

Opportunities for GHG Mitigation in Agricultural Systems and the Technology Transfer

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ABSTRACT

Agriculture is a worldwide critical strategic resource expected to double its production in 30 years to feed the world. Agriculture can contribute modestly to mitigation through reducing emissions and carbon sequestration in soils. Emissions from manure can be turned into methane fuel. Methane from ruminants can be reduced through straw ammoniation and increased feed efficiency, and methane from rice paddies can be mitigated. Better nutrient management can reduce emissions of nitrous oxide. But, there are many barriers that may be encountered for adopting these mitigation options. Some of these options require more labors and some need more capital investment, which may represent the main constraints slowing adoption of the technologies.

The effectiveness of technology transfer response strategies would depend to a great extent on the suitability of transferred technologies to the socioeconomic and cultural context of the recipients, considering development, equity, and sustainability issues. This transfer demonstrates the success of a policy that responds to present need, concentrates researchers, devises cheap technology, and promptly benefits farmers. This is also particularly relevant when applied to north-south technology transfers in this sector. Governments can facilitate transfer with incentives by regulating and by improving institutions.

Some technologies will not be so easily transferred. Banks should extend credit to farmers. Research and training should be turned to “no-regret” mitigation technologies. Trade free of barriers facilitates technology transfer. Education lies at the heart of technological transfer. Private business can announce technology in advertisements or demonstrate it at fairs. Governments have a role in monitoring claims and educating broadly.

Despite uncertainties, past successes, established by embattled researchers and trainers, and the incentive of feeding the world encourage hope. The aim is reliable and adequate agricultural growth with less emission and more storage of greenhouse gases.

1. Overview

Agriculture is a worldwide critical strategic resource expected to double its production in 30 years to feed the world. Recently, increased attention has been focused the potential for agriculture to contribute to reducing greenhouse gas emissions. Agriculture can contribute

modestly to mitigation through reducing emissions and carbon sequestration in soils. Emissions from manure can be turned into methane fuel. Methane from ruminants can be reduced through ammoniated straw and increased feed efficiency, and methane from rice paddies can be mitigated. Better nutrient management can reduce emissions of nitrous oxide.

What are the major gases of concern for agriculture? Carbon dioxide (CO₂), nitrous oxide (N₂O) and methane (CH₄) are all important for agriculture. The concentration of each of these gases has increased dramatically over the past several decades due to human activities, including agriculture. Agriculture provides a potential sink for CO₂, through building up soil organic matter stocks, which incorporate CO₂ taken from the atmosphere by plants. Agriculture is an important source for N₂O emissions, which occur as a consequence of nitrogen cycling in the soil, where nitrogen added through fertilizers are of particular concern. There are no significant sinks or uptake mechanisms for N₂O in agricultural systems, so that the mitigation focus is entirely on emission reductions. Within agriculture, methane is emitted by animal, especially ruminants - cows, sheep and goats, digestive processes and from livestock waste systems. Flooded rice cultivation is a major source world-widely, but of getting less importance in some countries even in China. Reducing emissions is the most important component of mitigation of methane, but well aerated soils also act as a sink due to taking up and oxidizing CH₄. The most effective sinks are in non-agricultural soils, like grassland – cultivated and fertilized soils take up less methane than less intensively managed soils. An important point to consider in the overall effect of greenhouse gases is the relative difference in ‘greenhouse effect’, also know as global warming potential. Relative to CO₂, N₂O has about 310 times the effect of CO₂ and CH₄ about 21 times the effect. Thus, while the concentration and flux rates of N₂O and CH₄ are much lower than for CO₂, their effects are significant due to the characteristics of those gases with respect to global warming.

Within agriculture of the world, the largest emission sources are attributed to N₂O, stemming largely from fertilizer use, and methane emissions from livestock. China is as similar.

For each of the major greenhouse gases, there are significant mitigation opportunities within agriculture. For nitrous oxide, the best mitigation opportunities lie in the development of new fertilizers, as well as wider use of nitrification inhibitors, and in general, a more efficient use of nitrogen fertilizers. Methane losses from livestock can be reduced by improving overall livestock productivity, including breeding and nutrition, i.e. using forage additive. Technology exists for greatly reducing methane emissions from manure handling facilities, i.e. biogas generator in farmer level Methane capture and use as energy, i.e. natural gas, has a ‘double’ effect in that animal farm the energy produced can offset CO₂ emissions from fossil fuel.

