Environmental Defense Fund

UNLOCKING THE CO-BENEFITS OF AGRICULTURAL METHANE MITIGATION IN CHINA

—— CASE DEMONSTRATIONS AND PRACTICAL IMPLICATIONS

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1. GLOBAL AND CHINA'S AGRICULTURAL METHANE EMISSIONS

Total global methane emissions reached 580MtCO_2e in 2023 (IEA, 2024). Anthropogenic methane emissions from energy, agriculture, waste, and biomass burning amounted to about 351 MtCO_2e, of which agricultural methane emissions were approximately 145MtCO_2e, accounting for 41% of global anthropogenic methane emissions. Within agricultural methane emissions, livestock accounted for 110MtCO_2e (76%) and rice cultivation for 30MtCO_2e (21%) (Figure 2) (FAO, 2023; UNEP, 2025).

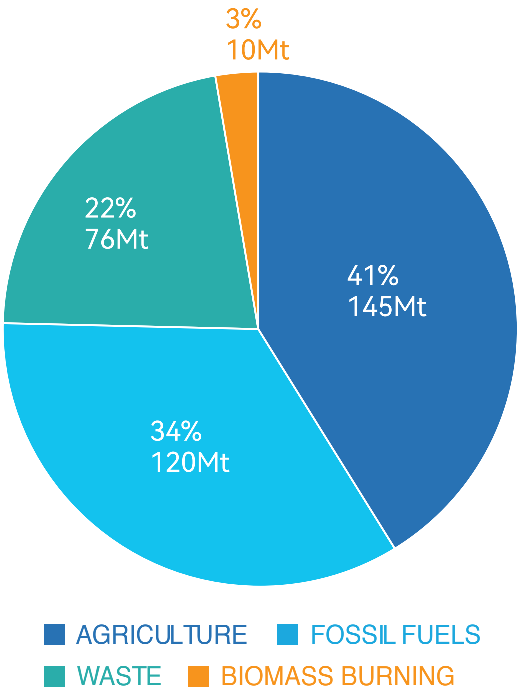

Figure 1. Global Anthropogenic Methane Emission Sources

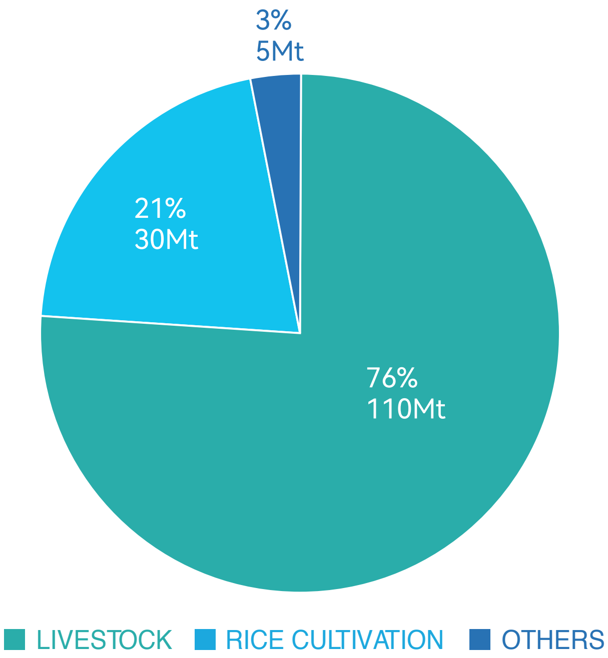

Figure 2. Global Agricultural Methane Emissions

According to China's First Biennial Transparency Report on Climate Change, China's total methane emissions (including land use, land-use change and forestry, LULUCF) reached 60.6Mt of CH_4 in 2021, of which agricultural methane emissions were about 24.3Mt, accounting for about 40% of China's total methane emissions (Figure 3). By subsector, livestock emissions were 15.3Mt (63% of agricultural methane) and rice cultivation emissions were 8.9Mt (36%) (Figure 4) (Ministry of Ecology and Environment of the People's Republic of China, 2024).

