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Livelihoods impacts of carbon sequestration

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Abstract

Modification of the carbon cycle through interventions in forestry and agriculture could do much to mitigate climate change, especially if avoided deforestation and article 3.4 activities are eligible for offsetting national carbon budgets under any successor to the Kyoto Protocol, which expires in 2012. However, such activities may have concrete livelihood effects, especially for the poor. Avoided deforestation may cause coercion of forest users, who may then not see the benefits; they may also not easily be able to assess any commercial carbon contract they are offered. In agriculture, farmers could be pressured into adopting technologies that are inappropriate for their particular farm, or are uneconomic when any intervention ceases, and there may be uncertainty about the sequestration potential of techniques used. The paper also looks at particular issues in dry areas, where sustainable rangeland management needs to be designed carefully around the range users. A number of policy recommendations are made, including work with forest user groups, the continuing eligibility of unilateral funding for carbon projects, the inclusion of already-protected areas in carbon offsetting, the use of ODA for capacity-building, development of carbon-friendly agricultural technologies in collaboration with farmers, rangeland management that permits continued mobility of herds, and the careful modelling of biomass use under any carbon project in arid areas.

Introduction

This briefing paper reviews and summarizes the main issues regarding terrestrial carbon sequestration and its livelihoods impacts on the poor and discusses policy measures that might mitigate them. It is concerned with those forms of sequestration that act on the natural carbon cycle – that is to say, protecting or augmenting biomass storage through agriculture or forestry. It does not review carbon capture and storage (CCS).

1 What is biological carbon sequestration?

Carbon circulates, changing its form but not its nature. The modification of this cycle so that more carbon resides on the earth's surface as plant biomass or other organic forms, rather than CO_2, is the objective of biological carbon sequestration.

CO_2 is created by the combination of carbon with oxygen. Photosynthesis converts it to sugars and carbohydrate, providing about 90-95 percent of a plant's dry weight (Wittwer, 1995: 9); about 40-45 percent of the plant material is organic carbon. The most obvious place to store it (or, as such storage is called, a carbon sink) is in the form of trees. However, other plant material, including that created by agriculture, will find its way underground as part of the plant's root system. When the plant dies, its residues are mineralized through microbial activity; the carbon within them is thus either released again as CO_2, where it will contribute to the atmospheric carbon pool, or is humified, passing into more stable longer-lived soil carbon pools. So it makes sense to either retain carbon in plant biomass, in the soil, by slowing mineralization, reducing residue burning etc.; or encourage its reconversion to plant material by encouraging plant growth, increasing the storage of biomass on the earth's surface. The mitigation of climate change achieved can then be reflected in the global carbon-trading system.

This process raises many technical, scientific and accounting questions, but this paper reviews the implications for low-income land-users – farmers, and those who depend on forests. Will this process be in their interests, and if not, what can be done to ensure that it is? The paper looks at the implications of three forms of carbon storage: in forests; through soil carbon, which mainly means agriculture; and finally the conservation of drylands, which contains relatively little organic carbon per hectare but significant amounts overall. It measures them, very roughly, against the four criteria that Adger et al. (2002) have argued environmental policy must have to be workable; efficiency, effectiveness, equity and legitimacy. Of these, only equity and to a lesser extent legitimacy are discussed, but it is assumed that inefficient and ineffective ways of sequestering and storing carbon would, in the end, have few livelihoods benefits.

The first area reviewed is forestry.

2 Forestry: the road to REDD

The Kyoto Protocol acknowledges the importance of terrestrial carbon storage and articles 3.3 and 3.4 provide for its incorporation into a country's carbon accounting; broadly speaking, the first includes forests while the second covers other forms, including agriculture. The arm of the Protocol under which developed countries can pay to offset their own emissions with projects in the South is the Clean Development Mechanism (CDM). It will operate until the end of the first Kyoto protocol in 2012; what happens then is not yet clear.

However, the CDM can only be used to offset a small percentage of a country's emissions, and forestry is only allowed to constitute 5% of total reductions within that. Moreover article 3.4 activities are not eligible; forestry is, but subject to very tight methodological restrictions, and there has been just one such project approved.

It might thus appear that the rural poor need not expect Kyoto to affect their lives much one way or the other. However, at COP13 in Bali in 2007, it was agreed that reduced emissions from deforestation and degradation (REDD) would be part of Kyoto II after 2012.[1] Avoided deforestation[2] was not included in the CDM at the Marrakesh negotiations because of concerns about leakage, and because the amounts of credits involved could be so large as to flood the market (Schlamadinger et al., 2007: 278). There has also always been opposition to REDD because it pays people to do what they should be doing anyway. However, there is an overwhelming economic case. During the 1990s, emissions from deforestation were 5.8 gigatons (GT) a year, a fifth of the total anthropogenic carbon emissions and more than those from the entire transport sector (Karousakis, 2007: 6).