For nitrous oxide emissions, the key is to reduce the amount of nitrogen cycling through the soil while still meeting plant nutrient needs. The most effective practices are to improve the efficiency of nitrogen fertilizer use by better forecasting of actual plant needs, better timing of application, better application methods and improvements in fertilizer formulations and additives. Reducing methane from livestock is possible through improving the diet, nutrition and food assimilation of the animals. Such practices are already widespread in the US (although further improvements are possible) and in other developed countries, but much greater potential gains are possible with improved livestock management in developing countries, so the technology transfer

will have large potential. Improved manure management, especially methane captures and use as bio-fuel has considerable potential. Techniques exist to reduce methane emissions from rice paddies through better water, nutrient management and rice variety selection

2. Effectiveness of technology transfer

Technology transfer has been the focus of considerable attention in the effort to mitigate and adapt to global climate change. Successful technology transfer programs have included variations of the following 5 steps (Climate Technology Initiative, 2002):

- 1. Establishment of collaborative partnerships between key stakeholders with the common purpose of enhancing technology transfer.*
- 2. Implementation of technology transfer needs assessments (including both evaluation of alternative technologies and definition of technology transfer priorities).*
- 3. Design and implementation of technology transfer plans and specific actions.*
- 4. Evaluation and refinement of the actions and plans (an ongoing process).*
- 5. Dissemination of technology information.*

Several alternative arrangements and organizational designs have successfully been used to carry out these basic steps.

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Technology transfer within the Framework Convention on Climate Change provides both opportunities and incentives for international cooperation. The developed countries should provide incentives to assist and encourage developing countries in taking actions: "The extent to which developing country parties will effectively implement their commitments under the Convention will depend on the effective implementation by developed country parties of their commitments under the Convention related to financial resources and transfer of technology" (UNFCCC Article 4.7).

A key issue in designing effective mitigation policies is to consider the effects of management on different gases and what the overall effects are on global warming potential. In a transferred study of southern Michigan US, where all three gases were monitored, researchers found that compared to conventional annual crops, carbon sequestration under a no-till system greatly reduced the net GHG emissions (Climate Technology Initiative, 2002). However, CO₂ emissions associated with fossil fuel use (e.g. fuel and fertilizer) as well as N₂O emissions were slightly higher, on a carbon equivalent basis, such that the no-till system remained a small net source. An organically managed cropping system, which had less fossil fuel use but also lower carbon sequestration, had higher GHG emissions than the no-till system, but still less than the conventional. A recently established grassland (analogous to a conservation set aside) had both high C sequestration as well as reduced NO emissions,

making it a strong net sink for greenhouse gases.

Meanwhile, we need to be aware of the potential for promoting practices that reduce emissions for one gas but have the opposite effect on another gas, thereby partially offsetting the intended mitigation benefits, or even leading to an overall negative outcome. It is dangerous to generalize, since offsetting or negative outcomes may only occur in some cases and not in others, but a couple of examples can be given. For example, increasing N fertilizer rates in situations where nitrogen is already good enough, that is likely to lead to more N₂O, offsetting any potential gains in soil C from increased productivity. However, on nutrient deficient sites and/or where other nutrients are needed and supplied, such as phosphorus, benefits to productivity and soil C gain may well outweigh the effects of increased N₂O emission. As another example, CH₄ emissions are increased where the manure is kept under anaerobic conditions, whereas N₂O emissions are favored by aerobic conditions. Thus, improvements in manure handling systems face a complex set of tradeoffs.

The most important features of agricultural greenhouse gas mitigation strategies are the many ancillary benefits that exist. Practices that enhance soil C sequestration will improve the quality and fertility of soils, help reduce erosion and improve water quality. Conservation reserve lands, one of the most effective mitigation options for all three greenhouse-gases, provide wildlife habitat and increased biodiversity. Improved nitrogen management to reduce N₂O emissions will pay big dividends in improved water quality and can reduce fertilizer costs and waste. Better manure management systems can also improve air and water quality and potentially serve as a source of bio-fuel.

3. Barriers and encourage

There are many barriers that may be encountered for adopting these mitigation options and its technology transfer. Some of these options require more labors and some need more capital investment, which may represent the main constraints slowing adoption of the technologies.

At present, technology transfer has still occurred under normal commercial terms, which demand large returns for intellectual property rights. Therefore, it goes against the spirit of the UNFCCC. The governments of the rich countries argue that the private sector companies own the technologies and the better way to get them is to associate yourself with any flexibility mechanisms; namely, joint implementation, emissions trading and the Clean Development Mechanism. For developing countries, if these mechanisms can help their people to have enough food and access to technologies, the governments may be forced to join. It is my wish that the negotiators of that will take decisions that provide the greatest benefits for the developing countries. Technology transfer remains one of the important issues in the implementation of the Convention. It was proposed that to reach an agreement on the establishment of an effective mechanism for the development and transfer of technology under the Convention. Perhaps this can be considered as the way in which developed countries can take the lead in combating climate change and its adverse effects (Article 3.1).

