Agriculture and Climate Change: An Agenda for Negotiation in Copenhagen

Reducing Methane Emissions from Irrigated Rice

Reiner Wassmann, Yasukazu Hosen, and Kay Sumfleth

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Rice is grown on more than 140 million hectares worldwide and is the most heavily consumed staple food on earth. Ninety percent of the world's rice is produced and consumed in Asia, and 90 percent of rice land is—at least temporarily—flooded. The unique semiaquatic nature of the rice plant allows it to grow productively in places no other crop could exist, but it is also the reason for its emissions of the major greenhouse gas (GHG), methane.

Methane emissions from rice fields are determined mainly by water regime and organic inputs, but they are also influenced by soil type, weather, tillage management, residues, fertilizers, and rice cultivar. Flooding of the soil is a prerequisite for sustained emissions of methane. Recent assessments of methane emissions from irrigated rice cultivation estimate global emissions for the year 2000 at a level corresponding to 625 million metric tons (mt) of carbon dioxide equivalent (CO_2e).

Midseason drainage (a common irrigation practice adopted in major rice growing regions of China and Japan) and intermittent irrigation (common in northwest India) greatly reduce methane emissions. Similarly, rice environments with an insecure supply of water, namely rainfed rice, have a lower emission potential than irrigated rice. Organic inputs stimulate methane emissions as long as fields remain flooded. Therefore, organic inputs should be applied to aerobic soil in an effort to reduce methane emission. In addition to management factors, methane emissions are also affected by soil parameters and climate.

Accounting for nitrous oxide (N_2O) and CO_2 emissions

Recent studies suggest that rice cultivation is an important anthropogenic source of not only atmospheric methane but also of N_2O. Rice soils that are flooded for long periods of the year tend to accumulate soil organic carbon, even with complete removal of above-ground plant biomass. Significant input of carbon and nitrogen is derived from biological activity in the soil–floodwater system, and conditions are generally more favorable for the formation of conserved soil organic matter. It is currently unknown whether rice systems in the tropics and subtropics truly sequester atmospheric carbon and how soil organic carbon levels will react to a changing climate or new management practices.

Losses of soil organic carbon are of major concern for certain developments in the agricultural sector that are undergoing rapid intensification and diversification of crop land. At the International Rice Research Institute (IRRI), however, 12 years of continuous rice cropping in flooded fields did not cause any significant decline in soil organic carbon. In contrast, the soil organic carbon immediately declined after a shift to a nonflooded system, namely maize. The modification of flooding patterns encompassing one or more dry periods may somehow accelerate decomposition, but—unlike a complete shift to upland systems—the recurring periods of flooding will keep the overall soil organic carbon at a fairly stable level. Thus, we do not include CO_2 emissions in our considerations of mitigation options.

Mitigation options

Changing water management appears to be the most promising mitigation option and is particularly suited to reducing emissions in irrigated rice production. Midseason drainage and intermittent irrigation reduce methane emissions by over 40 percent. Shallow flooding provides additional benefits, including water conservation and increased yields. A recent study estimates large potential for additional methane reductions from Chinese rice paddies through modifications of water-management strategies, even though midseason drying is widely practiced there.

Midseason drainage or reduced water use also creates nearly saturated soil conditions, which may promote N_2O production. There are conflicting reports on the net global warming potential (GWP) of midseason drainage, but there seems to be a growing consensus that this practice decreases the net GWP of paddy fields as long as nitrogen is applied in appropriate doses. According to an empirical model proposed by Yan et al. (2005), midseason drainage generally tends to be an effective option for mitigating net GWP, although 15 to 20 percent of the benefit gained by decreasing methane emission was offset by the increase in N_2O emission.

We can conclude that midseason drainage has a potential to be an effective option to mitigate the net GWP from rice fields, especially when larger amounts of rice straw are returned into the soil. However, there is the risk that N_2O emission offsets the reduction of methane emission when nitrogen fertilizer is applied at a high rate. Therefore, modifications of water regime should be coupled with efficient fertilizer application in order to reduce both GHG emissions and costs (for irrigation water and fertilizers).

The immense variability of environmental factors affecting the 140 million hectares of annually harvested rice fields denies the use of blanket strategies to reduce emissions. Moreover, technological options in rice production have to remain economically viable despite rapid changes in both socioeconomic development and the environment. Two case studies looking at two different countries—India and the Philippines—at vastly different scales, illustrate the mitigation potential of water regime modifications.

