Cultivating Climate-Smart Cooperation:

Incentivizing Chinese and American Rice Farmers to Reduce Methane Emissions

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DISCLAIMER

The author conducted this study as part of the program of professional education at the Frank Batten School of Leadership and Public Policy, University of Virginia. This paper is submitted in partial fulfillment of the course requirements for the Master of Public Policy degree. The judgement and conclusions are solely those of the author, and are not necessarily endorsed by the Batten School, by the University of Virginia, or by any other agency.

HONOR STATEMENT

On my honor as a student, I have neither given nor received unauthorized aid on this assignment.

Sarah Spakes

TABLES AND FIGURES

GLOSSARY AND ABBREVIATIONS

Methanogenesis: the process by which anaerobic bacteria emit methane

AWD — Alternate Wetting-and-Drying
CEF — China Environment Forum
EQIP — Environmental Quality Incentives Program
FAO — Food and Agriculture Organization of the United Nations
GHG/GHGs — greenhouse gas/greenhouse gases
IRA — Inflation Reduction Act of 2022
MARA — Ministry of Agricultural and Rural Affairs
MT CO2e — Metric tons of carbon dioxide equivalent
NGOs — Non-governmental organizations
RCPP — Regional Conservation Partnership Program
RMB — Chinese yuan, also called the renminbi
UN — United Nations
USD — United States Dollars ($)
USDA — United States Department of Agriculture

EXECUTIVE SUMMARY

The following report, in partnership with the China Environment Forum (CEF) at the Wilson Center, analyzes incentives to encourage rice farmers to reduce methane emissions. Rice was domesticated thousands of years ago and still sustains over half the world's population each day. This is due to its high nutrient-density, easy storage, and culinary versatility. It thrives in humid and water-intensive conditions, growing in flooded fields for the whole growing season, called rice paddies. However, rice emits 12% of global methane emissions. Methane is 28 times stronger than carbon dioxide as a greenhouse gas (GHG) over the course of 100 years. This potency contributes to the unpredictable and unprecedented weather events that destabilize towns, economies, and institutions.

Flooded fields and rice straw decomposition are the top two contributors to methanogenesis from rice; scientists have found that alternate wetting and drying (AWD) and straw management are promising practices to reduce methane emissions from rice.

China and the United States (U.S.) are leading global rice traders and GHG emitters. Without China and the U.S. at the table, there cannot be progress to combat climate change from methanogenesis from rice agriculture while maintaining food security. Thus, China and the U.S. must incentivize rice farmers to reduce methane emissions while maintaining current crop levels.

This project analyzes the following incentivization mechanisms to encourage farmers to reduce methane emissions through AWD and straw management:

1. Status Quo
2. Market-Based Incentives
3. Regulations
4. Cross-Compliance
5. Organizational and Community Building

To develop a recommendation to CEF, this report uses the following criteria: cost to governments; cost to farmers; likelihood of farmer compliance; likelihood of desired outcomes, which are reducing methane emissions and maintaining crop yields; and political feasibility, in the U.S. and China. Based on conversations with stakeholders in the fields, the highest weighted criterion is the likelihood of desired outcomes, which are reducing methane emissions and maintaining crop yields.

After conducting the analysis, this report recommends that CEF focus on cross-compliance in its analyses and stakeholder conversations. Cross-compliance has a high likelihood of achieving the desired outcomes of reducing methane emissions and maintaining crop yields while requiring comparatively lower costs for farmers and governments.

PROBLEM STATEMENT

Each day, rice sustains over half of the world's population. However, rice farming alone emits 12% of global methane emissions each year. These emissions contribute to the unpredictable and unprecedented weather events that destabilize towns, economies, and institutions. For the sake of global political and food security, China and the U.S.—as the world's largest rice traders and GHG emitters—must incentivize rice farmers to reduce methane emissions while maintaining current rice yields.

INTRODUCTION

Rice may be a staple crop, but it fuels the climate crisis. While its nutrient-dense grains nourish billions, rice farming also emits a staggering 12% of global methane emissions, a GHG 28 times more potent than carbon dioxide. These emissions are not just a threat to the environment; they fuel extreme weather events that destabilize economies and communities worldwide.

In a world where the need to combat climate change grows more urgent, addressing methane emissions from rice paddies is critical. China and the U.S., as the two largest rice producers and greenhouse gas emitters, play a key role in addressing this problem.

This report explores alternatives to incentivize rice farmers to adopt practices like alternate wetting and drying (AWD) and straw management, which promise to cut methane emissions without compromising harvests. By evaluating various mechanisms, this report outlines the most effective path forward, recommending a focus on cross-compliance for its ability to deliver the best outcomes for both the environment and farmers. It is time to shift the balance in rice farming from a climate burden to a climate solution.

CLIENT OVERVIEW

This analysis was conducted for the Wilson Center's China Environment Forum (CEF). The Wilson Center is a Washington D.C.-based think tank that researches foreign affairs. The Wilson Center is not an advocacy think tank; rather, it provides analysis on global affairs so policymakers and stakeholders can make informed decisions. Within the Wilson Center, the China Environment Forum creates a space for research and collaboration between a variety of stakeholders from the U.S. and China. CEF works at the intersection of energy, environment, diplomacy, and scholarship. Because the Wilson Center and CEF create opportunities for dialogue, research, and policymaking in China and the U.S., they can offer impactful analyses to policy influencers in both countries.

BACKGROUND AND PROBLEM ORIENTATION

RICE'S GLOBAL POPULARITY

Rice is a staple crop for billions of people for several reasons. First, rice has a long shelf life. Brown rice can last up to six months if kept in a dry, cool place. If white rice is kept in a dry, cool place, it can last nearly indefinitely. Other cereals and staple crops have more temperamental storage needs. Various climates can accommodate these storage practices, making rice an accessible and long-term food option (*How To Store Rice*, n.d.).

Second, rice has nutritional and culinary benefits. Over 20% of calories consumed worldwide come from rice, and rice contains nutrients like B vitamins, folic acid, iron, magnesium, manganese, niacin, potassium, thiamin, and zinc (Ziska & Fukugawa, 2019; *Rice Nutrition*, n.d.). As a complex carbohydrate, rice provides long-lasting energy (*Rice Nutrition*, n.d.). Moreover, rice can be served hundreds of different ways. Almost every region of the world has a signature dish that features rice. Humanitarian programs like UN World Food Programme use rice in their programs for these reasons ("Types of Food the UN WFP Delivers in a Humanitarian Crisis," n.d.). Billions of people rely on rice to sustain them and serve their cultural comfort foods.

Third, rice is ingrained into millennia-long cultural traditions. Religiously, rice is believed to have divine origin. Rice and the deity are worshipped, with rice and rice beverages offered in reverence. Secularly, rice announces births or marriages as a symbol of prosperity and fertility. Many regions have festivals celebrating different milestones in the growing season. Idioms, songs, and superstitions feature rice in Japan, India, China, and other rice-growing regions. To not have rice would shatter a central part of people's identity and traditions (Ahuja & Ahuja, 2006).

DEMAND FOR CHINESE AND AMERICAN RICE

The U.S. is neither the top rice producer nor rice trader; however, the U.S. supplies high-quality and accessible rice to global markets. While most exports are milled rice, the U.S. has been the only major exporter of rough rice for decades, filling a significant gap in the market. The primary markets for American rice include Latin American countries, the Caribbean, Canada, and some Middle Eastern countries. Figure 1 maps where rice is grown in the U.S. (*Rice Sector at a Glance*, 2025).

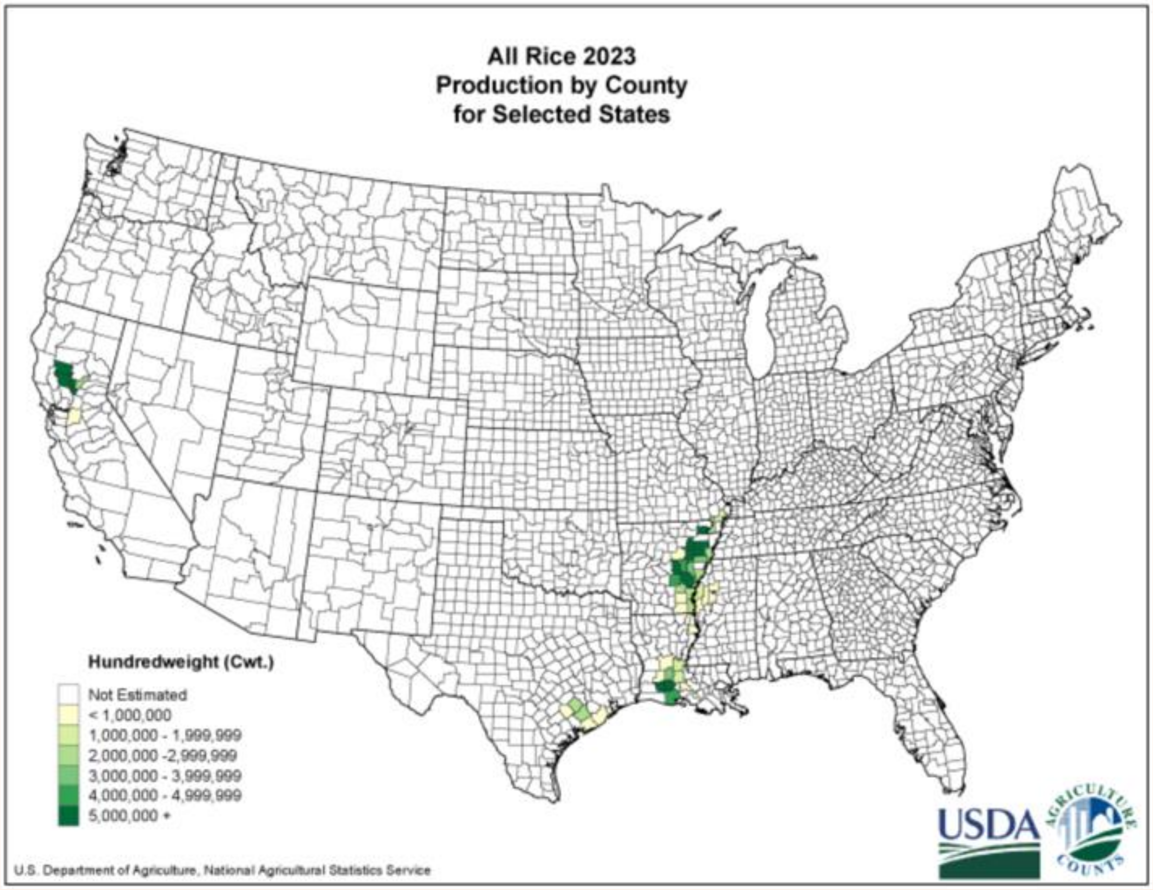

Figure 1: American Rice Growing Regions (https://www.nass.usda.gov/Charts_and_Maps/graphics/AR-YI-RGBChor.pdf)

Historically, China has been the top rice-producing country thanks to its vast lands and large population, as seen in Figure 2. China supplies abundant and cheaper rice, especially compared to American rice. The primary markets for Chinese rice are in Asia and Africa. The rice planted in 2024 is projected to have the highest yield in at least 10 years, partially due to investments in research and development (*China Rice Area, Yield and Production*, 2024).

Figure 2: Chinese Rice Growing Regions (*China Rice Area, Yield and Production, 2024*)

AMERICAN VERSUS CHINESE FARMING SYSTEMS

In the U.S., the Department of Agriculture (USDA) maintains a robust structure. State-level agriculture departments implement national policies. While sometimes an unpredictable living, farmers in the U.S often have a middle-class status (Kassel, 2024). Most farms in the U.S. are small farms, but most of the output comes from large farms and there are significant incentives to expand a farm or to sell to a large farm (Hurt, 2010; Kassel, 2024). American society and government recognize that farms built the communities that built the country. As such, the U.S. government offers a variety of programs to ensure that farming families have income and support (Zhang, 2015).

In China, the government tries to balance its centralized power after the Great Leap Forward. The Great Leap Forward lauded the hardworking rural peasant while pushing all resources to urban centers by collectivizing all farming that had traditionally been done in household units (Chen, 2001). In the present two-tier system, farmers have some flexibility in what they plant, the tools they use, and the cooperatives they join (Ministry of Agriculture and Rural Affairs of the People's Republic of China, 2017). However, rural farms fuel industry and urbanicity rather than the farmers and their communities. Farmers in China are often poorer, less politically prioritized, and less economically supported than their American counterparts (Zhang, 2015; Hurt, 2010).