Besides, REDD looks like good value against other emissions reductions, including afforestation and reforestation (A&R) – the only land-use activities currently admitted by the CDM. This is because, to succeed, a carbon-mitigation strategy had to pay the users of a resource more than they would gain from their current practice. And the gains from deforestation are – perhaps surprisingly – not always that high. Swallow et al. (2007: vi-vii) report that in three areas studied in Indonesia where emissions were increasing, the economic returns from deforestation were less than US$ 1 a ton of carbon emitted in up to a fifth of cases, while in others in Indonesia and Peru, emissions from land-use change generally returned less than US$ 5 per ton. The price of carbon fluctuates, but would normally exceed that by a wide margin. Chomitz (2007: xii, 1) argues that since clearance of Latin American tropical forest to create pasture releases 500 tons of CO_2 per hectare to create pasture worth only a few hundred dollars, monetizing the carbon should do the trick. "This implies… that deforesters are destroying a carbon storage asset theoretically worth $1,500–10,000 [for carbon trading] to create a pasture worth $200–500 (per hectare)," he says.

2.1 What the poor have to gain and lose

This is good in theory, but the benefits of trading the carbon instead might not accrue to the farmers who would have emitted it, and they may be left with nothing. The fact that mitigation costs per ton are so low with REDD are part of the reason why there may be adverse, as well as positive, livelihood effects for lower-income land users. As Brown and Corbera (2003: 8) put it: "The development of carbon markets may privilege global claims over those of other users and scales."

This can be seen from the sheer weight of the market that may be opened up. Olander and Murray (2007: 91-10) suggest estimates of the annual value by region from a 50% reduction in deforestation: US 26-53 billion for the tropics, with US12-25

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[1] COP stands for Conference of the Parties (to the original United Nations Framework Convention on Climate Change, not the Kyoto Protocol to it). "Kyoto II" is used here as a shorthand; no-one knows what it will be called.

[2] It will be referred to from here as REDD.

billion for tropical Latin America, US$ 10-20 billion for tropical Asia and US$ 4-8 billion for tropical Africa. At ground level, Staddon (2009: 28-29) quotes the carbon sequestered in the area covered by three Nepali Community Forest User Groups (CFUGs) as 6.89 t/ha a year, and says that at current CDM market prices that would be worth US$ 82.68; given that 1.1 million ha of forest are managed by CFUGs, that is US$ 90.9 million: "An almost tenfold increase over existing sources" (ibid.).

Once again, there should be caveats. One, as Staddon herself points out, is that the market might not provide these sorts of capital flows for this sort of project, because of the higher transaction costs – this is discussed below. Another is that a forest under REDD may be preserving carbon but not sequestering it, as an old-growth forest would not accumulate much in above-ground biomass; there would therefore have to be a theoretical gain against a previous deforestation baseline, which could be more than 6.89 t/ha but might also be a great deal less. Nonetheless, there could be livelihood benefits if these sums to accrue to the forest users; and in a structure such as a CFUG, they might.

So funding flows from REDD could have either positive or negative consequences for low-income groups. The following sections review risks of some negative consequences and how they might be controlled. The risks are as follows.

- **The "real" land-users do not benefit,** although they must comply with REDD. This could happen through corruption, but also because national-level carbon accounting provides no link between them and the carbon market.
- **Transaction costs.** Although REDD looks good value, it could have high transaction costs in areas where there are many smallholders – e.g. the poor. This is because the costs of verification, monitoring and making payments will recur more frequently over a given area. High abatement costs per ton in projects that most benefit the poor mean that the market may stay away and invest instead in areas where there are few forest users, and therefore lower social gains to the poor from REDD.
- **A poor deal from the developers:** Poorer land-users may not be in a position to assess the contract they have been offered. Land-users may contract to deliver carbon, the price of which then drops to below the opportunity cost of not deforesting. Or they may find they have been led to assume obligations that could never be economic, or are unjust.
- **Elite capture.** The money, or benefits in kind, do reach the community but are unevenly divided within it, so that the really poor gain little.

The following subsections look at these risks in turn.

2.2 The "real" land-users do not benefit

A danger of large-scale REDD is that the poor will incur the opportunity costs of not deforesting, but the cash from the carbon market will then not be used to reimburse them. This could occur because of corruption. But it could also be a result of REDD design at international level.