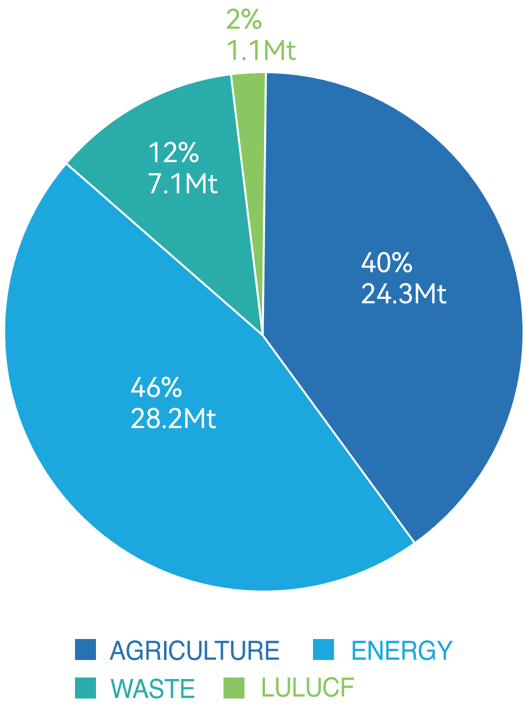

Figure 3. China's Anthropogenic Methane Emission Sources

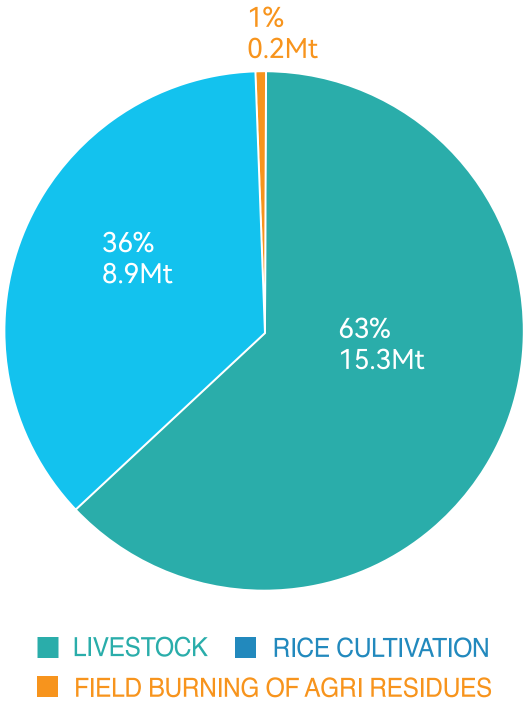

Figure 4. China's Agricultural Methane Emissions

2. MAJOR AGRICULTURAL METHANE MITIGATION TECHNOLOGIES AND MEASURES

Livestock farming and rice cultivation are the key emission sources of agricultural methane. Table 1 summarizes current major technologies and measures for agricultural methane mitigation, organized by sector and intervention category.

These measures work by either limiting methane production (e.g., suppressing methanogenic activity) or capturing methane before release (e.g., biogas recovery). For example, alternate wetting and drying (AWD) in rice paddies reduces soil anaerobic conditions, inhibiting methanogenic archaea. In livestock, feed additives such as 3-nitrooxypropanol (3-NOP) directly block the final step of methanogenesis in the rumen, while anaerobic digestion of manure captures biogas that would otherwise be emitted directly.

Importantly, most of these technologies also generate co-benefits beyond methane reduction: lower water and fertilizer use, reduced feed costs, improved animal productivity, and production of renewable energy or organic fertilizer. These co-benefits are essential for voluntary adoption by farmers and form the basis of the environmental, economic, and social multiple-benefits framework analyzed in the following sections.

Table 1. Major Agricultural Methane Mitigation Technologies and Measures

FIELD	CATEGORY	METHANE MITIGATION TECHNOLOGIES AND MEASURES	TECHNICAL DESCRIPTION
Rice Cultivation	Water Management	Alternate Wetting and Drying (AWD) Water Management	Adopts water management practices such as alternate wetting and drying irrigation to improve the soil redox environment and reduce methane emissions from paddy fields
	Organic Additives	Application of Specific Organic Additives	Regulates the microbial community in paddy soil, inhibits methanogens, and reduces methane emissions
	Fertilizers and Other Amendments	Application of Sulfate-Containing Fertilizers	Sulfates have an inhibitory effect on methanogens
	Cropping and Tillage Management	Direct Rice Seeding (DRS)	—
		Rice-Upland Crop Rotation, Fallowing	—
		Ridge and Furrow Cultivation	—
		Aerobic Rice Cultivation	Aerobic cultivation leverages the drought tolerance of water-saving and drought-resistant rice; irrigation is only applied during water-sensitive stages throughout the entire growth period after seedling emergence, without maintaining a permanent water layer
	Rice Variety Breeding	Breeding Low-Methane Emission Rice Varieties	Selects rice varieties with strong disease resistance, high photosynthetic efficiency, and low carbon emissions
		Water-Saving and Drought-Tolerant Rice	—
	Straw Management	Straw Composting and Returning to Fields	—
		Straw Removal from Fields	Avoids direct straw return to paddy fields
		Biochar Application to Paddy Fields	—
	Emerging Technology R&D	Use of Methane Inhibitors such as Diazotrophs	—

