



Managing Tropical Lands to Mitigate Climate Change

Dramatic changes in the global climate are already inevitable, as a result of rising greenhouse gas emissions over the two last centuries. It is thus critical, as emphasized in an April 2007 report from the United Nations Intergovernmental Panel on Climate Change (IPCC), that developing countries gain the knowledge, technology and capacities they require for agriculture to cope with the expected impacts.

International support for these efforts should depend not just on the generosity or even the self-interest of affluent countries, but on a strong moral imperative that pertains to all of Earth's inhabitants. It derives from the injustice inherent in the fact that developing country inhabitants, especially the rural poor, will face the worse consequences of a phenomenon that has resulted in large part from rapid economic development in the industrialized world.

While bearing little to no responsibility for having created this problem, developing countries, nonetheless, recognize the need and opportunities for helping solve it over the long term. Their commitment is highly important since current levels of emissions caused by land use (particularly agriculture) and by changes in land use (mainly deforestation) together account for 40 percent of total emissions, with the rest coming largely from industrialized countries.

Some of the most promising options available for reducing emissions involve innovative approaches to the management of tropical lands. These can permit the capture of significant amounts of carbon and other greenhouse gases from the atmosphere, thus mitigating future climate change. In order for these approaches to be implemented on a massive scale, though, numerous technological, institutional and other barriers must be overcome.

Land Use and Global Carbon Markets

One approach that has great, but underexploited, potential for achieving climate change mitigation through improved tropical land use involves the new and rapidly growing world trade in certified reduction of carbon emissions. Under the Clean Development Mechanism (CDM) established by the Kyoto Protocol on climate change, countries that do not meet their agreed targets in emission reductions can buy the service from other countries. Numerous carbon funds have been established for this purpose, but so far they have traded mainly with sectors such as energy and transportation in just a few developing countries.

Some schemes, such as the BioCarbon Fund of the World Bank, have been set up that cater specifically to agricultural and forestry projects. But limits on payments to such projects and the complexity of the procedures pose significant barriers to participation, especially for small farmers.

Curbing Deforestation

Since deforestation through burning accounts for at least 20 percent of global carbon emissions, measures to curb this complex phenomenon ought to be one of the principal strategies for reducing greenhouse gas

emissions. Yet, the Kyoto Protocol skirts this issue almost entirely, as countries rich in tropical forests initially resisted calls to reduce deforestation as a means of lowering emissions.

In recent years, however, those countries have relaxed their opposition. So, the way is open for negotiating new international agreements under which forest-rich countries would have fiscal and other incentives to reduce deforestation. The end of the Kyoto Protocol in 2012 offers a key opportunity to reformulate such agreements.

At the invitation of the United Nations Framework Convention on Climate Change (UNFCCC), the Center for International Forestry Research (CIFOR), along with three other intergovernmental organizations, offered their views on how best to reduce emissions from deforestation under a future agreement. CIFOR's input, based on a large body of research on the underlying causes of deforestation, strongly influenced a UNFCCC background paper on this subject, presented at a Rome workshop in 2006. Among other measures, the CIFOR submission suggested that comprehensive monitoring systems be put in place (along the lines of the accountability measures that are obligatory for Kyoto Protocol signatories), requiring that developing countries report on all emissions from land use.

Sustainable Forest Management

Where communities derive their livelihood from forests, simply forbidding the use of this resource is not an option. But CIFOR research demonstrates that under these circumstances it is feasible to foster sustainable forest management for the production of timber and other products. The Center's work has produced a rich collection of knowledge and tools for this purpose, which are providing conservationists and others with better means of monitoring forest management and certifying whether it is sustainable in specific cases.

Of the total forest area certified so far, more than 80 percent (some 37 million hectares) has been certified by companies that acknowledge they used the products of CIFOR research, resulting in more sustainable forest management. Although this practice does not capture as much carbon as curbing deforestation, it is preferable to converting forests for agricultural use, and it contributes to more sustainable livelihoods for forest dwellers.



Agroforestry: “Working Trees” in Agriculture

Agroforestry systems offer another option for mitigating climate change, while also helping rural people adapt to its consequences. Agroforestry is the practice of integrating “working” trees into agricultural landscapes as natural vegetation is cleared. In addition to capturing carbon and helping maintain soil health through nitrogen fixation and use of cuttings as fertilizer and mulch, these trees provide useful products, such as animal fodder, fruit, timber, fuel, medicines and resins.