REDD can either follow the project-based approach of the CDM, or it can be based on accounting for carbon stocks at the national level. Angelsen et al. (2008: 33-34) explain that most parties to the UNFCCC have advocated a national approach, in which "no direct credits would be issued internationally for activities that reduce emissions at the national level". This reflects concern over the transaction costs of projects (discussed below), and leakage – that is, deforestation prevented in a given area may simply be displaced, not prevented. Choosing the national approach also acknowledges that preventing deforestation needs policy changes (for example, on agricultural inputs) and can't be done piecemeal. Last but not least, it prevents sovereignty issues; as Dutschke (2002: 385) has pointed out, if a project creates 'permanent' sinks, this may conflict with the sovereignty of the host country; but this is avoided if that country has instead agreed, internationally, to control emissions from the whole sector.

However, this would mean that any funds transferred – whether as aid, or through some market mechanism – to reflect reductions in deforestation might accrue to the government concerned, which could then ensure the poor complied through simple coercion. The latter has a long history in forestry and still occurs; it need not be discussed in detail here.[3] Such coercion would be even more likely in a country where the national government *did* decide that the money should be either paid to, or used for, the forest communities, but corruption at local level deprived it of the means to ensure this was done. Forest users would then be very vulnerable to harassment, perhaps violent, by local elites. Some of the countries with the most to gain from REDD score lowest on a range of governance indicators (Ebeling, 2006, quoted Boyd et al., 2007: 36).

Angelsen et al. (2008: 33-34) are aware of these drawbacks of national-level accounting. They add (op. cit.: 39) that, "at the international level, a regime allowing only national approaches to REDD could exclude most of the low-income countries

[3] The writer worked for several years in the 1990s in an Asian country where Forestry Extension Officers (FEOs) prevented cutting for long-established uses, and this so antagonized rural people that some apparently set fire to forest areas out of sheer fury. To add insult to injury, it was said some FEOs overlooked illegal hunting, provided they got half the carcass – which led two expatriates to call them Forestry Extortion Officers, to the irritation of their Ministry.

on grounds that they have inadequate infrastructure for MRV[4] and poor governance." They also point out that, "a centralised national approach could limit the participation of rural communities in the design and implementation of REDD" (ibid.)

However, the alternative – a project-based system – presents problems of its own besides leakage, policy and sovereignty implications. One is that investors who try to work with the poorest will be faced with much higher transaction costs under a project-based system (though there can be answers to this, such as working with community user groups; this is discussed later). Another is that projects might be declared ineligible if they were in areas that are already protected, as this would breach any additionality requirement that REDD might have.[5] But REDD will be severely weakened if it does *not* apply to such areas. Campbell et al. (2008: 26) report that 312 Gt, or 15.2%, of the world's terrestrial carbon is held in them. Moreover, the percentage of carbon that is held in protected areas is especially high in developing regions where there are high emissions from deforestation. Thus it is 25.2% in Central America and the Caribbean, 26.8% in South America, 13.7% in Africa, 16.3% in East Asia and 15% in South Asia (op. cit.: 13). There would also be a difficult equity issue if people who lived in protected areas were now to see their neighbours rewarded for ceasing an activity that had for them been forbidden for many years, and which they had been and would still be forced to forego without compensation.[6] If the additionality requirement applies to national-level baselines and not project areas, then existing protected areas are more likely to benefit.

There is no obvious policy answer in this area. Bleaney et al. (2010: 6) report that in discussions of REDD at COP15 in Copenhagen, most countries "agree that accounting will ultimately have to be conducted at the national level to account for displacement of emissions [known as leakage] and to implement [REDD] at national scale." The only strong objectors were Colombia (apparently because some forest areas are currently outside the national government's control) and the United States; in the latter case, the reasons are not clear, but Bleaney et al. suggest it may be because the private sector wishes to participate in the purchase of offsets from REDD, which might be easier under a sub-national approach.

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[4] MRV = measurable, reportable and verifiable. At COP 13 in Bali, developed countries extracted a hard-won commitment from developing ones that they would take mitigation actions that were MRV; just exactly what this means has been much discussed (see Robbins, 2008).

[5] Additionality means that the project must sequester or retain more carbon than would otherwise be the case. It is a difficult part of the CDM certification requirements. REDD is unlikely to come under the CDM as currently set up, but it is inconceivable that there will not be a strict requirement.

[6] An exception might be an area that was protected in theory, but in practice was exploited. REDD payments could therefore be made for better enforcement, as that would reduce carbon losses against the real baseline, and would therefore constitute additionality. However, such arrangements could only be agreed upon in a certain number of cases.