RICE FARM SIZE AND RISK TOLERANCE

Farm size can be determined by acreage, by annual sales, or both. Small farms in the U.S. are classified as having less than $500,000 or less in annual sales or as having 50 acres or less (*Costs to Farmers and Consumers – Produce Rule*, n.d.; McCullough & Hamilton, 2021). The average American rice farm size is between 520 and 600 acres, but most rice farms are small compared to other crops and animal farms (McBride et al., 2018; *U.S. Rice Facts*, n.d.). Small rice farms in China are between 0.2 and 2 acres, and they make up 98% of rice farms in China (Liu, 2025; McDonald, 2023; Hurt, 2010; Zhang, 2015). Because rice farms are smaller, they do not have the resources, land, and flexibility to take on risk. This cultivates risk-aversion.

HOW TO GROW RICE

Growing rice is a year-long cycle. Before planting, farmers level their fields to optimize irrigation and water flow. Farmers stir up the top layer of soil—called tilling—to aerate it and redistribute nutrients. Farmers plant their rice between February and May, depending on the region. Rice can be planted directly into the soil as seeds, or it can be grown in a controlled environment (like in a greenhouse) and transplanted after germination (*How Rice Grows*, n.d.). Rice is harvested around five months after sowing. After sowing, farmers must decide how to manage leftover rice straw and the dry fields. Rice straw can be burned, chemically repurposed, or left in the fields. Flooding the fields prevents weed growth, and it creates year-round habitats for fauna (anonymous former USDA staffer, personal communication, October 9, 2024; Gummert, 2010; *How Rice Grows*, n.d.; K. Mancl, personal communication, September 30, 2024; Zhou et al., 2024).

Traditionally, rice is grown in "rice paddies" that are flooded and maintained for the whole growing season. This kind of rice is called "aerobic" or "lowland" rice. Rice historically grew in humid climates, where water was abundant. As rice farming became more widespread, farmers realized that the flooded conditions yielded more rice. Flooded fields also prevented weeds from growing and provided a symbiotic habitat for fowl, fish, and burrowing animals (*How Rice Grows*, n.d.).

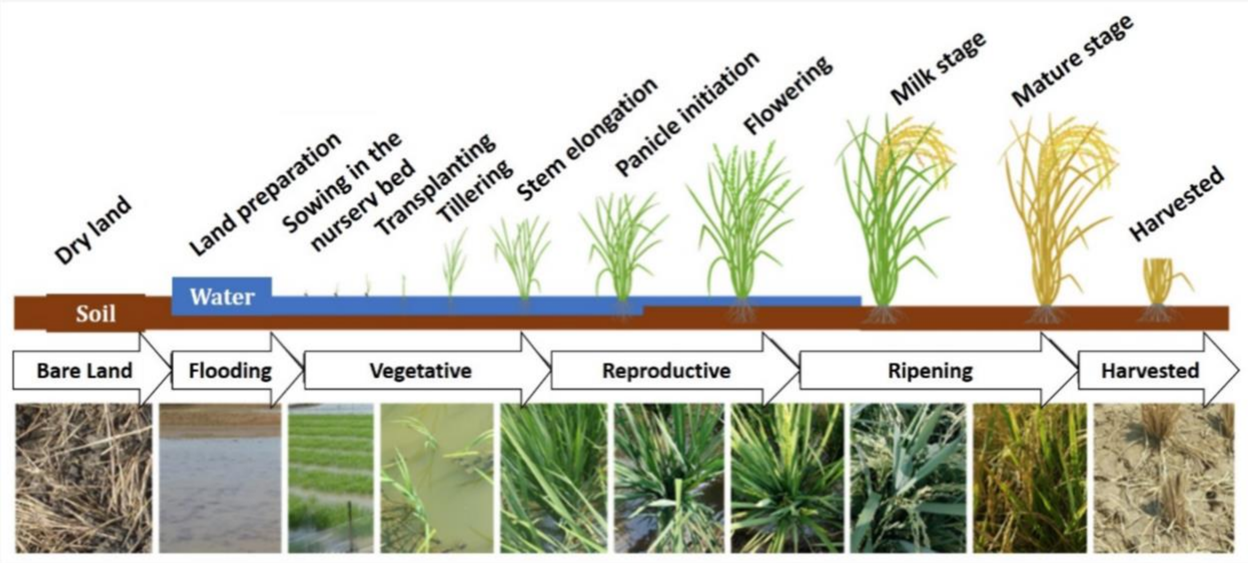

Figure 3: Rice Growing Stages (Shen et al., 2022)

GREENHOUSE GAS EMISSIONS FROM RICE

When the rice fields are flooded, water stifles the oxygen, and the anaerobic (meaning "without oxygen") bacteria thrive. They feed off decomposing organic materials, which triggers a chemical reaction that releases methane, a process called methanogenesis, in Figure 4. Methane is primarily released through the rice plant itself (Conrad et al., 1996). Methane has a shorter life span in the atmosphere than carbon dioxide, but over a 100-year period, it is 28 times more potent as a GHG (Overview of Greenhouse Gases, 2024).

Additionally, the plant and soil emit nitrous oxide from nitrogen in fertilizers during rice-growing. Nitrous oxide is 265 times more potent as a GHG then carbon dioxide over a 100-year period. However, nitrous oxide is only 6% of GHGs in the atmosphere while methane is 12% (Overview of Greenhouse Gases, 2024). Even though carbon dioxide and nitrous oxide have longer-lasting effects, methane has greater short-term impacts on climate change.

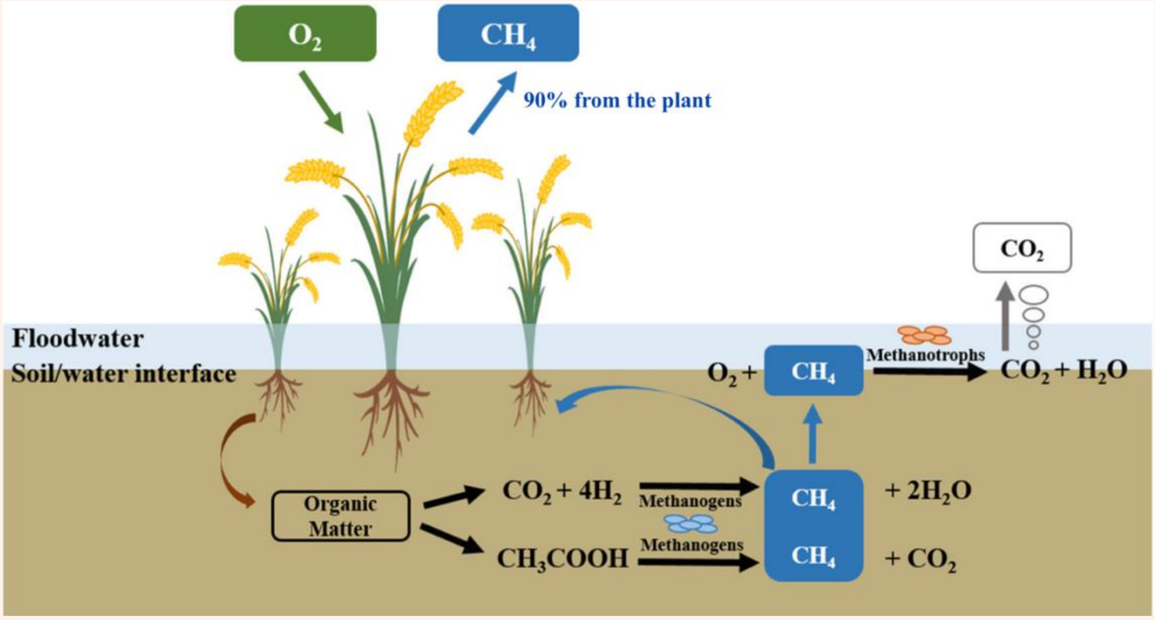

Figure 4: Methanogenesis in Rice (Gu et al., 2022)

AMERICAN AND CHINESE CLIMATE COOPERATION

Chinese-American agricultural-environmental collaboration began as scientists realized that the climate was changing. In 1973, the U.S. became China's second-highest trading partner, and Chinese scientists visited American research institutions to study insect-resistant crop varieties (Durbin, 1973; Mancl, 2024). Following the normalization of U.S.-China relations in 1979, the two countries signed the *U.S.-China Science and Technology Cooperation Agreement*, fostering exchanges between researchers and institutions (Sutter & Blevins, 2024; Turner et al., 2024). In 1985, the U.S. and China established collaboration between the US and China as they researched and developed fossil fuel energy (*The Protocol on cooperation*…, 1985; Turner et al., 6, 2024).

In 1992, both states became parties to the United Nations Framework Convention on Climate Change, which set and implemented international climate protocols (*U.S.-China Climate Cooperation Timeline*, 2024; *What Is the United Nations Framework Convention on Climate Change?*, n.d.). In 1997, the *Kyoto Protocol* established emissions targets for countries based on the country's level of industrialization (*U.S.-China Climate Cooperation Timeline*, 2024). At the turn of the 21st century, the US and China created an *Agreement on U.S.-China Agricultural Cooperation* (Turner et al., 6, 2024). Simultaneously, the U.S. and China successfully negotiated the *U.S.-China Bilateral WTO Agreement*, which opened the trade relationship for agricultural goods, including rice (*U.S.-China Bilateral WTO Agreement*, 1999).

TECHNICAL SOLUTIONS

As scientists and farmers have begun to realize the effects of climate change, they are urging policymakers to create room for climate-smart agriculture in agriculture and research. Continuous flooding and straw burning are the top two contributors to GHG emissions in rice production (Wassmann et al., 2022). Thus, researchers argue that alternate wetting and drying (AWD) and straw management are the most effective ways to reduce methane emissions while maintaining yields. These practices are implemented each season. I highlight AWD, with an honorary mention for straw management, in this section and in policy alternatives to make the analysis more concrete.

ALTERNATE WETTING-AND-DRYING

In AWD, farmers flood their farms but let the rice use all the water before reflooding. This prevents anaerobic bacteria from inducing methanogenesis, showing potential to reduce methane emissions by almost 28% (Zhou et al., 2024). Yields have not been drastically impacted using AWD. However, one environmental tradeoff is that the aerobic conditions are perfect for nitrous oxide emissions, which are 265 times more potent than carbon dioxide emissions over 100 years (Overview of Greenhouse Gases, 2024). Farmers have shown reluctance to try this new technique due to the long tradition of flooding fields and the benefits of deterring weeds and symbiosis with fauna, despite evidence that it decreases irrigation infrastructure and water use costs (anonymous former USDA staffer, personal communication, October 9, 2024; Chakravorty et al., 2020; Connor et al., 2023).

STRAW MANAGEMENT

Straw management optimizes the potential of discarded rice straw after the grain is harvested. Scientists have confirmed that leaving the unwanted rice straw to decompose in the flooded fields increases methane emissions because anaerobic bacteria feeds on decomposing matter to fuel methanogenesis (Zhou et al., 2024; Lee et al., 2024).

There are three main alternatives for rice straw disposal: burning, straw return, or biochar. Burning is a convenient and inexpensive way to eliminate all the rice straw. However, it emits air pollutants and deteriorates community health. Straw return incorporates the straw into the soil during the off-season to promote aerobic decomposition, which provides nutrients to the soil and rice plants. Scientists found that off-season straw return reduces methane emissions by up to 26% (Zhou et al., 2024; Wassmann et al., 2022). Converting straw and husks to biochar involves burning the straw in the absence of oxygen, producing a nutrient-dense product. While using biochar does show a decrease by 21.79% in methane emissions, it fluctuates with rice variety (Zhou et al., 2024; Lee et al., 2024). Despite programs and education established to help farmers transition to biochar and straw return in southeast Asia, many farmers continue to burn straw because of its convenience (Connor et al., 2023).

POLICY SOLUTIONS

Five policy alternatives were developed to analyze ways to incentivize farmer compliance with methane-reducing practices. These were informed by conversations with experts in the field and by literature.

1. Status Quo
2. Market-Based Incentives
3. Regulations
4. Cross-Compliance
5. Organizational and Community Building

ALTERNATIVE 1: STATUS QUO

This alternative assumes no policy intervention is pursued to incentivize American and Chinese rice farmers to reduce methane emissions. Thus, methane emissions, rice outputs, and U.S.-China cooperation would be expected to continue as is. These expected outcomes serve as the baseline to compare to the other alternatives.

ALTERNATIVE 2: MARKET-BASED MECHANISMS

This alternative leverages supply, demand, and competition to encourage producers to reduce their methane emissions. Price controls set maximums for methane-reducing inputs—called price ceilings—and set maximums for outputs produced with methane-reducing practices—called price floors. Rice priced with the price floor is marketed with its climate-smart status. Government set price controls and establish markets, including cap-and-trade and carbon credits. Methane producers can trade their emissions or capture emissions for money (Canales et al., 2024; Ding et al., 2022; Piñeiro et al., 2020; Shen et al., 2024; Zhu & Chen, 2022).