Recent evidence compiled by the World Agroforestry Centre underlines the appeal of agroforestry and the potential for promoting it more widely. In Zambia, for example, an estimated 80,000 to 90,000 farm families have adopted various agroforestry species, especially of the genera *Gliricidia*, *Sesbania* and *Tephrosia*, to raise soil fertility on fallow land. The “fertilizer tree” technology is now spreading to Malawi, Mozambique, Tanzania and Zimbabwe as well.

The Biofuels Conundrum

A further land-use option that shows great potential for reducing greenhouse gas emissions — but might also involve difficult tradeoffs — is the production of renewable biological fuels, or simply biofuels, such as charcoal, livestock manure, biogas, biodiesel and bioethanol. Such products are derived chiefly from materials referred to in their raw form as “biomass.” This includes agricultural residues and wastes but increasingly also crops grown specifically for biofuel production.

Unlike fossil fuels, biofuels can be produced by practically any country. While supplying only a minor portion of energy supplies in the industrialized world, they account for a third of the energy used in developing countries. There biofuels are mostly burned by rural households to provide energy for cooking and heating. The use of liquid biofuels as an energy source for transport is still relatively minor, with the important exception of Brazil, where ethanol has displaced 40 percent of gasoline use. A few other developing countries, including China and India, have embarked on pilot programs for liquid biofuel development.

Biofuels can reduce carbon emissions, because the plant materials from which they are derived capture carbon from the air. When biofuels are used to generate energy, this carbon is subsequently returned to the atmosphere, thus completing the cycle. In other words, the consumption of biofuels, unlike that of petroleum products, involves no net increase in carbon emissions. So, to the extent that biofuels displace petroleum in energy markets, emissions should decline.

Biofuels may offer the additional benefits of helping cope with increased energy prices and providing rural communities with new sources of income and employment. In fact, many tropical countries, including those in Africa, may find that they have a comparative advantage in

producing and exporting energy-rich biomass, biofuels or both.

The promise of biofuels, however, must be tempered with caution about a number of potentially negative consequences. One of the principal concerns is that production of biofuels will compete with that of food and feed, driving up the price of basic foods. Poor consumers would be hurt most by rising prices, though farmers would benefit. On the other hand, the poor might benefit from lower energy prices and from new employment opportunities in the bioenergy sector.

The prospect of a biofuels revolution has also aroused concerns about possible environmental impacts. More extensive and intensive food production in recent decades has already put tremendous pressure on natural resources. And though more sustainable production systems have started to take hold, the "doubly Green Revolution," which former Rockefeller Foundation president Gordon Conway called for in the 1990s, is still a distant goal. What remains to be seen is the effect that increased production of biomass might have on already degraded tropical agroecosystems and on forests. Moreover, since the production of biofuels requires fossil fuels (in the form of agrochemicals, for example), it is not at all clear what will be the net balance between carbon capture and carbon emissions.



Toward Pro-Poor Biofuel Development

The International Food Policy Research Institute (IFPRI) has embarked on research aimed at helping determine how those and other factors could balance out. The results of such work will be essential for determining the conditions (including technologies, markets, policies and institutional arrangements) under which biofuel production can mitigate climate change, while also benefiting the poor in ways that are environmentally sustainable.

Other Centers supported by the CGIAR are examining those issues as well within the framework of research on crops and natural resource management. For example, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is assembling the elements of a biofuels initiative designed specifically to benefit the poor in regions facing the threat of desertification. One of the initiative's components consists of new varieties of high-sugar, or sweet, sorghum, which can be grown for ethanol production. Since sorghum produces grain and fodder as well, the new varieties should help address the food-feed-fuel dilemma. In addition, sweet sorghum is well adapted to drought-prone environments, requiring only a seventh of the amount of water required for sugarcane, from which ethanol is produced in Brazil.

Another option being explored by ICRISAT with public- and private-sector partners in watershed management projects is the production of *Pongamia* and *Jatropha* trees for biodiesel. Because these have low water requirements and are inexpensive to cultivate, they could provide the rural poor of semi-arid regions with an attractive option for profitable and sustainable biofuel development.

Meanwhile, the International Maize and Wheat Improvement Center (CIMMYT) has begun investigating the use of maize — already the principle source of biomass for ethanol in the USA — for biofuel production in the developing world.

Other Land-Use Options in Agriculture

The various land-use options outlined above are perhaps the most obvious candidates for reducing greenhouse gas emissions. But agricultural research offers many other possibilities as well for capturing carbon from the atmosphere and for reducing emissions of other greenhouse gases, specifically methane and nitrous oxide. Two significant agricultural sources of methane emissions are irrigated rice production and livestock, while nitrous oxide results from the application of nitrogen fertilizer.