But the national approach is likely to prevail, so measures are needed to ensure a link between national governments and land-users. The answer may be international commitments to sustainable development, but also to community forest management, through which governments could finance local development in return for forestry conservation; this would effectively put in place a project structure without the problems that a CDM-like international project structure would cause. There is now quite a lot of experience with such projects (they are discussed further below), and they could prove to be the necessary compromise.

2.3 High transaction costs mean that activities with the poor will not attract investment

This applies most strongly to project-based initiatives, but could also affect incentive structures devised by governments, and would certainly affect any market mechanism.

At a transnational level, investment in some countries involves higher transaction costs (and risks) than others – something that has long been reflected in patterns of foreign direct investment (FDI). At a sub-national level, mitigation measures that involve the poor are likely to have higher transaction costs than those where there is a smaller human element. There are sustainable development considerations, a need to provide for forest users, and limitations on the type of development, especially in forestry. They will therefore have higher per-ton mitigation costs and will attract less investment. This will reduce livelihoods gains for the poor – and will be inequitable. Framing policy to take account of this involves two main issues. The first is to devise a funding regime for carbon that makes it less disadvantageous to fund such projects; the second is to try and reduce the transaction costs themselves.

2.3.1 Funding for high-cost mitigation

On a conventional bilateral model of investment, market-based mechanisms would favour the lowest mitigation costs per ton and would therefore direct carbon funding in the same directions as other types of FDI in the developing world, and for similar reasons – such as existence of mechanisms, and lower transaction costs (Baumert et al., 2000: 1-4). This would imply over 50% split between Brazil, China and India, with other countries fighting for what was left.

In the case of the CDM, this proved true early on. In the first three quarters of 2006, China accounted for 60% of CDM projects (by volume transacted), although this was down from 73% the previous year. India transacted 15% and Latin America 9% (but nearly half of the latter was Brazil). Africa hosted 7% of CDM projects by volume, up from 3% the previous year (Capoor and Ambrosi, 2006a: 8).

The latest figures from the UNEP/Risø pipeline (February 1 2010) show the inequity is now, if anything, rather worse. The Asia-Pacific region (which includes China) accounting for 78.5% of the projects, Latin America 17% and Africa and the Middle East 2.4% and 1% each. (The balance is split between Central Asia and Europe; the latter figures in the list because unlike the CDM it is eligible for Joint Implementation projects, but there have so far been few of these). The number of Certified Emissions Reductions, or CERs, to be issued per capita is nearly six times as high for Asia-Pacific as it is for Africa. Even within Africa, three countries – South Africa, Egypt and Nigeria – accounted for over 77% by volume between them. Moreover the volumes transacted are heavily skewed by type of project. Afforestation/deforestation activities account for just 1% of the projects – and have not produced any CERs so far.[7]

However, REDD may shift the balance towards the disadvantaged reasons. Also, Baumert et al.'s prediction was based on carbon investment following a conventional bilateral FDI model, but they themselves pointed out that although this had been widely assumed, it need not be the case. They suggested other types, including a 'unilateral' model under which there is no project developer in an Annex 1 (developed) country, and the finance may be from a (say) government or investment corporation whose motives are not completely commercial. This could include an environment ministry whose main motives were preservation of a forest for its own sake, but which could sell the credits on the market later for the same price as those generated by lower-cost alternatives; they will not make the same profit, but that was not why they did it – and anyway, they may still make one, albeit smaller. Events so far have proved Baumert et al. correct, with India in particular a big enthusiast for the unilateral model. If large-scale REDD is introduced with national accounting, governments will have more of an incentive to do this.

However, not everyone sees unilateral projects as a good thing. A recent submission to a UNFCCC working group by Tuvalu, for example, protested that they undermined the concept of additionality (they do not say why, but arguably such projects are ones that local interests wanted anyway). They also feel that such projects do not provide the North-South technology transfer that was supposed to be part of the CDM.

The second argument may not be true, as the existence of finance for an activity implies transfer of the technology needed for it, even by indirect means. Such transfers may not figure so strongly in the REDD provisions, in any case; they are

[7] The African share of the CDM has actually been *below* its share of FDI, according to Capoor and Ambrosi (2006b: 4), who explain: "Many African countries have thin energy and industrial sectors with limited opportunities to reduce carbon emissions, certainly relative to countries such as China and India."

less relevant to forests. As for the first argument, if international agreements accept REDD in principle, they have swallowed a bigger additionality concern than any presented by unilateral investment. The challenge may be to give governments the greatest possible incentive to unilaterally fund measures that reduce deforestation.In any case, continuing tolerance of unilateral funding for mitigation actions is an important policy key for equity in mitigation policy, and applies especially to land-use projects.