It is recommended that the International Society should give a higher priority to set up an international mechanism on sustainable development and technology transfer in order to provide guidance on ways and means to promote the international cooperation in this area on a grant or concession term. For this purpose, an international technology information center shall be established in a cost-effective manner, and where appropriate and to promote capacity

building in developing countries.

Technology transfer under the UNFCCC is fundamentally a country-driven process. The needs assessment phase of the work constitutes a country's primary means to define its technology transfer priorities and the most effective mechanisms to address them.

Lack of national human and institutional capacity and information in the developing countries is getting more barriers for the technology transfer. CGIAR systems used to be a good mechanism for that but currently are experiencing difficulty as their funding slows. The systems have not transferred capacity to national centers in the developing countries that they are expected to serve. The national centers also lack access to information, and are not aware of technologies that suit their local conditions (IPCC, 2000).

Intellectual property rights still a barrier for the technology transfer. To some extent the reduced public funding on new technologies has been replaced by the private sectors contribution. Private sector funding offers one approach to increasing investment for mitigation projects worldwide. For example, private plant breeding research has more than quadrupled in the US in real terms between 1970 and 1990. A new variety of rice would reduce CH₄ emissions. But its transfer would be difficult by IPR. Generic resources are easily transported and replicated, which discourages the private sector from making investments. But Governments of technology provider can propel the transfer through some domestic arrangement to the private sectors, like revenue free and other encourage measures

4. No-regret options

Article 4.5 of the UNFCCC states that developed countries "shall take all practicable steps to promote, facilitate, and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention." In this context, technology transfer is designed to assist developing countries with responding to climate change through the diffusion and use of appropriate climate change mitigation and adaptation technologies.

Some technologies will not be so easily transferred due to some financial and political issues. Banks should extend credit to farmers. Research and training should be turned to "no-regret" mitigation technologies. Trade free of barriers facilitates technology transfer. Education lies at the heart of technological transfer. Private business can announce technology in advertisements or demonstrate it at fairs. Governments have a role in monitoring claims and educating broadly.

In order to assist the implementation of preferential mitigation technologies, relevant departments of the government need to strengthen studies on how to remove the barriers and promote the implementation. Proper and effective ways should be analyzed and evaluated for raising funds, expediting the reconstruction of institutions and organizations, formulating necessary policies and regulations, improving market mechanism, expanding international cooperation, and selecting and implementing demonstration projects.

Domestic Actions

Undoubtedly, government measures with economic and price reforms will enhance the profitability for the implementation of preferential mitigation technologies. These economic reforms will not be discussed in more detailed here, because their targets are not focused only

on the GHG mitigation. This discussion focuses on actions that go beyond present economic reform.

(1) Establishing favorable financing mechanisms: Making efforts to create favorable policies for stimulating investments in agriculture both raising productivity and emitting emissions..

(2) Importing and mastering technologies and better manage them: To make rapid progress in the production and management of some priority technologies, it will be important to improve the understanding of foreign advanced technologies.

(3) Training personnel: Involvement of a large amount of skilled personnel will be a necessary guarantee for the successful implementation of diffusing priority GHG mitigation technologies. So programs and legal guidelines to conduct and guide the personnel training activities will needed.

(4) Enhancing information exchange and dissemination: With the support and help of international organizations and experts, governments shall organize and coordinate relevant institutions to establish a common information management system so as to strengthen and assist information exchange and dissemination.

(5) Analyzing the barriers of GHG mitigation and response strategies: During the implementation of priority GHG mitigation technologies, a series of problems concerning financing, policies, technology adaptation, personnel capabilities and others will be identified. Governments shall coordinate, support and organize research activities among concerned organizations, and work out feasible measures and response strategies.

International Actions

International supports are very important to assist with implementation of priority GHG mitigation technologies by helping to find foreign donor funding and private sector partners, to share technology information, to assist with policy reform, to organize training programs and to establish information exchange channels. The kind of actions may be summarized as follows:

(1) Searching funding for projects. Identifying high priority among the selected technologies, and provide assistance in preparing project proposals for the international donors.

(2) To organize technical consultation activities. Inviting international consultants and experts to provide advice on programs for overcoming technology implementation barriers.

(3) To organize and to support training program. Providing funds for organizing training programs and assisting with the training courses on GHG mitigation technologies.

(4) To support the establishment of an information service center. The tasks of this center are to remove obstacles owing to lack of information on the cost-effective of mitigation technologies. In addition, this center can also provide international organizations, investment organizations, foreign companies and individual with domestic market information and a more complete picture of benefited countries and their GHG mitigation opportunities.