Price ceilings have been used globally in agriculture and other sectors. In certain contexts, states and provinces can set their own price ceilings. For example, four eastern Canadian provinces implemented legislation for a price ceiling on self-serve gas prices while two in the east did not (Sen et al., 2011). Pharmaceutical drugs often receive price ceilings that are legislated at the national level. China and India have used price ceilings on drugs for decades, while the U.S. has more recently started using them (Cui et al., 2023; Li & Wu, 2022; Cubanski et al., 2023; Benischke & Bhaskarabhatla, 2024).

Set with either consumers or producers in mind, price controls create inefficiencies in markets. In Figure 5, rice grown with AWD is sold to consumers at market price, which is where supply from farmers and demand from the population meet. While this creates no inefficiencies, sometimes, farmers do not make enough profit to proceed into the next season because of the inherent cheap price of rice or because of high fertilizer costs that season from a global event. Thus, in Figure 6, the government sets a price floor to ensure that farmers earn enough profit to proceed into the next season. The price floor is above the market price, but this creates inefficiency, or quantity not sold, due to the higher price. However, because of the higher selling price, farmers make up for the lower quantity sold (Kirk, 1985; Mbiti, 2023, University of Virginia; Tucker, 2021).

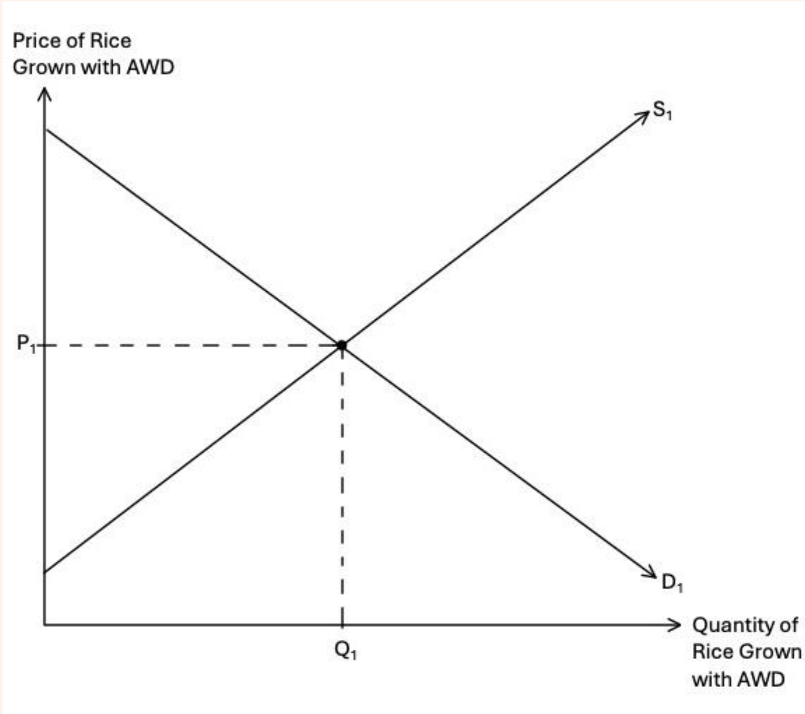

Figure 5: Rice Sold without Price Floor

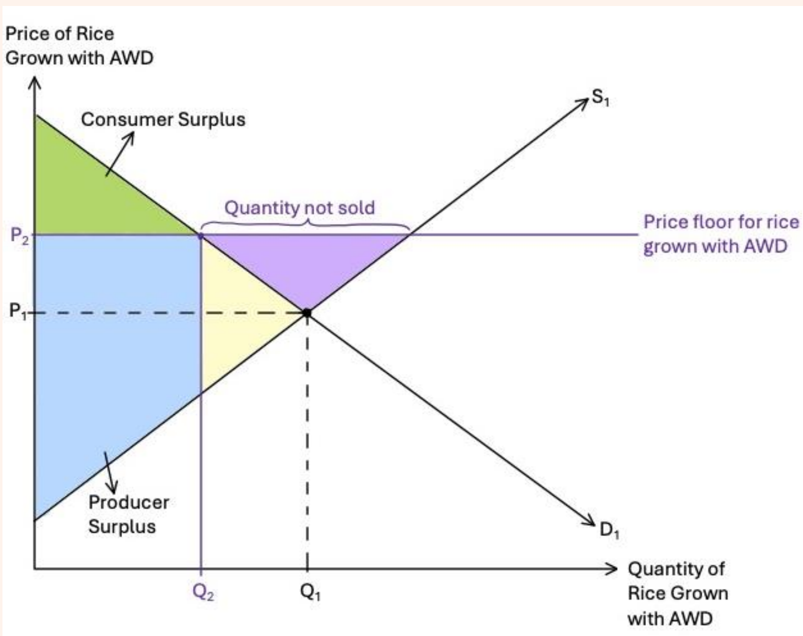

Figure 6: Rice Sold with Price Floor

ALTERNATIVE 3: REGULATIONS

This alternative involves governments creating a scheme to mandate AWD or straw management for rice. For example, the U.S. regulates pollutants that are released into waterways and water supplies according to the Clean Water Act of 1972. The Environmental Protection Agency has the authority to measure, develop plans for, and litigate against those who violate the Clean Water Act (*Clean Water Act (CWA) and Federal Facilities*, 2024). The Chinese government implemented regulations on farming practices to encourage consumers to buy organic, sustainable, and hazard-free food, which has successfully increased its organic food output since the 2000s (Zhang, 2015; Scott et al., 2018, 40-44). These regulations are created and implemented at a national level with local partners. Regulations are usually mandatory, or farmers could lose access to markets (Canales et al., 2024; Piñeiro et al., 2020; J. Shimshack, personal communication, February 5, 2025).

ALTERNTIVE 4: CROSS-COMPLIANCE

This alternative pays farmers in crop insurance, government subsidies, and loans in exchange for proving that they switched to methane-reducing practices, such as AWD or climate-smart straw management. While these programs are typically voluntary, the financial incentives are designed to make participation more attractive than opting out. Some scholars call this category "nonmarket incentives." However, that is a broad term that encapsulates all incentives that are not the market-based incentives, which blocks nuances when comparing market-based incentives to regulations, cross-compliance, and organizational building (Canales et al., 2024; Piñeiro et al., 2020).

Subsidies have been used in free-market economies for decades, including the U.S., Japan, Taiwan, and South Korea, in agriculture and other sectors, while China started to use them since the early 2000s. Subsidies are paid to the farmers, and they are specified for crops, machinery, and other inputs (*History of the U.S. Farm Bill*, n.d.; *Ministry of Agriculture and Rural Affairs of the People's Republic of China*, n.d.; Sumner, n.d.; Zhang et al., 2020)..

Similarly, crop insurance has been used in free-market economies for decades, but Asian countries have more recently started implementing crop insurance, including Thailand, Bangladesh, and China (Agricultural Insurance in Asia and the Pacific Region, 2011; Baych, 2022; Le & Panella, 2022; Ye & Mu, n.d.; Kimura et al., 2022). Farmers receive crop insurance ahead of each season, and they can insure all or part of their fields. In the U.S., the government does not insure farms. Rather, crop insurance companies insure crops, and the government helps farmers pay for premiums or helps the insurance companies pay for indemnities (J. Turner, personal communication, March 5, 2025).

ALTERNATIVE 5: COMMUNITY AND ORGANIZATIONAL BUILDING

This alternative expands the capacities of existing organizations and networks farmers are members of to share information, technology, resources, and power. China operates through a vast network of cooperatives, and the U.S. operates through both cooperatives and trade associations (Zhang, 2015; *Law of the People's Republic of China on Specialized Farmers' Cooperatives (2017)*, 2022; Liu et al., 2024). Most of these networks are voluntary and member-run, but governments can regulate them.

Governments should build the capacities of existing organizations to provide a sense of community and accountability to farmers. In China, where rice farms are smaller and more rural and the culture is more community-centered, cooperatives help rural individuals stay relevant in a fast-changing market. However, some cooperatives are registered in name only, without any network structures, while some have poor management and resources that harm its members (Zachernuk, 2019). In the U.S., the number of cooperatives has been declining since the 1930s (Munch, 2024). American rice farmers benefit from cooperatives' and trade associations' bargaining power, community-building, and scaling up their economies. Building these networks also promotes information-sharing and awareness, which has proven to increase the uptake of new farming practices by up to 7% (Ding et al., 2022; Udimal et al., 2022). Cooperatives keep farmers afloat and educate farmers on ways to keep farming as a sustainable and growing option for future generations (Liu et al., 2024; Munch, 2024).

EVALUATIVE CRITERIA

Five criteria—with four sub-criteria—were developed to analyze the above alternatives and make a final recommendation. There evaluations are shown in Table 3.

Table 1: Evaluative Criteria

Criterion	Definition	Measurement Sub-Criteria	Source of Measurement
Cost to Governments	The additional cost governments pay.		Precedent from previous programs, interviews
Cost to Farmers	The additional cost farmers pay.		Precedent from previous programs, literature
Likelihood of Farmer Compliance	The rate or willingness to accept for farmers to take up the new practice.		Precedent from previous programs, literature, interviews
Likelihood of Desired Outcomes	The outcomes that stakeholders aim for in this analysis.	Reducing Methane Emissions	Precedent from previous programs, literature, interviews
		Maintaining Crop Yields	Precedent from previous programs, literature, interviews
Political Feasibility	The ability for an alternative to become codified based on the current political context and historical precedent.	American	Analysis of current political context, precedent from previous programs, literature
		Chinese	Analysis of current political context, precedent from previous programs, literature

COST TO GOVERNMENTS

This criterion estimates the additional costs governments will pay when choosing each alternative. Finding cost data from the Chinese government is difficult, so I primarily focus on costs to the American government, with the assumption that the cost to the Chinese government will be similar. While the Chinese government has a stricter structure to create more efficiency, the Chinese population is triple that of the U.S.'s, and rural individuals are more remote than American rural individuals. Thus, I assume that capacities and population will counterbalance each other. This cost is for year one of implementation because governments fund programs like these in large packages, rather than incrementally. Costs are calculated in Appendix A. Using previous examples, I estimate costs, and then I label them as "high," "medium," or "low," with low being preferable.

COST TO FARMERS

This criterion estimates the additional cost farmers will pay when choosing each alternative. Finding quantified cost data for Chinese farmers is difficult, so I primarily focus on costs to American farmers, with the assumption that the cost to Chinese farmers is similar or even greater due to their rural and small characteristics. This cost is for the first two years of implementation because farmers operate on a debt cycle, in which farmers use profits from the current season to pay off loans and insurance premiums that they will incur in the next season (Bhatnagar, 2021; U.S. Department of Agriculture Economic Research Service, 2025). Costs are calculated in Appendix A. Using previous examples, I estimate costs, and then I label them as "high," "medium," or "low," with low being preferable.

LIKELIHOOD OF FARMER COMPLIANCE

This criterion measures the rate of or willingness to accept for farmers to take-up a new practice, such as AWD or climate-smart straw management. For each alternative, I measure a binary uptake variable to find the rate of compliance and apply that to AWD or straw management. The studies measured new technical practices that are implemented each season to be more comparable to AWD and straw management. The rates are compared to each other and given a rating of "high," "medium," or "low," with high being preferable.

LIKELIHOOD OF DESIRED OUTCOMES

This criterion measures the projected outcomes of reducing methane emissions and maintaining crop yields when taking up these alternatives. These outcomes are weighted with highest priority based on interviews with stakeholders. This is correlated to likelihood of farmer compliance, with the assumption and evidence-backed literature that AWD and straw management do not increase methane emissions but maintain rice yields. The rates are compared to each other and given a rating of "high," "medium," or "low," with high being preferable.

POLITICAL FEASIBILITY

This criterion projects the ability for each alternative to become codified in the current political context, with historical precedent also being considered. This criterion analyzes current political actions and rhetoric, previous codification and rhetoric, and data to ascertain American and Chinese political feasibility. The rates are compared to each other and given a rating of "high," "medium," or "low," with high being preferable.

EVALUATING THE ALTERNATIVES

ALTERNATIVE 1: STATUS QUO

Cost to Governments

Pursuing no intervention incurs no additional cost to the U.S., Chinese, or state/provincial governments (when applicable).

Cost to Farmers

Pursuing no intervention incurs no additional cost to farmers.

Likelihood of Farmer Compliance

Pursuing no intervention has high likelihood farmer compliance because there would be no incentive to change behavior.