2.3.2 Reducing transaction costs

A funding regime that covers high mitigation costs is one requirement. But other policy options in this context could relate to reducing those costs. They include everything related to setting up a project and monitoring its carbon outcomes.

This will be more expensive when there are low-income participants, as their holdings are likely to be smaller and the number of those involved will be greater per ton of emissions mitigated. As Jindal et al. (2008: 126) put it: "Gaining information about landowners, contacting them, and certifying changes in land use, all increase the cost per hectare and per unit of carbon sequestration when working with many small holders." Jindal et al. point out that for CDM projects, there are also costs of registration, certification and verification, which are not scale-dependent – a small-scale project with smallholders will have costs at least as high as (say) an HFC-destruction project in Chinese industry. They quote Michaelowa and Jotzo's (2005) estimate that transaction costs in the CDM can range from US$1.48 per t/$CO_2$ for large projects to US$14.78 for small ones. If accounting is at national level, some of these differences may matter less, but they will still confront governments that wish to offer incentives for REDD activity.

Besides making it harder to finance pro-poor activities, these costs may reduce the livelihoods benefits when they do take place, not only because they will bite into carbon payments, but because they may make it unprofitable to include sustainable-development goals in the project design. This is evident from one of the first A&R activities to be mounted with both carbon and development goals.

This is the Scolel Té project in Chiapas, Mexico. Its main customer was the International Automobile Federation, which up to 2004 had bought 5,500 tons a year from the project at $11 a ton; the project also sold carbon to the British "retail" carbon trader Future Forests[8] (Corbera, 2004: 5). Scolel Té means "growing trees" in Mayan.[9] The activities have been taking place within the context of a subsistence

[8] Now the Carbon Neutral Company. The retail, or voluntary, market does not sell CERs for compliance; rather, it allows individuals and companies to offset their emissions for ethical reasons.
[9] Nelson and de Jong (2003: 22fn) say it means "the growing tree" in four local dialects.

farming system based on maize and beans, with some extra income from coffee, cattle and itinerant labour, and the majority of the carbon contracts have been with farmers who earned their living that way (Nelson and de Jong, 2003: 20).

Between its inception in 1995 and 2004, the project grew from six communities consisting of 42 farmers to 33 communities with a total of 650 farmers (op. cit.: 6-7). Initially, the technician from the local implementing NGO knew the participating farmers, and kept files on their contracts and monitoring procedures. When he left, however, much of this knowledge went with him, and the two technicians who replaced him in 1998 were forced to tighten the administration. But they then spent much more time on such administrative duties than they did in providing technical advice; not all the farmers were happy about this, but the technicians had no option as project did not generate enough revenue for them to do both. Indeed, Nelson and de Jong pointed out that the project had evolved from sustainable development concerns to becoming a much more focused carbon 'bank' (op. cit.: 27-28). There are also potential equity and biodiversity concerns about the project's evolution (op. cit., 26; Corbera, 2004: 13-16; Brown and Corbera, 2003: S53-S54).

There are possible policy options to address transaction costs and ensure that there is equitable distribution of carbon benefits among income groups. One, described earlier, is to admit funding arrangements (most obviously, unilateral projects) that are less sensitive to per-ton mitigation costs. Another is the streamlining of the certification process, within the CDM and any other mechanism, for those countries that have so far been disadvantaged. The least-developed countries, or LDCs, advocated this at COP14 in Poznan at the end of 2008, to counter the unfair geographical distribution of CDM projects discussed above (Santarius et al., 2009: 17). This was not universally supported, as some countries that were not LDCs but also felt disadvantaged under the CDM (such as Colombia and Saudi Arabia) thought no one group should get special treatment (ibid.). It should be noted too that the process can only be streamlined up to a point; additionality, for example, remains a very sensitive issue in international negotiations, and there can be few shortcuts in ensuring that a project really is additional. Indeed, at the time of COP14, the CDM Executive Board had just suspended accreditation of one of the validating bodies for this reason[10] (op. cit.: 15-16). So great care would be needed in arguing for an easing of certification requirements, especially in land use, where methodology is especially difficult. Nonetheless this should be considered.

Other options include reducing transaction costs by contracting with groups. Jindal et al. (2008: 128) quote a case in Indonesia where 10,000 farmers have organized themselves into about 20 groups in order to provide environmental services, taking

[10] It was Det Norske Veritas (DNV), a venerable Norwegian concern that started out by certifying ships.

responsibility for monitoring their own members. This might be done by contracting with the Nepali CFUGs mentioned above, or the Van Panchayats (VPs) in India.