Case study: Country-wide mitigation in India

Indian agriculture accounts for approximately 5 percent of the global CH_4 budget. Nelson et al. (2009) used field-level data collected by Pathak et al. (2005) with two global land-use data sets to assess the costs and benefits of a midseason drying. They found that, with one midseason drying, net revenue drops less than 5 percent, while GHG emissions drop by almost 75 million mt of CO_2e. The opportunity cost is US$1.20 per mt CO_2e, which is well below current carbon prices in European markets.

Case study: Mitigation within one irrigation system in the Philippines

Bohol Island, one of the largest rice-growing areas in the Visayas region of the Philippines, has experienced declining productivity and income from existing irrigation systems. The problem has been aggravated by the practice of unequal water distribution and unnecessary water use by farmers who insist on continuous flooding to irrigate their rice crop. The construction of a new dam was accompanied by a plan to implement a water-saving technology called alternate wetting and drying (AWD), developed by IRRI in cooperation with national research institutes. Visible success of AWD in pilot farms and specific training programs for farmers have helped to dispel the widespread misperception of possible yield losses in nonflooded rice fields. Adoption of AWD facilitated improved use of irrigation water and increased rice productivity. Using the methodology of the Intergovernmental Panel on Climate Change (IPCC), modification of water regime also can reduce methane emissions by almost 50 percent as compared to rice produced under continuous flooding. The Bohol case is an example of new technologies that increase the income of poor farmers while decreasing GHG emissions.

Suggested negotiating outcomes:

The two case studies demonstrate the potential for large reductions in rice production GHG emissions with relatively low opportunity costs and, in some cases, increases in productivity. Adapting the technologies to local conditions is necessary, and involving local farmers, extension agents, and research institutions in technology design and dissemination is critical. Measuring the reductions in GHG emissions can be done by using process methods supplemented with some field testing. Methane reduction from irrigated rice should be made eligible for offsets and other mitigation funding opportunities as an outcome of the Copenhagen negotiations.

Rice production also demonstrates the potential pitfalls of allocating Certified Emission Reductions (CERs) in the land-use sector. Water-saving techniques can reduce GHG emissions in a given area of rice land, but, in most cases, the saved water will then be used to irrigate more rice land or new crops in future seasons. Subsequently, emission savings are offset by emissions created in newly irrigated land. Ironically, if the saved water was channelled to other users, for example, in residential areas, one could rightfully claim CERs because of a net reduction in GWP caused by the mitigation project.

Increasing food production is an absolute necessity for the human population, and improved resource-use efficiencies are imperative to achieving this goal. As an agricultural research institution devoted to the increase in food production, IRRI proposes specific provisions for CER allocations in the land-use sector to converge the legitimate goals of food security and GHG mitigation in a Copenhagen agreement. Our suggestion is to compute for net GWP savings based on food production targets. As long as saved resources, namely water and fertilizers, are used to increase food production in a resource-efficient manner, it seems undue to account for new emissions as offsets or leakages of a mitigation project. ■

For Further Reading: G. C. Nelson et al., *India Greenhouse Gas Mitigation: Issues for Indian Agriculture,* IFPRI Discussion Paper (Washington, D.C.: International Food Policy Research Institute, forthcoming); G. Pan et al., "Storage and Sequestration Potential of Topsoil Organic Carbon in China's Paddy Soils," *Global Change Biology* 10 (2003): 79–92; H. Pathak et al., "Greenhouse Gas Emissions from Indian Rice Fields: Calibration and Upscaling Using the DNDC Model," *Biogeosciences* 2, no. 2 (2005): 113–123; X. Yan et al., "Global Estimations of the Inventory and Mitigation Potential of Methane Emissions from Rice Cultivation Conducted Using the 2006 IPCC Guidelines," *Global Biogeochemical Cycles*, forthcoming; X. Yan et al., "Statistical Analysis of the Major Variables Controlling Methane Emission from Rice Fields," *Global Change Biology* 11 (2005): 1131–1141.

Reiner Wassmann *(r.wassmann@cgiar.org) is the coordinator of the Rice and Climate Change Consortium at the International Rice Research Institute (IRRI) and senior scientist at Karlsruhe Research Center,* ***Yasukazu Hosen*** *(y.hosen@cgiar.org) is a senior researcher at the Japan International Research Center for Agricultural Sciences and a soil scientist at IRRI, and* ***Kay Sumfleth*** *(k.sumfleth@cgiar.org) is a Centrum für internationale Migration und Entwicklung (CIM) integrated expert and visiting research fellow at IRRI.*

International Food Policy Research Institute
2033 K Street, NW • Washington, DC 20006-1002 • USA
Phone: +1-202-862-5600 • Skype: ifprihomeoffice • Fax: +1-202-467-4439 • Email: ifpri@cgiar.org
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