(5) Facilitating direct private investment in non-regret technologies through assistance in finding international business partners and business financials.

5. Uncertainties

The IPCC *Special Report on Methodological and Technical Issues in Technology Transfer* identifies key stages in the technology transfer process, while acknowledging that the process of technology transfer is complex and intertwined. These stages include identification of needs, choice of technology, assessment of conditions of transfer, agreement, implementation, evaluation, adjustment to local conditions, and replication. For each of these stages or implementation steps, the stakeholders, technology transfer pathways, and barriers to implementation will vary.

The aim is reliable and adequate agricultural growth with less emission and more storage of greenhouse gases.

Several issues require more researches and pilot testing to better understand the potential for agricultural mitigation options. One is the need for comprehensive greenhouse gas accounting, which has been discussed at above. Another is the fact that we need to have knowledge of what is occurring across the entire landscape, and not just in agriculture system, since all ecosystems are connected to and contribute to the atmosphere. It is important that accurate quantification procedures be used for developing and accessing mitigation strategies. Agricultural GHG are for the most part from 'non-point' sources, which makes direct measurement more difficult. However, different quantification procedures are possible, either based on sampling schemes to directly estimate emissions or through measurement and monitoring of different agricultural activities, which can be assigned appropriate emission factors. Present inventory procedures are largely based on the latter approach. Although technical potentials for mitigation may be high, there are a variety of barriers and/or incentive structures that need to be addressed to realize as much of that potential as possible. These factors include economic issues, e.g. profitability, risk, as well as behavioral and educational issues that need to be addressed.

The Special Report on Land use, Land-use Change, and Forestry estimated a significant potential for increasing carbon stocks in the agricultural sector. Improved management of cropland and grazing-lands, agro-forestry, and rice paddies have the potential to sequester 398 MtC annually, and the conversion of cropland to agro-forestry practices and grasslands can sequester an additional 428 MtC annually by 2010. These estimates are highly uncertain, however, and do not include the impact on the emissions of CH₄ or N₂O from agricultural practices or wetlands and/or permafrost management [IPCC WGIII, 2001].

Methane emissions from agriculture produce about 8% of the radiative forcing of all greenhouse gases. Emissions capture from manure can be turned into fuel, and ammoniated straw reduces emissions from ruminants, while improving digestibility. Emissions from rice paddies can be mitigated. Small size of farms and related business risk aversion, lack of information, human and financial capital, inadequate transportation, temporary tenure, and unreliable input discourage the market penetration of modern technologies that could reduce GHG emissions. Among these barriers we highlight the ones that are especially critical to this sector.

Lot of the mitigations for above opportunities may provide multiple benefits to the farmer and society with improving soil management for crop production, for instance, can also improve water relations, nutrient retention, and nutrient cycling capacity (Paustian et al., 1998). Retiring surplus and not suitable agricultural lands may result in improved water quality, reduced soil erosion, and increased wildlife habitat. However, farmers will bear costs up front

while the benefits are longer term and to the society at large.

For realizing these opportunities many farmers shall have to be convinced to adopt mitigation options. Economic, cultural, and institutional barriers exist which restrict the rate of adoption of such practices. Farmers who are accustomed to traditional practices may be reluctant to adopt new production systems. Crop price supports, scarcity of investment capital, and lack of economic incentives for addressing environmental externalities are some of the economic barriers. Limited applicability of mitigation options to different types of agriculture, negative effects on yield and soil fertility for rice production, and the increased skilled labor requirements are some of the other constraints. These include small farm size, credit constraints, risk aversion, lack of access to information and human capital, inadequate rural infrastructure and tenurial arrangements, and unreliable supply of complementary inputs. Participatory arrangements that fully engage all the involved actors may help to overcome many of the barriers.

6. Conclusion

There are opportunities for GHG mitigation in agricultural systems. For these purpose, technology transfer is needed. There are some barriers for mitigation technology transfer, so several measures may be pursued to address the barriers. These include

- The expansion of internationally supported credit and savings schemes, to assist rural people to manage the increased variability in their environment and to reduce the emissions;
- Shifts in the allocation of international agricultural research for the fertilizer use, forage additives and animal waste treatment, as well as water-use efficiency, irrigation management.
- Facilitate direct private investment in non-regret technologies through assistance in finding international business partners and business financials
- The development of institutional linkage between countries with high standards in certain technologies transfer, for example forage additive.
- Intellectual property rights shall not be barrier for the technology transfer. Governments of technology provider can propel the transfer through some domestic arrangement to the private sectors, like revenue free and other encouraged measures.

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