The latter had their origins in India under British rule. Tewari and Phartiyal (2006: 27) explain that towards the end of the 18th century, the British began to set aside large areas as forest reserves. However, these were always resented by local people, and between 1911 and 1917 they began to burn the forests in retaliation, rather as in the case mentioned briefly above but on a much larger scale. It is a reminder of what might happen if governments decided to comply with nationally-accounted REDD by coercing forest users. In 1921 the British Kumaon Forest Grievance Committee held an enquiry into the causes, and the end result was the Van Panchayat Act of 1931, which took powers over the forest away from the authorities and gave them to community bodies – the VPs. The land remains owned, at least in theory, by the State, but the VPs manage it and the State Forest Department provides technical backstopping. The VP, say Tewari and Phartiyal, "probably represents one of the largest experiments in decentralized management of common property in collaboration between the locals and the state" (ibid.).

Murdiyarso and Skutch (2006) have collected a number of case studies in which community forest management (CFM) has been used for carbon mitigation. They include CFUGs and VPs, but also pilot projects in Indonesia, Tanzania, Senegal and the Philippines. Of the 13 projects reviewed, half were effectively REDD projects, while the remainder involved the land users actually planting trees. They found that, in principle, these activities were practical and profitable. They also found that user groups could be trained to do the monitoring themselves, using hand-held computers of GPS receivers (op. cit.: 121); it was thus possible for the user groups to internalize some of the transaction costs in a way that does not seem to have happened with Scolel Té. This is important not only for reducing transaction costs, but also because remote sensing – while excellent for monitoring changes in forest cover – is less good for monitoring forest *degradation*, from which many emissions come (op. cit.: 121-122). User groups could sometimes do the job.

Some caution is needed. There would of course be a need to monitor the monitors in this case, as user groups are not impartial. Also, Murdiyarso and Skutsch state that the institutional structures must be right. There are also some cases of user groups reflecting gender inequalities and elite capture. This can lead to a different form of inequity within, as opposed to between, stakeholders, and is discussed in 2.4 below. Excessive State involvement can also be counterproductive, as in the case of the VPs and Forest Protection Committees in parts of India (Ballabh et al., 2002).

However, contracting with user groups looks like an essential way of reducing transaction costs and, with them, the relative disadvantage of the poor in the carbon market. So might certification requirements designed for them, and this should be pursued as a policy option. Last but not least, funding arrangements accepted under international markets should be flexible enough to permit up-front funding by groups other than bilateral investors in developed countries.

2.4 Land-users and predatory investors

Given the large sums that may be involved in REDD, land-users may find themselves standing between investors and carbon stocks that are worth a lot more than they are. Staddon (2008: 30) sees this danger regarding CFUGs: "At the moment CFUGs in Nepal keep all revenue from the sale of forest products… If carbon forestry were implemented, it can only be guessed at whether the Nepali government would claim all revenues from carbon financing, only a portion through taxes, or none (i.e. allow CFUGs to retain all funds)," she states.

She adds later that negotiations over carbon projects would bring local user groups into contact with international investors with considerable resources. "The interests and expectations of these two parties may not necessarily be the same," she states, pointing out that the international trader "will generally be in a position of far greater power in negotiations than the often illiterate and inexperienced rural poor." Staddon mentions a further danger, which is that under afforestation projects, the poor may agree to activities (such as tree planting) that cost them more to implement than the payments to which they have agreed. Others have also made this point (Coad et al., 2008: 30; Campbell et al., 2008: 13).

If this is the case, then the same could happen because the user groups have underestimated the opportunity costs of ceasing certain activities (using fuelwood is the obvious example), so the same applies to REDD. They may also not understand fluctuations in the price of carbon, which could be considerable. A rapid expansion of REDD might release too much carbon onto the market and undermine the price. Predicting such movements is hard enough for the experienced trader, and legislative changes could also cause huge drops. They could also cause the carbon price to shoot up. For example, although an EU linking directive[11] allows CDM credits to be traded under the European Emissions Trading System (ETS), land-use projects are excluded. After 2012 this may not apply, and the demand for REDD-generated credits could be even higher than anticipated. Also, bringing aviation into the ETS could force European emitters to buy credits more quickly than expected.