Likelihood of Desired Outcomes

Reducing Methane Emissions

Pursuing no intervention predicts that methane emissions will continue to increase. Methane tonnage doubled between 2010 and 2020 to 42 million tons, which contributes to 30% of global warming (Garthwaite & Jackson, 2024; Raymond & Hamburg, 2024). Since most methane emissions are anthropogenic from agriculture, and since methane emissions are expected to accelerate, this sub-criterion ranks as low (*Methane Emissions Are Driving Climate Change. Here's How to Reduce Them.*, 2021; Lee, 2022; Raymond & Hamburg, 2024; Garthwaite & Jackson, 2024).

Maintaining Crop Yields

Pursuing no intervention would have no predictable effect on rice yields, as there is no change in mechanisms to alter practices. This sub-criterion ranks high.

Political Feasibility

American Political Feasibility

Pursuing no intervention has high political feasibility in the U.S., as there is no change in mechanisms to alter practices.

Chinese Political Feasibility

Pursuing no intervention has high political feasibility in China, as there is no change in mechanisms to alter practices.

ALTERNATIVE 2: MARKET-BASED INCENTIVES

Cost to Governments

Market-based incentives do not incur many additional costs from the government because the government is resetting markets. The governments will need enforcement entities. In the U.S., this could be part of the Federal Trade Commission, whose program analysts, auditors, and lawyers are paid between $90,000 and $160,000 (*Andrew William Loomis,...* n.d.; *Andria Twanette Jones,...* n.d.; *Abigail Una Wood,...* n.d.; *Irina C. Rodriguez...*, n.d.).

Governments must build the cap-and-trade market. California created a market to trade air pollutant for most sectors in 2011. In 2011, California employed 32 people to develop and implement cap-and-trade, which totaled around $5,000,000, and spent $4,000,000 in contracts for implementation. The state of California creates the auction market and sets caps and prices, and it projected between $600 million to $3 billion in revenues in 2013 (*The 2012-13 Budget: Cap-and-Trade Auction Revenues*, 2012). In 2024 dollars, this development implementation would cost California $12,982,472.38. (*Summary of LAO Findings and Recommendations on the 2011-12 Budget*, 2011; California's Cap-and-Trade Program Step by Step, 2018). California grows the second-most rice in the U.S. (*Where Rice Grows*, n.d.), so expanding it to the other five states would likely cost at least double what it cost in California.

China created a nation-wide cap-and-trade market in 2020 with full development by 2035. Experts estimate that it will cost the government between 2 trillion and 15 trillion Chinese yuan renminbi (RMB), which is between $274 trillion $2.055 quadrillion over 15 years (Goulder et al., 2024). The first two phases of the market roll-out have already begun, and phase three will begin in 2026, without agriculture being mentioned (Goulder et al., 2024). Phase three addresses the sectors that contribute to 70% of carbon dioxide emissions, which is not mutually exclusive to sectors in phases one and two. Agriculture emits 17% of GHGs in China, which include all carbon-based GHGs (*Chinese Yuan Renminbi to U.S. Dollar Spot Exchange Rate*, 2025; Goulder et al., 2024).

The international gold standard of implementing and monitoring prescribes annual monitoring for carbon trading, which would be part of an agriculture or environmental department. The U.S. would be starting this market from scratch, but China would be adding an agriculture component to the existing 2020-2035 plan. To highlight agriculture in Phase 3, this could cost the Chinese government $6.467 million, which is 17% of 70% of Phase 3. To create this market in the U.S. by doubling California's budget, this could cost the U.S. $25 million (Magill, 2015; Liu et al., 2023). Thus, this ranks as low.

Cost to Farmers

Price controls do not generally require farmers to pay more for inputs or changes. For a price ceiling on inputs that reduce methane emissions, farmers would still have to pay for these with their existing means, but it would be lower than market price or current pricing. For a price floor on rice that was grown with AWD or climate-smart straw management, farmers would be guaranteed to receive a price that is above market price, as shown in **Error! Reference source not found.** and **Error! Reference source not found.**. While this creates inefficiency, or quantity not sold due to the higher price, the higher selling price helps farmers make up for the lower quantity sold (Mbiti, 2023, University of Virginia; Tucker, 2021).

Regarding creating markets for emissions, farmers can earn money for trading excess or for their lack of emissions. The government should decide if they should supply the methane measuring equipment or if the farmers should. Because of this potential cost to farmers, this ranks medium for cost to farmers (Kirk, 1985; Tucker, 2021).

Likelihood of Farmer Compliance

Overall, studies indicate that market incentives encourage farmers to comply with different standards by changing their behavior. However, certain market mechanisms had stronger effects than others. In China, having differentiated prices for tea leaves and vegetables that had less fertilizer applied decreased fertilizer overdosage by 30 and 38 percentage points (Canales et al., 2024; Ding et al., 2022; Zhao et al., 2018). Additionally, having differentiated prices increased the intent to mitigate climate impact by 10 to 18 percentage points (Ma et al., 2023; Shen et al., 2024).

Another measurement is the price for willingness-to-accept different incentives. Compared to direct payments—cross-compliance in this report—American farmers would need an extra $6.06 per acre in incentive enroll in a carbon market for switching to conservation techniques like no-till or cover crops (Canales et al., 2024). Thus, market-based incentives have a medium likelihood of farmer compliance to switching to AWD or straw management.

Likelihood of Desired Outcomes

Reducing Methane Emissions

Market-based incentives may not sufficiently reduce methane emissions to meet climate change goals. With price controls, suppliers try to maximize the price. Studies in various sectors in India, China, and Canada found that after implementing price ceilings, the prices on effected goods rose by 5-10% (Li & Wu, 2022; Sen et al., 2011). For inputs necessary implement AWD and straw management that are sold to farmers, prices might not be significantly lower than market value, which might not compel farmers to switch to these inputs. Another reason is additionality: creating markets for methane may reduce methane emissions that were emitted because of the market (Hughes et al., 2024; Piñeiro et al., 2020; Zhu & Chen, 2024). Because of the medium likelihood of farmer compliance to switching to AWD or straw management and of the other considerations, there is a medium likelihood of reducing methane emissions.

Maintaining Crop Yields

Market-based incentives help change farmer behavior by creating new avenues for farm viability and profitability. As mentioned in **Error! Reference source not found.** and **Error! Reference source not found.**, price floors could create a rice quantity surplus, which could encourage farmers to decrease supply of rice grown with AWD (Mbiti, 2023, University of Virginia; Piñeiro et al., 2020; Zhu & Chen, 2024). Thus, this sub-criterion ranks medium for likelihood of maintaining rice yields.

Political Feasibility

American Political Feasibility

The U.S. government has been setting price floors for crops since the earliest Farm Bills, both by buying American crops and by codifying price thresholds (*Fair Prices for Farmers*, n.d.; *2018 Farm Bill - Crop Commodity Programs*, 2025). American private industries verify the carbon emissions and give out the credit (Piñeiro et al., 2020; Ding et al., 2022; Ma et al., 2023; Canales et al., 2024; Hughes et al., 2024). Given the current administration's glorification of free markets and rhetoric and executive orders countering anthropogenic climate change, manipulating markets for climate-smart practices would be misaligned with their goals. Thus, this sub-criterion ranks low.

Chinese Political Feasibility

The Chinese government started implementing market-based incentives in 1979, and it implemented a modified version of cap-and-trade for energy (Goulder et al., 2024; Zhang, 2015). While there was a reported 99.5% compliance rate in the first year of the program, there has since been dwindling trading and selling due to lack of accurate data and too few energy units to meaningfully trade (Liu et al., 2023). China has been using price ceilings and floors to keep certain sectors afloat, including housing, gas, and lithium (Xie, 2023; Cui et al., 2023; Liu & Patton, 2023). These industries uplift Chinese economy and self-sufficiency. Agriculture alone contributes 7.8% to China's GDP, and China seeks to become agriculturally self-sufficient. Thus, this sub-criterion ranks high.

ALTERNATIVE 3: REGULATIONS

Cost to Governments

Governments must implement and measure outputs for regulations. Equipment to measure methane emissions and inputs must be replaced periodically. Individuals who measure and enforce practices and emissions must be paid annually. The USDA had a robust Agriculture Research Service, with 23 offices across the six states that grow rice. A team could be between 1-4 people, with a post-doctoral position having a salary range of $69,000 to $90,000, and more senior members' salary often exceeds that range (*Careers : USDA ARS*, 2024; anonymous former USDA staffer, personal communication, October 9, 2024). Most teams have a mix of seniority, so a team of four could have a total salary of $324,000.

Adding the Produce Safety Rule of 2015 to update the Food Safety and Modernization Act (FMSA), the FMSA cost increased by $41.5 million, or $56.4 million in 2024 dollars (Karst, 2015; Standards for the Growing, Harvesting, Packing, and Holding of Produce for Human Consumption, 2016). This additional spending went to inspection training, education, safety measures, risk management, staffing, and more (Karst, 2015). Congress authorized an additional $104 million to be spent on the FMSA to educate farmers and processors on new regulations (Eskin, 2015). It is reasonable to predict that such appropriations will be necessary to reduce methane emissions, too. In 2025, this would total $197.77 million (*Bureau of Labor Statistics Data*, n.d.). Thus, this ranks as high.

Cost to Farmers

Switching practices, equipment, and outputs to comply with regulations is costly for farmers. From PSR, small farms bear higher costs as a share of profits than larger farms. In 2020, even though very small farms only had $5,375 in compliance costs to PSR, these costs were 6.55% of their profits while large farms had $29,228 in compliance costs that were 0.92% of the profits (Bovay et al., 2018; "Smaller Farms Likely to Face Higher Food Safety Compliance Costs," 2018; McCullough & Hamilton, 2021; *Costs to Facilities and Consumers – Preventive Controls Rule*, n.d.; *Costs to Farmers and Consumers – Produce Rule*, n.d.). Because of the higher costs as a share of profits that smaller farms disproportionately bear and because rice farms are typically small farms, regulations rank as HIGH additional costs to farmers.

Likelihood of Farmer Compliance

Overall, studies indicate that regulations increase rates of farmers taking up new practices, like AWD. Certain types of regulations have a stronger positive effect, while some had an ambiguous effect on intent. In studies conducted on Chinese vegetable, peach, and tea leaf farmers, having regulations increased uptake of climate-smart practices by 8 to 48 percentage points (Huang et al., 2022; Shen et al., 2024; Yang et al., 2021; Zhao et al., 2018). Having supervision yielded ambiguous results, with one study on peach farmers concluding that it increased the correct application of pesticides by 48 percentage points but one study on vegetable farmers concluding that it decreased the correct application of pesticides by 32 percentage points (Huang et al., 2022; Zhao et al., 2018). Both studies were conducted in central eastern China, but peaches receive special treatment for certifications and regulations that vegetables do not seem to be as subject to (Huang et al., 2022; Zhao et al., 2018).

Having regulations increased intent to change behaviors by 8 to 29 percentage points (Ma et al., 2023; Shen et al., 2024). The threat of regulations can be alarming for farmers, and they will immediately say that they will comply. In reality, switching practices comes with uncertain costs and knowledge. Wealthy and hobby farmers were particularly compelled by regulations, but farmers who relied on farming as their primary income found regulations rigid, opaque, and confusing (*Agriculture and Regulatory Reform*, n.d.; Zhao et al., 2018; Udimal et al., 2022; Zhu & Chen, 2024). Thus, this ranks as medium.

Likelihood of Desired Outcomes

Reducing Methane Emissions

Regulations would incentivize farmers to reduce methane emissions by mandating practices such as AWD to ensure that methane emissions are below a set threshold. A study that reviewed thousands of studies found that regulations have a moderate impact on the environmental outcomes they seek to address (Piñeiro et al., 2020). Studies conducted in China on pesticide use regulations attribute this moderate impact to the fact that there is inconsistent effectiveness of regulatory oversight (Piñeiro et al., 2020; Shen et al., 2024; Udimal et al., 2022; Zhao et al., 2018). Thus, this sub-criterion ranks medium.

Maintaining Crop Yields

Regulations should ensure that maintaining crop yields is highlighted as a priority, and AWD and straw management have not indicated a decrease in crop yields. The study on thousands of studies found that regulations have a moderate effect on productivity and profit, which are proxies for rice yields (Piñeiro et al., 2020). Thus, this sub-criterion ranks medium.

Political Feasibility

American Political Feasibility

The U.S. government has used regulations for decades to correct environmental, health and safety, and agricultural concerns. Agencies and departments implement, monitor, and enforce acts, including the Clean Water Act; the Endangered Species Act; the Federal Insecticide, Fungicide and Rodenticide Act; the Food Safety Modernization Act; and the Plant Variety Protection Act (US EPA, 2015). With the overturning of *Chevron U.S.A. Inc. v. Natural Resources Defense Council, Inc.*, several bureaucrats being laid off in all U.S. departmental agencies, and a return to more oil and natural gas, it seems that there is less of an appetite for regulations, particularly those for to combat climate change (*Agriculture and Regulatory Reform*, 2018; Turrentine, 2024; Plumer et al., 2025). Thus, regulations rank low.

