]. This gap signals significant growth potential for sustainable food cold chain.

Benefits:

- Cold chain infrastructure saved **49.21km^3** of water and avoided **4.7** million tons of CO_2e emissions[22] in the 14th Five Year Plan period.
- Reaching developed-country cold chain levels could cut food loss-related GHG emissions by **~70%** by 2035.[23]

- The average agricultural product loss rate dropped **from 19.7% to 7.1%**, equivalent to **RMB 53 billion** .
- Created **1 million** jobs and added **RMB 18 billion** in labor income.[24]

- Slows spoilage, reducing food safety risks and foodborne diseases.
- Cuts nutrient loss: Vitamin A by over **25%** , Vitamin E by over **40%** .[25]

Rural Energy & Black Carbon Emissions

Problem:

Solid fuel used for cooking, heating and diesel-powered farm machinery emits large amounts of **black carbon (BC)**, a super pollutant with a warming potential up to **1,500 times greater than CO_2**.[26] In 2021, global BC emissions were 5.28 Mt, with **China contributing 16.1%**; **34%** of this came from residential use of solid fuels in rural areas.[27] Nearly **40%** of black carbon (BC) emissions from **non-road machinery** in China came from **diesel-powered agricultural equipment** in 2020[28]. BC exposure is linked to approximately **74,500 short-term** and **538,400 long-term premature deaths**[29] nationwide.

Solution: Rural energy transition

Transitioning rural cooking and heating **away from solid fuels** (coal, crop residues) and promoting **electrification of agricultural machinery** are critical to cutting black carbon emissions and their harmful impacts. China should expand access to cleaner energy—natural gas, electricity, renewables—while developing centralized heating or promoting household-level solutions such as electric cookers, heat pumps, and gas boilers. Electrifying agricultural machinery by accelerating R&D and adopting electric equipment to replace diesel-powered machinery would reduce both environmental and health risks.

Benefits:

- Under a carbon neutrality scenario[1], decarbonizing rural cooking and heating could lower PM2.5 concentrations in northern China by **1.9–5.4 μg/m³** by 2050.[30]
- Replacing one large diesel tractor with an electric model can cut **19** tons of CO_2e and **0.06 tons** of pollutants/year.[31]

- Decarbonizing rural cooking and heating nationwide could avoid about **75,500** PM2.5 related premature deaths by 2050, with **69%** of benefits concentrated in northern China.[32]

- Clean cooking significantly improves rural women's physical and mental health[33] and increases labor participation by **0.9 days/week**.[34]
- Switching from diesel to electric tractors can reduce annual energy costs by **70%**.[35]

[1] Under the carbon neutrality scenario, the direct CO_2 emissions cap from rural cooking and heating for each province would reduce by 25–35% in 2035 and 90–95% in 2060, respectively, compared with the 2014 level.

Opportunities and Recommendations for Reducing Super Pollutants in China's Agri-Food System

Actions to cut CH_4, N_2O, and BC emissions in agri-food systems deliver triple benefits—climate, health, and socio-economic. Meanwhile, with strong policy support, financial incentives, and emerging agricultural actors, China faces a unique opportunity to accelerate super pollutant reduction.

Multiple policy windows are already open for actions to reduce super pollutants, with local implementation as the key factor:

- **China's Nationally Determined Contribution (NDC):** Targets a 7–10% reduction in net GHG emissions by 2035 from the peak level and calls for controlling agricultural CH_4 and N_2O emissions.
- ***Implementation Plan for Synergistic Reduction of Pollution and Carbon Emission:*** Proposes measures such as fertilizer efficiency improvements, optimized irrigation, straw utilization and burning control, and clean rural energy.
- ***Zero-Waste City Implementation Plan:*** Promotes organic fertilizer use, straw return, livestock waste recycling, and clean energy supply to cut super pollutants.
- ***Methane Emissions Control Action Plan:*** National and provincial initiatives to curb CH_4 emissions, reinforcing local implementation.

China offers strong economic drivers for cutting super pollutants, with support from financial measures and voluntary carbon markets.

- **Green finance:** The 2025 Green Finance Catalogue supports electric farm vehicles, efficient machinery, precision fertilization, new fertilizers, crop rotation, and clean heating infrastructure.
- **China's voluntary carbon market:** Methodologies for resource utilization of crop residues and food loss are now soliciting public opinion, signaling broader inclusion of super pollutants emission from agri-food system in China's carbon market.

New agricultural business entities are driving cost reduction and efficiency gains while enabling super pollutant mitigation.

- **Machinery Services:** Contracted operations and equipment leasing lower costs and improve efficiency, supporting adoption of advanced, cleaner machinery.[36]
- **Cold Chain Expansion:** During the 14^{th} FYP, 78,000 on-farm cold storage facilities were built, significantly reducing food loss.[37]
- **Precision Fertilization:** Coverage of soil testing has expanded by new agricultural business entities, reducing N_2O emissions and improving soil health.[38]
- **Resilience Infrastructure:** To address rising extreme weather risks, cooperatives are investing in mid-sized dryers and integrated service centers[39] for storage, cold preservation, initial processing, and agricultural waste management.

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