It is therefore very important that land-users should not be out-negotiated so that they lose their margin if the carbon price drops, but gain nothing if it rises. It is not

[11] Or, to give it its correct title, "Directive 2004/101/EC of the European Parliament and of the Council of 27 October 2004 amending Directive 2003/87/EC".

clear how forest users can be expected to (for example) deal with a company that contracted to buy at a variable carbon rate according to the current spot price on the Chicago Climate Exchange, then sold on the futures market; or fixed prices on the value of carbon before it had been certified, then sold it as a certified emissions reduction for a far higher price. Some would argue that in such cases, an investor was simply taking a risk, and being compensated by the profit from turning raw material into a finished product. Others would view it as colonial exploitation of the worst sort.

There may be far worse abuses than these, however. There are examples from forestry projects, not necessarily carbon-oriented; Pirard (2007: 85) records examples of pulpwood planters using what appeared to be waste land but was in fact used for shifting cultivation. Granda (2005: 54) relates the experience of farmers in the coastal region of Ecuador who became involved with a company planting large-scale monoculture plantation. The company bought the land, but finessed the allowance for slope so that one farmer claimed he had sold 58 ha and been paid for 44 ha. Other tactics included blocking rights of way to pressure farmers who had not yet sold out, or killing and eating their animals when they strayed. Granda reports a farmer as saying: "They paid Mr. G. 500 dollars a hectare for his land… he sold because it was far away from where he lives, and he's old and sick… He had cattle, and in the mornings he'd find them hacked up with machetes, or find the barbed-wire fence torn down… They even threatened to kill him, the workers on the neighbouring fields that were already sold, they were sent to threaten him so that he would sell out and leave… They killed his animals, he'd find them in the morning chopped to pieces, and they ate his pigs…"

In this context, perhaps it is worth repeating Brown and Corbera's (2003: 8) statement that "carbon markets may privilege global claims over those of other users and scales."

2.5 Local inequities

It has been suggested that one way the poor might be assured livelihood benefits from carbon is through community forest management. Although this paper broadly accepts that view, there are dangers. One, as discussed earlier, is that under national-level accounting the benefits may accrue to the national exchequer without "trickling down" to the user groups "making" the carbon. Another, outlined above, is that land-users may still be manouvred into making a bad bargain, even when they negotiate as a group. A third is inequity within the group itself. This is important because, as Adger et al. (2003) argue, environmental management needs to be both effective and equitable if it is to be either. Inequities could occur through elite capture, through ethnic and social divisions, or through gender imbalances. This section looks briefly at examples of all three.

First is an example of a user group taking control in its resources and then being subject to elite capture. This is San Martin Ocotlán in the Mexican state of Oaxaca, a case described by Klooster (2000). Exploitation of local forests by a private concessionaire began in 1958. But by 1980, the local community had had enough of poor logging practices and dependence on the logging firms for employment. With the help of the agrarian reform agency and a local union, the concessionaires were replaced by community forest management. Within a year the community's returns on the use of forest resources, which had considerable commercial value, had increased by 600%. This was ploughed back into public works and the business. However, forest management quickly fell into the hands of a few, and most stakeholders did not benefit because the co-operative made large loans to local elites, who did not repay them. The resulting cynicism had a negative impact on conservation. But by the late 1990s, the wider community was seeking to reassert itself – within the management structure, but also through direct action; in one village, women blocked the way of the co-operative's trucks by standing in front of them with their children in their arms.

This was a dramatic case, but in Nepal too, where the CFUGs are a potential model for community carbon production, there are equity issues. Parasai (2006: 35) comments that FUGs are "socially heterogeneous, with members from both the dominant and the weaker social groups. The statutes require democratic decision making within the FUG, so this would seem to offer a vehicle for more participation of women and of poorer and marginalized groups and thus also an equal share in the benefits. The question is, whether this is the case in practice."

Parasai's own case study, in the Baghmara Buffer Zone Community Forest (BZCF), in Chitwan, found that the CFUG had a democratic constitution with a socially heterogeneous executive committee. However, a marginalized group from a Musahar background said they had never been represented on it, and if they did turn up at the general meetings of the CFUG, no-one listened to them (op. cit.: 37-38). "As for women," says Parasai (op. cit.: 39), "when asked why they did not attend the meetings, most of them responded that… they sit at the back and don't hear what is being discussed and even if they put forward some ideas for discussion, their agenda is ignored."

Parasai records (op. cit.: 43-44) that women and disadvantaged groups (except the Musahar) did get a fair share of products such as fuelwood and fodder. But they did not get a fair share of the financial income from the forest; the richest people saw more of that. "If the local community were to be rewarded in financial terms for the carbon saved as a result of their forest management, would the principles of equality hold, and would the poorer and less powerful part of the population, and women, benefit at all?" asks Parasai (ibid.).