Chinese Political Feasibility

China seeks to become a global leader in environmental and food regulations. For example, China has used regulations to shift producer and consumer behavior toward more organic, hazard-free, safe, and climate-conscious food. These regulations have helped increase organic food production (Zhang, 2015; Scott et al., 2018, 40-44). Additionally, China has created several campaigns to reduce methane emissions, including the Methane Emissions Control Action Plan (Baych, 2022; IGSD, 2023), to be a global leader against climate change, though the reality of that leadership and change has been ambiguous (Gu Bin, 2024; Hale, 2023). Because the government is keen to adopt measures that signal methane reduction, this sub-criterion ranks high.

ALTERNATIVE 4: CROSS-COMPLIANCE

Cost to Governments

Governments ensure compliance and then pay farmers subsidies or insurance. In 2022, former President Biden signed into law the Inflation Reduction Act (IRA), which focused on climate-smart and conservation measures in all sectors. The IRA allocated an additional $8.45 billion for the Environmental Quality Incentives Program (EQIP) —which provides financial and technical assistance to farmers to help them integrate conservation onto their lands—and $4.95 billion for the Regional Conservation Partnership Program (RCPP)—in which farmers partner with NGOs and other government entities to continue to integrate conservation onto their lands—over the course of five years (USDA, 2023). The RCPP awardees were itemized, with relevant allotment as follows:

Table 2: RCPP Awardees, 2024

$12,811,585.00	Protecting California's Central Valley Rice Lands for migratory waterfowl during winter
$25,000,000.00	Protecting and enhancing water quality in the lower MS Delta in AR, MS, and LA
$18,983,000.00	Accelerating enteric methane emission reduction in CA dairy farms, with expected reduction at 201 metric tons of carbon dioxide equivalent (MT CO2e)
$20,765,000.00	Accelerating enteric methane emission reduction in IA dairy farms, with expected reduction by 25% or 72,000 MT CO2e
$19,833,000.00	Accelerating enteric methane emission reduction in OR and ID dairy farms, with expected reduction by 210,000 MT CO2e
$12,661,000.00	Accelerating enteric methane emission reduction in KS, OH, ID, and IN dairy farms, with expected reduction by 82,000 MT CO2e

Paired with funds from the partner organization, these funds paid for financial and technical assistance to farmers. I estimate that cross-compliance could cost between $36.684 million and $55.026 million. This is based on Table 2, the fact that reducing methane emissions in rice tends to be cheaper than cows, and that RCPP was half the amount of EQIP, which is more comprehensive and does not partner with other organizations (*Cost-Effective Strategies to Reduce Agricultural Greenhouse Gases*, n.d.; *Regional Conservation Partnership Program 2024 Awarded Projects*, n.d.; Searchinger et al., 2021). Thus, I rate this criterion medium.

Cost to Farmers

By complying with practices that reduce methane, farmers receive reimbursements. Farmers in the U.S. and abroad operate on a debt cycle, which means that the loans, subsidies, and credits they receive in the current year are for next season (Bhatnagar, 2021; *U.S. Department of Agriculture Economic Research Service, 2025*). In the current season, they hope to make enough profit to cover the insurance premium and interest to qualify for next season. Farmers do not have to pay to receive the loans or subsidies, but they do pay for a premium on insurance. However, in cross-compliance, the government could help pay for the insurance premium, which would decrease the farmers' additional payments (*Federal Farm Subsidies*, n.d.; Letourneau, 2025). Moreover, because AWD does not cost much money, this alternative ranks low for additional cost to farmers.

Likelihood of Farmer Compliance

Overall, studies indicate that cross-compliance mechanisms increase rates of farmers taking up new practices, like AWD. In studies conducted on central and eastern Chinese farms, having subsidies and loans increased uptake of new practices—like better pesticide application, no-till, and straw management—by 9 to 36 percentage points and 0.201 logarithmic odds (Xu et al., 2021; Yang et al., 2021; Yang & Wang, 2024; Zhu & Chen, 2022). Some studies in China did yield ambiguous results, such as a small positive percentage point increase or even being negative but neither being statistically significant (Fen et al., 2025; Liu et al., 2025). Cross-compliance mechanisms in China are less reliably consistent, which can obstruct their effectiveness (Fen et al., 2025; Liu et al., 2025; Yang et al., 2021).

Studies on American farmers found that for every additional $1 in incentive payments, farmers planted an additional hectare of cover crops for soil conservation (Surdoval, 2024). Moreover, farmers would be willing to accept $6.06 less in subsidy payments compared to carbon credits from a cap-and-trade market (Canales et al., 2024). This aligns with stakeholders advocating for farmers who want to receive cash payments for switching to climate-smart practices, especially in the U.S. (anonymous former USDA staffer, personal communication, October 9, 2024). Thus, this ranks as high.

Likelihood of Desired Outcomes

Reducing Methane Emissions

Cross-compliance provides farmers a financial cushion as they switch to AWD and bear risk. The likelihood of reducing methane emissions is directly correlated with farmer compliance rates. The review of thousands of incentives found that cross-compliance has a significant effect on environmental impacts (Piñeiro et al., 2020; Canales et al., 2024). Paired with high likelihood of farmer compliance, this sub-criterion ranks as high.

Maintaining Crop Yields

Cross-compliance incentives farmers to switch to AWD or straw management, which have not indicated a decrease in crop yields. The study on thousands of studies found that cross-compliance mechanisms, like insurance and subsidies, have a moderate positive effect on productivity and profit, which are proxies for rice yields (Piñeiro et al., 2020). Thus, this sub-criterion ranks medium.

Political Feasibility

American Political Feasibility

Since the New Deal, the U.S. government has been utilizing cross-compliance mechanisms to keep American farmers afloat and to keep American-grown products in grocery stores (*History of the U.S. Farm Bill*, n.d). The current White House won votes from American farmers and consumers by promising to champion these efforts, but it does not espouse incentives for environmental progress or additional spending. Because these promises and constituencies were a tipping point for victory, the current administration should hesitate to undermine farmers and American-grown groceries, which they argue helps keep consumer prices down (Felder, 2024; Goldman & Klein, 2025; Palen, 2025; Plumer et al., 2025). Thus, this sub-criterion ranks medium.

Chinese Political Feasibility

In the early 2000s, China started implementing cross-compliance programs to shape farmer behavior (Zhang, 2015; Ministry of Agriculture and Rural Affairs of the People's Republic of China, 2017). Chinese agriculture output has steadily increased since the early 2000s (China Production, n.d.; China Agricultural and Economic Data - National and Provincial Data; 2011). China's Methane Emissions Control Action Plan, Five-Year Plan for Agriculture and Rural Development (2021-2025), and Rural Revitalization program outline China's plan to use subsidies, crop insurance, environmental payments, and training programs (Baych, 2022; IGSD, 2023; *Outline of the 14th Five-Year Plan (2021-2025)...*, 2021; *Back to Countryside, New Trend amid China's Rural Revitalization Drive*, 2024). Even though uplifting Chinese agriculture is a way to promote urbanicity rather than Chinese rural populations, it allows China to project agriculture and climate change leadership. Thus, this sub-criterion ranks high.

ALTERNATIVE 5: ORGANIZATIONAL AND COMMUNITY BUILDING

Cost to Governments

Governments must expand existing networks to help farmers adopt methane-reducing practices like AWD and straw management. Currently, $30 million is available in value-added producer grants, which is just one option to farmers. Since the 1930s, cooperative membership has declined, with around 1.8 million farmers having membership in 2024 (Munch, 2024). In 2014, the Chinese government allocated 2 billion RMB for cooperative development (*Agriculture in China I*, 2017). In 2014, there were around 1.3 million agricultural cooperatives; in 2024, there were around 2 million (*Agriculture in China I*, 2017; Al-Assam, 2024; Zachernuk, 2019; Zhang et al., 2024). In 2024 dollars, 2 billion RMB is approximately $446 million. This could cost between $30 and $446 million to governments. This ranks high.

Cost to Farmers

Cooperatives and trade associations often charge membership dues in exchange for the benefits. Bolstering existing cooperatives and trade associations should not inherently incur significantly higher membership dues because the structures for support already exist. This alternative proposes using existing structures to offer support, community, and accountability as rice farmers switch to AWD or straw management. Thus, this ranks high.

Likelihood of Farmer Compliance

Overall, studies indicate that community and organizational networks increase compliance with new practices, like AWD. Studies on eastern and central Chinese farmers found that being cooperative or association members increased uptake with climate-smart practices, such as no-till and proper pesticide usage, by 6 to 22 percentage points (Fen et al., 2025; Huang et al., 2022). Because cooperatives are more integral in China than in the U.S., a range for the U.S. would likely be on the lower end. Thus, this criterion ranks low.

Likelihood of Desired Outcomes

Reducing Methane Emissions

Using county-level panel data and county fixed effects from 2013-2017 in rural China, one study found that cooperatives reduced carbon emissions by 1% (Wang & Qiu, 2024). However, another study found that there is no impact of GHG emissions based on being on a cooperative or not (Zhu & Chen, 2024). Cooperatives and trade associations are a less direct way of changing farmer behavior because they struggle with free-rider problems and limited members and resources (Liang et al., 2023). Even though this alternative has low likelihood of farmer compliance, this sub-criterion ranks high.

Maintaining Crop Yields

Many studies and farmer testimonies conclude that farmer cooperatives and trade associations help increase farmer productivity. In a study on Nigerian tomato farmers, farmers in cooperatives produced 9.159 times output per hectare of land (Akinola et al., 2023). In a study on Chinese rice farmers, researchers found that cooperative membership increases total rice production per household by 4.28%, but small and medium farms reap more output than large farms (Lin et al., 2022). However, one study found that publication biases in hundreds of studies overestimate the significance and magnitude of the positive effects of cooperative membership (Ma et al., 2022). Even though this alternative has low likelihood for farmer compliance, this ranks as high.

Political Feasibility

American Political Feasibility

Trade associations and cooperatives play a large role in the American political system. Not only do they allow for community and resource and knowledge sharing among farmers, they are also formidable constituencies across the country. Working with trade associations signals to voters that politicians are keen to work with a backbone of their communities. Given that the current White House seeks to use non-federal government entities to create efficiency, working with trade associations would be consistent with his plans (*Fact Sheet*, 2025). Thus, this alternative ranks high.

Chinese Political Feasibility

The Chinese government has used cooperatives in rural areas for agriculture since the Great Leap Forward in the 1950s (Chen, 2001). The Chinese government maintains them because of their benefits for the government, rural development, and urbanization (Liang et al., 2023; Zhang, 2015). The government has a heavy hand in cooperatives, and encouraging even more cooperatives would give the government an even bigger influence in rural development as they seek to urbanize and become global leaders in climate change. Thus, this ranks high.

OUTCOMES MATRIX

Table 3: Outcomes Matrix

Evaluative Criteria		Alternatives				
Criteria	**Sub-Criteria**	**Status Quo**	**Market-Based Incentives**	**Regulations**	**Cross-Compliance**	**Organizational/ Community Building**
Cost to Governments		Low ($0)	Low $6-25 million	High $198 million	Medium $36-55 million	High $30-446 million
Cost to Farmers		Low ($0)	Medium	High	Low	Low
Farmer Compliance Likelihood		High (100 pp)	High 30-38 pp; +$6.06	Medium 8-48 pp; -32 pp	High 9-36 pp; -$6.06	Low 6-22 pp
Likelihood of Desired Outcomes	**Reducing Methane Emissions**	Low	Medium	Medium	High	High
	Maintaining Rice Yields	High	Medium	Medium	High	High
Political Feasibility	**American Political Feasibility**	High	Low	Low	Medium	High
	Chinese Political Feasibility	High	Medium	High	High	High

RECOMMENDATION

Based on analysis, I recommended that CEF offer evidence-based analyses on cross-compliance to incentivize rice farmers to switch to methane-reducing practices like AWD and straw management. Cross-compliance promises high likelihood of farmer compliance, which increases the likelihood of desired outcomes, which are the most important criteria. Additionally, it has low cost to farmers and high Chinese political feasibility. Even though cross-compliance has a medium for American political feasibility, it is more likely than market-based incentives and regulations. Organizational and Community Building also had high likelihood of desired outcomes; however, it has high cost to government and lower likelihood of farmer compliance compared to cross-compliance.