FIELD	CATEGORY	METHANE MITIGATION TECHNOLOGIES AND MEASURES	TECHNICAL DESCRIPTION
Livestock Farming	Ruminant Enteric Fermentation	Feed Regulation	Optimizes feed structure and improves feed digestibility
		Feed Additives	Uses feed methane-inhibiting additives, such as 3-nitrooxypropanol (3-NOP) and *Asparagopsis taxiformis (red macroalgae)*
		Animal Welfare	Healthy herds are the foundation of high productivity, low morbidity, and longevity
		Animal Management	Improves animal production and reproductive performance, immune health, and reduces heat stress through herd management
		Feeding Management	Scientific, intensive, and intelligent feeding
		Breeding Selection of High-Yield, Low-Emission Ruminant Varieties	Develops ruminant varieties with high productivity and low methane emission intensity
	Animal Manure Management	Collection and Utilization of Biogas Produced by Anaerobic Fermentation	Collects and utilizes biogas produced by anaerobic digestion of manure to reduce methane emissions, recover energy, and apply digestate to fields
		Aerobic Composting of Manure	Composts or aerobically treats manure to increase oxygen supply, inhibit anaerobic methanogenesis, reduce methane emissions, and produce organic fertilizer
		Solid-Liquid Separation of Manure	Separates manure into solid and liquid fractions to alter the fermentation environment, reduce methane emissions, and enable separate utilization of the products
		Manure Methane Inhibitors	Adds methane inhibitors to manure to directly suppress methanogens; attention should be paid to residues and environmental impacts

3. MULTIPLE CO-BENEFITS OF AGRICULTURAL METHANE MITIGATION

Agricultural methane mitigation delivers three interlinked categories of benefits – environmental, economic and social – which together form a complete value system for low carbon agricultural transformation.

- Environmental benefits (ecological foundation) include greenhouse gas mitigation and carbon sequestration, climate change adaptation, reduction of water, soil and air pollution, and biodiversity conservation. These are achieved through measures such as feed optimization, manure treatment, and paddy water management.

- Economic benefits (internal driver) include increased productivity and income, cost savings and improved efficiency, revenues from carbon credits and policy incentives, industrial upgrading, and animal health improvements.

- Social benefits (support system) include job creation, development of green skills, industrial synergy, enhanced low carbon literacy among farmers, rural revitalization, and improved living environments.

These three categories form the “triple bottom line” (TBL) of sustainable development. They can reinforce each other through synergies (e.g., lower emissions often reduce input costs) or generate spillover benefits (e.g., environmental improvement enhances rural well being). However, trade offs may also occur under resource or policy constraints – for instance, a mitigation technology might require upfront investment that exceeds the capacity of smallholders. Achieving sustainable development therefore requires institutional and policy coordination that maximizes synergies, manages trade offs, and pursues a win win win outcome (Figure 5).

Crucially, these co-benefits transform methane mitigation from an externally imposed cost into an internally driven opportunity for farmers and agribusinesses. This reframes mitigation as a tool for productivity and resilience, not just a climate obligation.

The analysis in this report draws on 12 real world cases from China’s livestock and rice sectors, covering a range of operational scales and geographic regions. These cases were generously provided by project partners and practitioners, and they illustrate how the triple benefit framework operates in practice. A summary list of the cases and a detailed matrix of their multiple co-benefits are provided in Appendix A.

Building on this triple-benefit framework and the empirical evidence from the 12 cases, the following section presents four key findings: (1) resource efficiency as the foundation, (2) co-benefit synergy as the driver, (3) MRV as the conversion mechanism, and (4) stakeholder collaboration as the implementation model.