Lower methane emissions: Research conducted by the International Rice Research Institute (IRRI) during the 1990s determined that methane emissions from tropical irrigated rice are far lower than had previously been assumed. Building on that and other research, the Rice and Climate Change Consortium recently launched by IRRI will, among other tasks, promote the development of rice production systems with lower emissions of greenhouse gases as well as greater resilience to the impacts of climate change.

Options for reducing methane emissions from livestock production are emerging from research on diverse forage plants. Scientists at the International Center for Tropical

Agriculture (CIAT), for example, have identified leguminous forage species possessing high tannin content, which suppresses methane emissions. Center researchers have also determined that highly productive forage grasses (such as various species of the African genus *Brachiaria*) capture significant amounts of carbon from the atmosphere and retain it in their deep root systems.

Such grasses can be usefully combined with trees in so-called silvopastoral systems. In Colombia, for example, CIAT and several national partners are negotiating with the World Bank BioCarbon Fund a project aimed at recuperating degraded pasture lands through the introduction of silvopastoral systems.

Inhibiting nitrification: In other forage research, CIAT and collaborating scientists are studying a chemical released from the roots of a *Brachiaria* species, which triggers a process referred to as “biological nitrification inhibition” (BNI). This process slows the conversion of ammonium — the form of nitrogen used in most fertilizers — first into nitrite and then into nitrate and nitrous oxide. The latter, in addition to being a powerful greenhouse gas, contributes to depletion of the stratospheric ozone layer, making humans more vulnerable to ultraviolet radiation. Nitrate is crucial for crop growth, but much of it finds its way into streams and groundwater, causing serious contamination. If scientists succeed in isolating the genes responsible for BNI and can introduce it into other crops, the results could be truly revolutionary. Varieties that slow nitrification to a level that is still consistent with good crop growth would not only help reduce greenhouse gas emissions but also lower water pollution, while enhancing productivity through more efficient use of fertilizer.



With those goals in mind, wheat researchers at CIMMYT are seeking genes for BNI in wild plants related to the crop. At the same time, they are exploring a further means of reducing nitrification through more precise and efficient use of nitrogen fertilizer. This is achieved with the aid of hand-held infrared sensors, whose measurements of reflected light are used to calculate how much nitrogen fertilizer farmers need to apply in their maize and wheat crops.

Creating Conditions for Change

Despite the clear benefits of the options outlined above and the solid science underlying them, there are a number of obstacles impeding their further development and widespread adoption. A major one is that many of these options, such as agroforestry and other agricultural land uses, are generally ineligible for financial support under the CDM established by the Kyoto Protocol.

Even with carbon funds that do allow such options, implementation is hampered by various circumstances. One is the low value of Certificates of Emission Reduction associated with land-use projects — a consequence of the perceived risks. Another is high transaction costs, which result from the need to engage with multiple stakeholders — from rural communities to national authorities. Finally, the approval processes are unnecessarily complex, because of ambiguous rules and information.

Accurate measurement of greenhouse gas emissions: CGIAR-supported research now under way should reduce or eliminate at least one major barrier to increased carbon finance for improved land use. This is the difficulty of accurately measuring the reduction of greenhouse gas emissions in projects involving agriculture, agroforestry and forestry. To facilitate this task, researchers at the World Agroforestry Centre have devised and are applying a new technique in Eastern Africa that assesses soil conditions, including carbon stocks, with a high degree of accuracy. Involving the use of satellite imagery and infrared spectroscopy, the technique is much cheaper than on-the-ground verification.

Using this technology, a team of scientists supported by the World Bank and Global Environment Facility (GEF) in Kenya are providing government officials with environmental data from an area of 19,000 square kilometers for guiding a comprehensive effort to rehabilitate degraded agricultural land in the watersheds that feed Lake Victoria.

From the margins to the center: New soil assessment technology offers proof that practical impediments to large-scale support for land-use improvement through carbon finance can be overcome with the aid of sound research. Clearly, the time has come to reverse the exclusion and reduce the complexity of financing improved land use. The above-mentioned discussions of the post-2012 Kyoto regulations for carbon trading represent an invaluable opportunity to do precisely that.

By moving land-use change from the margins to the center of carbon markets, the governments and international agencies that shape new regulations will stand a far better chance of meeting new objectives in the reduction of greenhouse gas emissions. At the same time, they will gain a new and potentially powerful means to mobilize international support behind a whole range of effective measures for reducing rural poverty. Without such measures, the Millenium Development Goals will most likely remain an empty promise for many of the world's rural poor, particularly as they face the menace of global climate change.



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