IMPLEMENTATION

KEY STAKEHOLDERS

Chinese Government

Role

The Chinese government, including the Chinese Communist Party (CCP), the National Development and Reform Commission (NDRC), and the Ministry of Agriculture and Rural Affairs (MARA), would craft legislation and regulatory framework, provide funding, and oversee the implementation of cross-compliance mechanisms for AWD and straw management (McDonald, 2023). There will be no intervention without the Chinese government on board.

Perspective

The Chinese government seeks to project itself as a global leader in clean agriculture and climate-smart progress. To become a leader, it has been opening itself to more free-market systems internationally and domestically. However, the CCP will not sacrifice ensuring food security and agricultural autarky.

American Government

Role

The American government—including the USDA, EPA, the White House, and Congress—would craft legislation and regulatory framework, provide funding, and oversee the implementation of cross-compliance mechanisms for AWD and straw management. The national American government would be the most uniform and universal way to get cross-compliance to all farmers.

Perspective

The American government, under the current administration, prioritizes an "America first" strategy, which includes production autarky, projecting strength, and tariffs. The current administration also casts disbelief on anthropogenic climate change and the effectiveness of a large and "overreaching" government.

Farmers

Role

Farmers are the primary actors who will either adopt or resist the implementation of methane-reducing practices like AWD and straw management in exchange for subsidies or insurance. They will report on emissions reductions and engage with other stakeholders to implement these changes.

Perspective

Farmers want to preserve their livelihoods. 77.7% of farming-dependent counties supported the current administration because of his rhetoric to protect American industries (Felder, 2024; Palen, 2025). Working in the field, some researchers have found that farmers are open to climate-smart practices, but incentives like crop insurance and cash payments to prevent loss are even more motivating (anonymous former USDA staffer, personal communication, October 9, 2024; K. Mancl, personal communication, September 30, 2024).

Non-governmental Organizations (NGOs), Think Tanks, Universities

Role

NGOs can assist in providing technical expertise, training programs, creating awareness about the benefits of cross-compliance and AWD and straw management. NGOs also can provide data and analysis to support the policy. CEF will lead the advocacy campaign, building consensus among stakeholders, developing the policy framework, and ensuring alignment between government initiatives and farmer needs.

Perspective

NGOs have nuanced perspectives. CEF collaborates with several NGOs whose mission is to create scholarship and dialogue surrounding Asia and climate and sustainability. They all seek to move their missions forward.

International Partners (World Bank, the UN, FAO)

Role

These entities can offer valuable insights from their experience with similar programs and should be leveraged for financial support.

Perspective

Like NGOs, international partners are not a monolith. Broadly, they want to promote development, resilience, and cultural identities of individuals involved. Many partners are concerned with the U.S.'s move to become more isolated, and they see it as an opportunity to step up.

STEPS FOR IMPLEMENTATION

Table 4: Steps for Implementation

MONTH	PHASE	ACTION	OUTPUT
0-6	Advocacy Campaign and Stakeholder Alignment	Initiate a comprehensive campaign to engage policymakers, farmers, NGOs, think tanks, and international partners. This campaign will highlight the benefits of cross-compliance by focusing on the long-term economic and environmental advantages.	A consensus-building strategy that ensures support from various groups.
	Pilot Program Development	Work with governments and stakeholders to design and implement pilot cross-compliance mechanisms like subsidies and insurance in exchange for switching to AWD and straw management.	A detailed report outlining best practices, challenges, and recommendations for scaling up the program.
6-18	Policy Codification	Collaborate with policymakers to draft and codify the necessary legislation. This should outline the specific incentives for farmers. It should also include legislation drafting and public consultation. CEF should also look to other models of cross-compliance in Europe and south(east) Asia.	A comprehensive set of policy recommendations and draft regulations ready for approval by government bodies.
	Pilot Program Rollout	Collaborate with NGOs and International Organizations to roll out the pilot program and to monitor it.	A detailed report on measurements and feedback.
18-43	Policy Codification	Continue codification, as needed.	
	Program Scaling	Expand the program to other regions, with ongoing monitoring and evaluation to ensuring cross-compliance success.	Full program roll-out, with ongoing evaluations and adjustments.

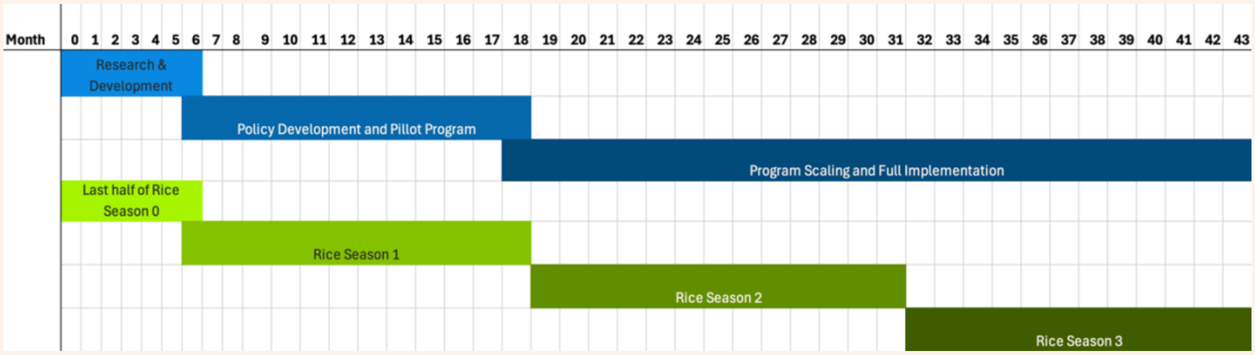

Figure 7: Implementation Timeline

CONCLUSION

Incentivizing Chinese and American rice farmers to take up AWD or straw management by implementing cross-compliance mechanisms, like subsidies and insurance, protects farmers from risk while reducing methane emissions and maintaining crop yields. Because rice alone emits so much methane, these mechanisms will help slow the effects of climate change that threaten the livelihoods of these farmers and the food supply billions of people worldwide. Additionally, with the fact that rice feeds half the world's population each day, these mechanisms ensure that rice yields are maintained, which is critical as the world's population increases. By reducing methane emissions while maintaining rice yields through AWD and cross-compliance, China and the U.S. can protect their agricultural self-reliance while protecting the world's populations from hunger and disastrous weather events.

REFERENCES

2018 Farm Bill—Research, Extension, and Related Matters. (n.d.). United States Department of Agriculture Economic Research Service. Retrieved February 16, 2025, from https://www.ers.usda.gov/topics/farm-bill/2018-farm-bill/research-extension-and-related-matters

Abigail Una Wood | General Attorney | FTC. (n.d.). OpenPayrolls. Retrieved February 19, 2025, from https://openpayrolls.com/employee/abigail-una-wood-9639

Agricultural insurance in Asia and the Pacific region. (2011). Food and Agriculture Organization of the United Nations. https://www.fao.org/4/i2344e/i2344e00.htm

Agriculture and Regulatory Reform. (2018). American Farm Bureau Federation. https://www.fb.org/issue/regulatory-reform/agriculture-and-regulatory-reform

Agriculture in China I. (2017, March 1). Ministry of Agriculture and Rural Affairs of the People's Republic of China. http://english.moa.gov.cn/overview/201910/t20191009_296612.html

Ahuja, S., & Ahuja, U. (2006). Rice in Religion and Tradition. *CCS Haryana Agricultural University*. https://www.researchgate.net/profile/Subhash-Ahuja/publication/321334487_Rice_in_Religion_and_Tradition/links/5bf4de87a6fdcc3a8de62413/Rice-in-Religion-and-Tradition.pdf

Akinola, A., Kehinde, A., Tijani, A., Ayanwale, A., Adesiyan, O., Tanimonure, V., Ogunleye, A., & Ojo, T. (2023). Impact of membership in agricultural cooperatives on yield of smallholder tomato farmers in Nigeria. *Environmental and Sustainability Indicators*, *20*, 100313. https://doi.org/10.1016/j.indic.2023.100313

Al-Assam, A. (2024, May 8). Cooperatives in China: Current status and prospects for significant growth. *Friends of Socialist China*. https://socialistchina.org/2024/05/08/cooperatives-in-china-current-status-and-prospects-for-significant-growth/

Andrew William Loomis | Auditing | FTC | 2023 | OpenPayrolls. (n.d.). OpenPayrolls. Retrieved February 18, 2025, from https://openpayrolls.com/andrew-william-loomis-150504466

Andria Twanette Jones | Management and Program Analysis | FTC | 2023. (n.d.). OpenPayrolls. Retrieved February 18, 2025, from https://openpayrolls.com/andria-twanette-jones-150504349

Back to countryside, new trend amid China's rural revitalization drive. (2024, February 24). The State Council of the People's Republic of China. https://english.www.gov.cn/news/202402/24/content_WS65d9ae75c6d0868f4e8e4521.html#

Baych, A. (2022). *Agricultural and Rural Modernization Plan Reiterates Prior Pledges* (CH2022-0023). United States Department of Agriculture Foreign Agriculture Service. https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Agricultural%20and%20Rural%20Modernization%20Plan%20Reiterates%20Prior%20Pledges_Beijing_China%20-%20People%27s%20Republic%20of_CH2022-0023.pdf

Benischke, M. H., & Bhaskarabhatla, A. (2024). Negative Incentives and Regulatory Capture: Noncompliance with Price Ceilings on Essential Medicines in India. *Journal of Management Studies*, *61*(2), 336–374. https://doi.org/10.1111/joms.12885

Bhatnagar, S. (2021, May 15). Economics of Indian Farmers' Movement: A Study of Agrarian Distress and a Vicious Debt Cycle. *Yale Journal of International Affairs*. https://www.yalejournal.org/publications/economics-of-indian-farmers-movement-a-study-of-agrarian-distress-and-a-vicious-debt-cycle

Bovay, J., Ferrier, P., & Zhen, C. (2018). *Estimated Costs for Fruit and Vegetable Producers To Comply With the Food Safety Modernization Act's Produce Rule* (EIB-195). United States Department of Agriculture Economic Research Service.

https://ers.usda.gov/sites/default/files/_laserfiche/publications/89749/EIB-195.pdf?v=24672

Bureau of Labor Statistics Data. (n.d.). Bureau of Labor Statistics. Retrieved March 5, 2025, from https://data.bls.gov/pdq/SurveyOutputServlet

Canales, E., Bergtold, J. S., & Williams, J. R. (2024). Conservation intensification under risk: An assessment of adoption, additionality, and farmer preferences. *American Journal of Agricultural Economics*, *106*(1), 45–75. https://doi.org/10.1111/ajae.12414

Careers: USDA ARS. (2024, June 6). United States Department of Agriculture Agriculture Research Service. https://www.ars.usda.gov/northeast-area/beltsville-md-barc/beltsville-agricultural-research-center/agil/careers/

Chakravorty, U., Dar, M., & Emerick, K. (2020). *Impact of alternate wetting and drying on farm incomes and water savings in Bangladesh* (Evaluation Report 108). International Initiative for Impact Evaluation. https://www.3ieimpact.org/sites/default/files/2020-03/IE108-DPW1.1081-Bangladesh-AWD.pdf

Chen, C., Zhong, Q., & Wang, L. (2024). Value Perception, Government Regulation, and Farmers' Behavior toward Continuing to Maintain the Sloping Land Conversion Program. *Land*, *13*(3), Article 3. https://doi.org/10.3390/land13030286

China Rice Area, Yield and Production. (2024, November 8). United States Department of Agriculture Foreign Agriculture Service. https://ipad.fas.usda.gov/countrysummary/Default.aspx?id=CH&crop=Rice

Chinese Yuan Renminbi to U.S. Dollar Spot Exchange Rate. (2025, March 24). https://fred.stlouisfed.org/series/DEXCHUS

Claassen, R., Duquette, E. N., & Smith, D. J. (2018). Additionality in U.S. Agricultural Conservation Programs. *Land Economics*, *94*(1), 19–35.