Figure 5. Diagram showing environmental, economic and social co=benefits, their interactions, and the pathway to a win-win-win outcome

Box 1. List of 12 Cast Studies (Note: These cases were generously provided by project partners, including research institutions, enterprises, and farming practitioners. Detailed descriptions are available in the full report (Part 2))

List of China's Agricultural Methane Mitigation Cases

1. Feed Additives:
   AustAsia Ranch Achieves Dual Improvement of Enteric Methane mitigation and Economic Benefits via Feed Additives

2. Pasture Restoration:
   Synergistic Benefits of Degraded Pasture Restoration and Sustainable Management at Nanshan Ranch

3. Bio-Bedding Manure Treatment Technology:
   Synergistic Efficiency of Beef Cattle Manure Pollution Control and Carbon Emission Reduction

4. Whole-Lifecycle Low-Carbon Ranch Management:
   Modern Dairy's Full-Chain Co-Benefits through Low-carbon Ranch Whole-Lifecycle Management

5. Manure Biogas Power Generation:
   Multiple Co-Benefits from Dairy Manure Treatment at Youran Ranch, Pingyin, Jinan

6. High-Efficiency Manure Fermentation:
   Emission Reduction and Income Increase via High-Efficiency Dairy Manure Fermentation by Shandong Jinniu Group

7. Coffee Grounds Feed Utilization:
   Cost Reduction and Emission Reduction by Converting Coffee Grounds into Functional Dairy Feed

8. Aerobic Cultivation of Water-Saving Drought-Resistant Rice:
   Synergistic Paddy Methane Mitigation and Water Conservation

9. Rice–Crayfish Integrated Culture:
   Win-win of Paddy Methane Mitigation and Economic Benefits

10. Large-Scale Rice Cultivation:
    Synergistic Improvement of Resource Efficiency and Mitigation Benefits

11. Rice–Green Manure Rotation:
    Dual Benefits of Emission Reduction and Carbon Sequestration

12. Integrated Rice Mitigation Package:
    Integrated Paddy Methane Mitigation in Qingshan Village, Hangzhou, Zhejiang

4. KEY FINDINGS

Finding 1: Resource efficiency improvement is the foundation of agricultural methane mitigation.

The core pathway relies on technological and business model innovation to optimize the use of land, water, feed, and nutrients while controlling emissions at key nodes. This shifts mitigation from passive compliance to proactive, efficiency driven action – meaning farmers and agribusinesses adopt measures voluntarily because they directly improve productivity and reduce costs, not because they are forced by regulations.

Finding 2: Co benefit synergy is critical for sustainable mitigation.

Synergies dispel the misconception that “mitigation inevitably raises production costs”. When designed well, methane reducing practices simultaneously increase yields, save inputs, or improve animal health. This unites emission reduction, productivity gains, and rural revitalization, creating genuine multi win outcomes that drive long term adoption.

Finding 3: MRV systems are the key mechanism for converting mitigation benefits.

A sound Monitoring, Reporting and Verification (MRV) system delivers measurable, reportable and verifiable results, providing the institutional foundation for credible mitigation action. More importantly, MRV enables the translation of environmental benefits into economic assets – such as carbon credits, green financing, or eco labelling. Without MRV, the ecological value of methane reduction remains externalized and cannot be captured by farmers.

Finding 4: Stakeholder collaboration ensures on the ground implementation.

A model of “large scale operators leading, smallholders inclusively participating” – supported by enterprise demonstration, enabling government policies, and technical assistance from research institutions – builds a targeted, multi stakeholder mitigation system. This requires tailored pathways for different farm types (e.g., commercial ranches vs. family farms vs. smallholders) rather than a one size fits all approach, thereby enhancing both feasibility and scalability.

5. RECOMMENDED ACTION FRAMEWORK

As the world's largest rice producer and a major livestock country, China's agricultural methane mitigation matters for global climate governance. Based on the 12 cases and key findings, this section outlines three policy pathways for China and four strategic directions for global action.

5.1 FOR CHINA: 3 POLICY PATHWAYS

PATHWAY	DESCRIPTION
Systemic governance	Strengthen cross ministerial coordination involving environment, agriculture, energy and development planning agencies. Improve MRV systems with dynamic emission factors and multi level standards. Prioritize mature technologies (intermittent irrigation, precision feeding, anaerobic digestion) and establish regional demonstration projects.
Climate financing	Use fiscal funds, green loans and carbon markets to unlock ecological value. Accelerate the development of CCER methodologies for rice cultivation and livestock methane mitigation. Turn methane reductions into tradable assets and green premiums through mechanisms such as "carbon credits + agricultural products" branding.
Differentiated, inclusive implementation	Tailor support to large enterprises, medium scale farms and smallholders. Link mitigation measures directly with cost savings and income growth (e.g., water saving rice, rice crayfish co culture, green manure rotation). Integrate these efforts with rural revitalization strategies and build multi stakeholder governance with benefit sharing mechanisms.