Connor, M., Gummert, M., & Singleton, G. R. (Eds.). (2023). *Closing Rice Yield Gaps in Asia: Innovations, Scaling, and Policies for Environmentally Sustainable Lowland Rice Production*. Springer Nature. https://doi.org/10.1007/978-3-031-37947-5

Conrad, R., Mitra, A. P., Neue, H. U., & Sass, R. (1996). *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual* (Vol. 3). Intergovernmental Panel on Climate Change. https://www.ipcc-nggip.iges.or.jp/public/gl/invs6.html

Cooperative Services. (2015, March 18). Rural Development. https://www.rd.usda.gov/programs-services/all-programs/cooperative-services

Cost-effective strategies to Reduce Agricultural Greenhouse Gases. (n.d.). United States Department of Agriculture Climate Hubs. Retrieved March 30, 2025, from https://www.climatehubs.usda.gov/hubs/northeast/topic/cost-effective-strategies-reduce-agricultural-greenhouse-gases

Costs to Facilities and Consumers – Preventive Controls Rule. (n.d.). National Sustainable Agriculture Coalition. Retrieved February 15, 2025, from https://sustainableagriculture.net/fsma/learn-about-the-issues/preventive-controls-rule/

Costs to Farmers and Consumers – Produce Rule. (n.d.). National Sustainable Agriculture Coalition. Retrieved February 15, 2025, from https://sustainableagriculture.net/fsma/learn-about-the-issues/costs-to-farmers-and-consumers-produce-rule/

Cubanski, J., Neuman, T., & Published, M. F. (2023, January 24). Explaining the Prescription Drug Provisions in the Inflation Reduction Act. *KFF*. https://www.kff.org/medicare/issue-brief/explaining-the-prescription-drug-provisions-in-the-inflation-reduction-act/

Cui, J., Yang, H., Wang, Y., & Yang, C. (2023). Dynamics of the gas retail market under China's price cap regulation. *Energy Policy*, *174*, 113424. https://doi.org/10.1016/j.enpol.2023.113424

Ding, X., Sarkar, A., Li, L., Li, H., & Lu, Q. (2022). Effects of Market Incentives and Livelihood Dependence on Farmers' Multi-Stage Pesticide Application Behavior—A Case Study of Four Provinces in China. *International Journal of Environmental Research and Public Health*, *19*(15), Article 15. https://doi.org/10.3390/ijerph19159431

Eskin, S. (2015, December 18). *Congress Approves Historic Increase in Food Safety Funding*. Pew Charitable Trusts. http://pew.org/1RU3AHo

Farm & Commodity Policy—Farm Bill Spending. (2025, January 8). United States Department of Agriculture Economic Research Service. https://www.ers.usda.gov/topics/farm-economy/farm-commodity-policy/farm-bill-spending

Federal farm subsidies: What the data says. (n.d.). USAFacts. Retrieved February 19, 2025, from https://usafacts.org/articles/federal-farm-subsidies-what-data-says/

Felder, N. (2024, November 12). GRAPHIC: Trump support grew in America's top farming counties despite first-term trade war—Investigate Midwest. *Investigate Midwest*. https://investigatemidwest.org/2024/11/13/trump-election-farming-counties-trade-war/

Fen, G., Jianjun, J., Dan, L., Jie, Y., & Zhanlu, Z. (2025). Factors Influencing Farmers' Behavior of Adopting Conservation Tillage Technology in China: A Meta-Analysis. *Journal of Resources & Ecology*, *16*(1), 49–61. https://doi.org/10.5814/j.issn.1674-764x.2025.01.005

Garthwaite, J., & Jackson, R. (2024, September 9). *The world hasn't hit the brakes on methane emissions*. Stanford Report. https://news.stanford.edu/stories/2024/09/methane-emissions-are-rising-faster-than-ever

Goldman, D., & Klein, B. (2025, March 30). Trump says he 'couldn't care less' if auto prices rise because of tariffs | CNN Business. *CNN*. https://www.cnn.com/2025/03/29/business/trump-auto-prices-tariffs/index.html

Goulder, L., Long, X., Qu, C., & Zhang, D. (2024, April 18). *Assessing China's New Nationwide Effort to Reduce Carbon Dioxide Emissions*. Resources for the Future. https://www.resources.org/common-resources/assessing-chinas-new-nationwide-effort-to-reduce-carbon-dioxide-emissions/

Gummert, M. (2010). *When to harvest—IRRI Rice Knowledge Bank*. International Rice Research Institute. http://www.knowledgebank.irri.org/training/fact-sheets/item/when-to-harvest-fact-sheet

History of the U.S. Farm Bill. (n.d.). [Software]. Library of Congress. Retrieved February 4, 2025, from https://www.loc.gov/ghe/cascade/index.html?appid=1821e70c01de48ae899a7ff708d6ad8b&bookmark=What%20is%20the%20Farm%20Bil

How cap and trade works. (2020, January 22). https://www.edf.org/climate/how-cap-and-trade-works

How Rice Grows. (n.d.). USA Rice. Retrieved March 26, 2025, from https://www.usarice.com/thinkrice/discover-us-rice/how-rice-grows

How To Store Rice. (n.d.). USA Rice Federation. Retrieved December 4, 2024, from https://www.usarice.com/thinkrice/how-to/how-to-store-rice

Howley, P. (2015). The Happy Farmer: The Effect of Nonpecuniary Benefits on Behavior. *American Journal of Agricultural Economics*, *97*(4), 1072–1086.

Huang, Q., Wang, H., & Chen, C. (2022). The Influence of Government Regulation on Farmers' Green Production Behavior—From the Perspective of the Market Structure. *International Journal of Environmental Research and Public Health*, *20*(1), 506. https://doi.org/10.3390/ijerph20010506

Hughes, A., Leonard, E., Rudek, J., Rosenstein, R., & Monast, M. (2024). *Carbon Credits for Livestock Methane Reductions: Making sense of compliance and voluntary offset methodologies*. Environmental Defense Fund. https://www.edf.org/carbon-offset-credits-livestock-methane-reductions-are-promising-need-better-science-and-technology

Hurt, D. R. (2010). American and Chinese Agricultural Policy since 1949: An Overview. *Procedia - Social and Behavioral Sciences*, *2*(5), 6692–6701. https://doi.org/10.1016/j.sbspro.2010.05.014

IGSD. (2023, November 8). China Releases Methane Emissions Control Action Plan. *Institute For Governance & Sustainable Development -*. https://www.igsd.org/china-releases-methane-emissions-control-action-plan/

Irina C. Rodriguez | General Attorney | FTC. (n.d.). OpenPayrolls. Retrieved February 19, 2025, from https://openpayrolls.com/employee/irina-c-rodriguez-9639

Karst, K. (2015, July 24). Senate and House Lawmakers Add to FDA's To-Do List in Fiscal Year 2016 Appropriations Bills. *FDA Law Blog*. https://www.thefdalawblog.com/2015/07/senate-and-house-lawmakers-add-to-fdas-to-do-list-in-fiscal-year-2016-appropriations-bills/

Kassel, K. (2024, September 5). *Farming and Farm Income*. United States Department of Agriculture. https://www.ers.usda.gov/data-products/ag-and-food-statistics-charting-the-essentials/farming-and-farm-income/

Kimura, S., Lin, W., Wehrhahn, R., & Zhang, L. (2022). *Developing a Sustainable Agricultural Insurance System in the People's Republic of China* (233). Asian Development Bank. https://www.adb.org/sites/default/files/publication/843866/adb-brief-233-agricultural-insurance-system-prc.pdf

Kirk, B. (1985, October 28). *Opposing price controls for farmers* [Interview]. https://docsouth.unc.edu/sohp/K-0013/excerpts/excerpt_286.html

Le, L. N., & Panella, T. (2022, September 12). *Here's How Better Crop Insurance Can Help Asia's Farmers Survive Climate Change*. Asian Development Bank. https://blogs.adb.org/blog/here-s-how-better-crop-insurance-can-help-asia-s-farmers-survive-climate-change

Lee, H.-S., Gwon, H.-S., Lee, S.-I., Park, H.-R., Lee, J.-M., Park, D.-G., Lee, S.-R., Eom, S.-H., & Oh, T.-K. (2024). Reducing Methane Emissions with Humic Acid–Iron Complex in Rice Cultivation: Impact on Greenhouse Gas Emissions and Rice Yield. *Sustainability*, *16*(10), Article 10. https://doi.org/10.3390/su16104059

Lee, N. (2022, August 23). *Addressing Methane Emissions Is Critical for Fighting Climate Crisis*. Environmental and Energy Study Institute. https://www.eesi.org/articles/view/addressing-methane-emissions-is-critical-for-fighting-climate-crisis

Letourneau, M. (2025, January 2). Farm Loans and Grants: Ag Funding for Farmers and Ranchers. *High Plains Farm Credit*. https://highplainsfarmcredit.com/farm-loans-and-grants-funding-for-farmers-and-ranchers/

Li, J., & Wu, D. (2022). The Price Effect of Drug Price Ceilings: Intended and Unintended Consequences. *Management Science*, *68*(8), 5758–5777. https://doi.org/10.1287/mnsc.2021.4166

Liang, Q., Ma, K., & Liu, W. (2023). The role of farmer cooperatives in promoting environmentally sustainable agricultural development in China: A review. *Annals of Public & Cooperative Economics*, *94*(3), 741–759. https://doi.org/10.1111/apce.12444

Liu, S., & Patton, D. (2023, March 23). Exclusive: Chinese lithium producers set price floor as demand evaporates, sources say. *Reuters*. https://www.reuters.com/world/china/chinese-lithium-producers-set-price-floor-demand-evaporates-sources-2023-03-31/

Liu, Y., Garnevska, E., & Shadbolt, N. (2024). Organizational structures of agriculture cooperatives in China: Evidence from the green vegetable sector. *Journal of Co-Operative Organization and Management*, *12*(2), 100246. https://doi.org/10.1016/j.jcom.2024.100246

Liu, Z., Yan, Q., Zhang, Y., & Qu, M. (2025). The Key Factors That Influence Farmers' Participating Behavior in Forest Management Plan Formulation Based on 1752 Households in China. *Forests (19994907)*, *16*(1), 73. https://doi.org/10.3390/f16010073

Ma, J., Gao, H., Cheng, C., Fang, Z., Zhou, Q., & Zhou, H. (2023). What influences the behavior of farmers' participation in agricultural nonpoint source pollution control?—Evidence from a farmer survey in Huai'an, China. *Agricultural Water Management*, *281*, 108248. https://doi.org/10.1016/j.agwat.2023.108248

Ma, W., Hu, S., Reed, B., Duan, J., & Luu, P. (2022). Yield effects of agricultural cooperative membership: A meta-analysis. *Annals of Public & Cooperative Economics*, *94*. https://doi.org/10.1111/apce.12411

Magill, B. (2015, September 25). *China Announces World's Largest Cap and Trade Program*. https://www.climatecentral.org/news/china-announces-cap-and-trade-program-19496

Mancl, K. (2024, December 5). US Agricultural Success Built on US-China Scientific Exchange. *New Security Beat*. https://www.newsecuritybeat.org/2024/12/us-agricultural-success-built-on-us-china-scientific-exchange/

McBride, W., Skorbiansky, S. R., & Childs, N. (2018). *U.S. Rice Production in the New Millennium: Changes in Structure, Practices, and Costs* (EIB-202). United States Department of Agriculture Economic Research Service. https://ers.usda.gov/sites/default/files/_laserfiche/publications/90926/EIB-202.pdf?v=45816

McCullough, M., & Hamilton, L. (2021). *Assessing the Economic Impacts of Agricultural Equipment Emission Reduction Strategies on the Agricultural Economy in the San Joaquin Valley: Phase Two, 2018 Costs*. California Polytechnic State University. https://digitalcommons.calpoly.edu/cgi/viewcontent.cgi?article=1160&context=agb_fac

Methane emissions are driving climate change. Here's how to reduce them. (2021, August 20). UN Environmental Programme. https://www.unep.org/news-and-stories/story/methane-emissions-are-driving-climate-change-heres-how-reduce-them

Ministry of Agriculture and Rural Affairs of the People's Republic of China. (2017, March 3). *Agriculture in China*. Ministry of Agriculture and Rural Affairs of the People's Republic of China. http://english.moa.gov.cn/overview/201910/t20191009_296610.html

Munch, D. (2024, June 24). *The Crucial Role of Farmer Cooperatives and Why Active Participation Matters*. Farm Bureau. https://www.fb.org/market-intel/the-crucial-role-of-farmer-cooperatives-and-why-active-participation-matters

Outline of the 14th Five-Year Plan (2021-2025) for National Economic and Social Development and Vision 2035 of the People's Republic of China. (2021, August 9). People's Government of Fujian Province. https://www.fujian.gov.cn/english/news/202108/t20210809_5665713.htm

Overview of Greenhouse Gases. (2025, January 25). United States Environmental Protection Agency. https://www.epa.gov/ghgemissions/overview-greenhouse-gases

Palen, B. (2025, February 17). A farmer writes: With Trump and Musk driving U.S. policy, farmers have been played for suckers. *Minnesota Reformer*. https://minnesotareformer.com/2025/02/17/with-trump-and-musk-driving-u-s-policy-farmers-have-been-played-for-suckers/

Piñeiro, V., Arias, J., Dürr, J., Elverdin, P., Ibáñez, A. M., Kinengyere, A., Opazo, C. M., Owoo, N., Page, J. R., Prager, S. D., & Torero, M. (2020). A scoping review on incentives for adoption of sustainable agricultural practices and their outcomes. *Nature Sustainability*, *3*(10), 809–820. https://doi.org/10.1038/s41893-020-00617-y

Plumer, B., Gelles, D., & Zraick, K. (2025, February 13). Tracking Trump's Biggest Climate Moves. *The New York Times*. https://www.nytimes.com/2025/02/13/climate/tracking-trumps-biggest-climate-moves.html

Raymond, P., & Hamburg, S. (2024, November 18). *Yale Experts Explain Methane Emissions* [Interview]. https://sustainability.yale.edu/explainers/yale-experts-explain-methane-emissions

Regional Conservation Partnership Program 2024 Awarded Projects. (n.d.). USDA Natural Resources Conservation Service. https://www.nrcs.usda.gov/sites/default/files/2024-10/rcpp-2024-awarded-projects.pdf

Rice Nutrition. (n.d.). USA Rice Federation. Retrieved December 4, 2024, from https://www.usarice.com/thinkrice/health-nutrition/rice-nutrition

Rice Sector at a Glance. (2025, January 7). United States Department of Agriculture Economic Research Service. https://www.ers.usda.gov/topics/crops/rice/rice-sector-at-a-glance/#

Scott, S., Si, Z., Schumilas, T., & Chen, A. (2018). *Organic Food and Farming in China: Top-down and Bottom-up Ecological Initiatives*. Routledge. https://doi.org/10.4324/9780203701706

Searchinger, T., Herrero, M., Yan, X., Wang, J., Dumas, P., Beauchemin, K., & Kebreab, E. (2021, November). *Opportunities to Reduce Methane Emissions from Global Agriculture*. Princeton University. https://searchinger.princeton.edu/sites/g/files/toruqf4701/files/methane_discussion_paper_nov_2021.pdf

Sen, A., Clemente, A., & Jonker, L. (2011). Retail Gasoline Price Ceilings and Regulatory Capture: Evidence from Canada. *American Law and Economics Review*, *13*(2), 532–564. https://doi.org/10.1093/aler/ahr008

Shen, L., Liu, W., Si, H., Li, H., Li, N., & Yan, F. (2024). What affects farmers' intention and behavior to mitigate the impact of climate change? Evidence from Hebei Province, China. *Journal of Rural Studies*, *114*. https://doi.org/doi.org/10.1016/j.jrurstud.2024.103525

Smaller Farms Likely to Face Higher Food Safety Compliance Costs. (2018, August 31). *National Sustainable Agriculture Coalition*. https://sustainableagriculture.net/blog/fsma-compliance-costs/

Standards for the Growing, Harvesting, Packing, and Holding of Produce for Human Consumption (2016). https://www.regulations.gov/document/FDA-2011-N-0921-18558

Summary of LAO Findings and Recommendations on the 2011-12 Budget. (n.d.). Retrieved March 29, 2025, from https://lao.ca.gov/laoapp/budgetlist/PublicSearch.aspx?Yr=2011&KeyCol=429

Surdoval, A. (2024). Financial incentive programs and farm diversification with cover crops: Assessing opportunities and challenges. *Environmental Research*, *19*. https://doi.org/doi.org/10.1088/1748-9326/ad35d8

Sutter, K., & Blevins, E. (2024). *U.S.-China Science and Technology Cooperation Agreement* (IF12510; p. 3). Congressional Research Service. https://crsreports.congress.gov/product/pdf/IF/IF12510

The 2012-13 Budget: Cap-and-Trade Auction Revenues. (2012, February 16). https://www.lao.ca.gov/analysis/2012/resources/cap-and-trade-auction-revenues-021612.aspx

The Protocol on cooperation in the Field of Fossil Energy Research and Development between the Dept. Of Energy and the Ministry of Coal Industry of the People's Republic of China. (1985, April 16). Energy.Gov. https://www.energy.gov/node/4812409

Tucker, T. (2021). *PRICE CONTROLS: HOW THE US HAS USED THEM AND HOW THEY CAN HELP SHAPE INDUSTRIES*. The Roosevelt Institute. https://rooseveltinstitute.org/wp-content/uploads/2021/11/RI_Industrial-Policy-Price-Controls_Brief-202111.pdf

Turner, J. L., Mancl, K., & Nguyen, J. (2024). *Cultivating US and Chinese Climate Leadership on Food and Agriculture: A Roadmap for Collaboration*. Wilson Center.

https://www.wilsoncenter.org/publication/cultivating-us-and-chinese-climate-leadership-food-and-agriculture-roadmap

Turrentine, J. (2024, June 28). *The Supreme Court Ends Chevron Deference—What Now?* Natural Resources Defense Council. https://www.nrdc.org/stories/what-happens-if-supreme-court-ends-chevron-deference

Types of Food the UN WFP Delivers in a Humanitarian Crisis. (n.d.). *World Food Program USA*. Retrieved December 4, 2024, from https://www.wfpusa.org/food-we-deliver/

Udimal, T. B., Peng, Z., Cao, C., Luo, M., Liu, Y., & Mensah, N. O. (2022). Compliance with pesticides' use regulations and guidelines among vegetable farmers: Evidence from the field. *Cleaner Engineering and Technology*, *6*, 100399. https://doi.org/10.1016/j.clet.2022.100399

U.S. Department of Agriculture Economic Research Service. (2025, February 6). *Farm Sector Income & Finances—Highlights from the Farm Income Forecast*. United States Department of Agriculture Economic Research Service. https://www.ers.usda.gov/topics/farm-economy/farm-sector-income-finances/highlights-from-the-farm-income-forecast

US EPA. (2024, September 24). *Clean Water Act (CWA) and Federal Facilities* [Other Policies and Guidance]. https://www.epa.gov/enforcement/clean-water-act-cwa-and-federal-facilities

U.S.-China Bilateral WTO Agreement. (1999, November 15). The White House. https://clintonwhitehouse4.archives.gov/WH/New/WTO-Conf-1999/factsheets/fs-004.html

U.S.-China Climate Cooperation Timeline. (2024, October 17). Asia Society. https://asiasociety.org/policy-institute/us-china-climate-cooperation-timeline

USDA. (2023, February 13). *Biden-Harris Administration Announces Availability of Inflation Reduction Act Funding for Climate-Smart Agriculture Nationwide*. https://www.usda.gov/about-usda/news/press-releases/2023/02/13/biden-harris-administration-announces-availability-inflation-reduction-act-funding-climate-smart

Value-Added Producer Grants. (2015, January 9). United States Department of Agriculture Rural Development. https://www.rd.usda.gov/programs-services/business-programs/value-added-producer-grants

Wang, H., & Qiu, T. (2024). The effects of farmer cooperatives on agricultural carbon emissions reduction: Evidence from rural China. *Journal of Cleaner Production*, *450*, 141881. https://doi.org/10.1016/j.jclepro.2024.141881

Wassmann, R., Van-Hung, N., Yen, B. T., Gummert, M., Nelson, K. M., Gheewala, S. H., & Sander, B. O. (2022). Carbon Footprint Calculator Customized for Rice Products: Concept and Characterization of Rice Value Chains in Southeast Asia. *Sustainability*, *14*(1), Article 1. https://doi.org/10.3390/su14010315

What is the United Nations Framework Convention on Climate Change? (n.d.). United Nations Climate Change. Retrieved December 5, 2024, from https://unfccc.int/process-and-meetings/what-is-the-united-nations-framework-convention-on-climate-change

Where Rice Grows. (n.d.). USA Rice. Retrieved February 19, 2025, from https://www.usarice.com/thinkrice/discover-us-rice/where-rice-grows

Wu, J., Xu, Y., & Liu, Z. (2024). A comprehensive review on agricultural greenhouse gas emission reductions in China: Opportunities and challenges. *Carbon Footprints*, *3*(4). https://doi.org/10.20517/cf.2024.23

Xie, S. Y. (2023, September 27). China Has Second Thoughts About Controlling Prices in Its Multi Trillion-Dollar Housing Market. *WSJ*. https://www.wsj.com/economy/housing/china-has-second-thoughts-about-controlling-prices-in-its-multi-trillion-dollar-housing-market-f0a06012

Xu, X., Zhang, Z., Kuang, Y., Li, C., Sun, M., Zhang, L., & Chang, D. (2021). Waste pesticide bottles disposal in rural China: Policy constraints and smallholder farmers' behavior. *Journal of Cleaner Production*, *316*, 128385. https://doi.org/10.1016/j.jclepro.2021.128385

Yang, Y., Li, Z., & Zhang, Y. (2021). Incentives or restrictions: Policy choices in farmers' chemical fertilizer reduction and substitution behaviors. *International Journal of Low Carbon Technologies*, *16*(2), 351–360. https://doi.org/10.1093/ijlct/ctaa068

Yang, Y., & Wang, Y. (2024). The Impact of Government Subsidies and Quality Certification on Farmers' Adoption of Green Pest Control Technologies. *Agriculture*, *15*(35). https://doi.org/10.3390/agriculture15010035

Ye, T., & Mu, Q. (n.d.). *Fostering Rural Resilience: A Closer Look at China's Agricultural Insurance Pilot*. World Bank Group. https://documents1.worldbank.org/curated/en/148591594886678703/pdf/Fostering-Rural-Resilience-A-Closer-Look-at-China-s-Agricultural-Insurance-Pilot-Learning-from-Experience-Insights-from-China-s-Progress-in-Disaster-Risk-Management.pdf

Zachernuk, T. (2019, January 4). Cooperatives in China. *Society for Anglo-Chinese Understanding (SACU)*. https://sacu.org/cooperatives/

Zhang, J., Jabbar, A., & Li, X. (2024). How Does China's Agricultural Subsidy Policy Drive More Commercially Productive Small Farmers? The Role of Farmland Scale, Labor Supply, and Cropping Structural Change. *Land*, *13*(12), Article 12. https://doi.org/10.3390/land13122058

Zhang, W. (2015). *The Commonalities and Differences between Chinese and U.S. Agriculture*. Agricultural Policy Review. https://agpolicyreview.card.iastate.edu/fall-2015/commonalities-and-differences-between-chinese-and-us-agriculture

Zhao, L., Wang, C., Gu, H., & Yue, C. (2018). Market incentive, government regulation and the behavior of pesticide application of vegetable farmers in China. *Food Control*, *85*, 308–317. https://doi.org/10.1016/j.foodcont.2017.09.016

Zhou, H., Tao, F., Chen, Y., Yin, L., Li, Y., Wang, Y., & Su, C. (2024). Paddy rice methane emissions, controlling factors, and mitigation potentials across Monsoon Asia. *Science of The Total Environment*, *935*, 173441. https://doi.org/10.1016/j.scitotenv.2024.173441

Zhu, Y., & Chen, J. (2022). Small-Scale Farmers' Preference Heterogeneity for Green Agriculture Policy Incentives Identified by Choice Experiment. *Sustainability*, *14*(10), 5770. https://doi.org/10.3390/su14105770

Ziska, L., & Fukugawa, N. (2019). Rice: Importance for Global Nutrition. *Journal of Nutritional Science and Vitaminology*, *65*(Supplement), 2. https://doi.org/10.3177/jnsv.65.S2

APPENDICES

Appendix A: Cost Calculation Spreadsheet

I used the following spreadsheet to calculate costs: https://myuva-my.sharepoint.com/:x:/r/personal/gvm3wy_virginia_edu/Documents/UVA/2024-2025/APP/Calculations.xlsx?d=w58de5a97bf1941368285e45887853b4b&csf=1&web=1&e=7xegY7

Appendix B: Image References

Cover Picture: https://fineartamerica.com/featured/chinese-rice-paddy-field-in-late-afternoon-light-donna-caplinger.html

Figure 1: https://www.nass.usda.gov/Charts_and_Maps/graphics/AR-YI-RGBChor.pdf

Figure 2: *China Rice Area, Yield and Production*. (2024, November 8). United States Department of Agriculture Foreign Agriculture Service. https://ipad.fas.usda.gov/countrysummary/Default.aspx?id=CH&crop=Rice

Figure 3: Sheng, R. T.-C., Huang, Y.-H., Chan, P.-C., Bhat, S. A., Wu, Y.-C., & Huang, N.-F. (2022). Rice Growth Stage Classification via RF-Based Machine Learning and Image Processing. *Agriculture*, *12*(12), 2137. https://doi.org/10.3390/agriculture12122137

Figure 4: Gu, X., Weng, S., Li, Y., & Zhou, X. (2022). Effects of Water and Fertilizer Management Practices on Methane Emissions from Paddy Soils: Synthesis and Perspective. *International Journal of Environmental Research and Public Health*, *19*(12), 7324. https://doi.org/10.3390/ijerph19127324