5.2 FOR THE GLOBAL COMMUNITY: 4 STRATEGIC DIRECTIONS

DIRECTION	DESCRIPTION
Climate food development synergy	Agricultural methane mitigation need not compromise food security or farmer livelihoods. Encourage countries to include agricultural methane as a standalone target when updating their Nationally Determined Contributions (NDCs). Strengthen the agricultural agenda under the Global Methane Pledge (GMP) and link mitigation explicitly to SDGs 2, 6, 13 and 15.
Hierarchical, mutually recognizable MRV	Address the lack of localized emission factors and inconsistent standards. Develop tiered MRV approaches – measurement based for large commercial farms, activity data based for smallholders. Build regional emission factor databases for Asia, Africa and Latin America. Explore cross border mutual recognition for carbon credits under the Paris Agreement Article 6.
Private sector and financial capital	Scale up three proven business models: efficiency driven (feed additives), resource circular (manure to energy or fertilizer), and brand premium (low carbon certification). Use blended finance instruments (first loss guarantees, sustainability linked loans) to de risk projects. Encourage major food companies to set SBTi Scope 3 targets and adopt green procurement practices.
Global knowledge sharing and South South cooperation	China's 12 cases provide a "solution atlas" adaptable to other developing countries – for example, water saving rice for Southeast Asia and bio bedding for Africa. Establish an open knowledge platform via FAO and CGIAR. Create a dedicated agricultural methane window under the Green Climate Fund to support technology adaptation, demonstration projects and capacity building through South South cooperation.

5.3 CONCLUDING REMARKS

Agricultural methane mitigation is a systemic opportunity that aligns climate action with food security, farmer income, and rural development. China's cases show that through technological innovation, improved MRV, market incentives, and inclusive governance, triple win outcomes are achievable. Moving forward, stronger cross sector coordination, climate finance, grassroots empowerment, and international cooperation will be essential to scale up agricultural methane mitigation globally.

Appendix A. Summary of Multiple Co-Benefits of China's Agricultural Methane Mitigation Cases

		ENVIRONMENTAL BENEFITS				ECONOMIC BENEFITS						SOCIAL BENEFITS							
	PRACTICE CASES	GHG emission reduction and carbon sequestration	Adaptation to climate change	Reduce water, soil, air pollution	Biodiversity conservation	Improvement of production efficiency	Cost reduction and income growth	Carbon credits and other revenues	Industrial upgrading	Brand value premium	Animal health	Job creation	Green talent cultivation	Industrial development promotion	Low-carbon awareness enhancement	Rural revitalization advancement	Rural living environment improvement	Ecological health safeguard	International image enhancement
1	Feed Additives	✓		✓		✓	✓	✓	✓	✓			✓	✓	✓				✓
2	Pasture Restoration	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓			✓	
3	Bio-Bedding Technology	✓		✓			✓		✓		✓		✓	✓	✓	✓	✓	✓	
4	Full-Lifecycle Mitigation	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
5	Manure Biogas Power Generation	✓		✓			✓	✓				✓	✓	✓	✓		✓	✓	✓
6	High-Efficiency Manure Fermentation	✓		✓			✓	✓				✓	✓	✓	✓	✓	✓	✓	
7	Coffee Grounds Feed Utilization	✓		✓			✓			✓		✓	✓		✓		✓	✓	✓
8	Aerobic Cultivation of Water-Saving Drought-Resistant Rice	✓	✓	✓		✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓
9	Rice-Crayfish Co-Culture	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓			✓	✓
10	Large-Scale Rice Cultivation	✓		✓		✓	✓	✓	✓			✓	✓	✓	✓			✓	✓
11	Rice-Green Manure Rotation	✓				✓	✓			✓			✓		✓	✓		✓	✓
12	Integrated Rice Mitigation Package	✓	✓	✓		✓	✓	✓		✓		✓	✓		✓			✓	✓

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