3 Agricultural sequestration: Special issues

Agriculture was excluded from the CDM for mainly methodological reasons, but cannot be ignored as a mitigation strategy, both because of its potential to sequester CO_2 as soil carbon, and because of the amount it currently emits, both from mineralization and other processes.

What its mitigation potential is, is not clear. In march 2009 the Food and Agriculture Organization (FAO) has made a submission to the UNFCCC calling for agriculture's inclusion in the CDM or any successor, and this quotes the Intergovernmental Panel on Climate Change (IPCC) estimate of 5-5.6 Gt of CO_2e a year (in Smith et al., 2007a: 499). "This potential is extremely large, especially relative to emissions from the sector. About 89% of this potential could be achieved through soil carbon (C) sequestration," it states (FAO, 2009: 1).

That sounds very high indeed. Even if that figure is optimistic, however, the numbers are still large. The soil organic carbon pool is about 1,550 Pg[12] (Follett, 2001: 78-89), or roughly twice the atmospheric carbon pool, which is 770 Pg (Lal, 2002: 353). Soil carbon, contained in soil organic matter (SOM), can be converted to CO_2 through land-use change, ploughing and erosive processes that are mainly connected to agriculture. Agriculture has therefore caused huge losses to the atmospheric pool ever since it began in settled form about 8,000 years ago. How much, is arguable; Lal (2004: 1623) reports that estimates vary from 44 Pg to 537 Pg, but that they typically range from 55 Pg to 78 Pg.

However, emissions from agriculture are not just from mineralization of soil carbon. Smith et al. (2007a: 14) report an overall growth of greenhouse gas (GHG) emission from agriculture of 14% between 1990 and 2005. Emission of N_20 from fertilizer and methane from livestock are the two fastest growth areas, with N_20 from soils at 21% and N_20 from manure management at 18%; CH_4 from enteric fermentation increased nearly as fast at 12%, but in absolute terms N_20 increased almost twice as rapidly at 31 Mt of CO_2e a year (ibid.). This growth has been driven by the developing, not the developed, world. N_20 emissions from soils and manure management in developing countries are therefore an important driver of climate change. Activities to sequester CO_2 through carbon sequestration could, if badly planned, increase them (for example by attempting to raise SOM using N fertilizer) – a point acknowledged in the IPCC's Fourth Assessment Report (Smith et al., 2007b: 509). But with careful planning, the extra N_20 emissions can be offset by the extra carbon. Better still, well-

[12] 1 Pg (petagram) C is equivalent to 10^{15}g – that is, 1,000 million metric tons; also used is a Tg, or teragram, of C (10^{12}g), 1,000,000 tons; and a gigaton (Gt), which is a billion tons. To reduce confusion, these measurements are quoted here in the same way as they are at source.

designed activities could sequester CO_2 and *reduce* N_20 emissions at the same time, not least by reducing soil erosion that has an impact on soil fertility.

There is also a link between sustainable soil use, with its higher organic carbon content, and deforestation. As Bloomfield and Pearson (2000: 13) point out: "Only half of the land that is converted from tropical forest to agriculture actually increases the productive agricultural area; the other half replaces previously cultivated land that has been degraded and abandoned from production… Thus, if existing agricultural land can be used more effectively, less forest and savannah land will need to be converted to cropland and pasture, reducing the greenhouse gas emissions associated with land conversion." Evidence for this has been presented on a global scale by Vlek et al. (2004); at local level, Tschakert and Tappan (2004) noted the relationship between intensification and extensification in a carbon-related study in Senegal. In fact, there is an argument for integrating non-forest land use with REDD in a single sector, but this was rejected at COP14 in Poznan (Loisel, 2008: 2).[13] But if carbon stocks in agricultural land are accounted for nationally, just as those in forests are also likely to be under REDD, this may not matter.

Last but not least, carbon conservation and sequestration in agriculture has – unlike forestry – a low danger of leakage. As higher soil organic matter increases rather than reduces the productivity of the land, carbon interventions should not reduce activities that cause emissions, rather than simply displace them elsewhere.

3.1 Livelihood considerations

The livelihoods concerns arising from carbon management in agriculture are often the same as in forestry. Transaction costs, community management, equity and the need to find funding for mitigation with high per-ton costs are all issues. The topics discussed here are those that differ from A/R and REDD. They are:

- Pressure to adopt **inappropriate technology**. This has always been a problem, and today there are serious ideological splits in agricultural development concerning what farmers should do. This may have livelihoods consequences.
- Failure to understand the **macroeconomic environment**. Farms that have low carbon balances may be that way because of external factors; paying farmers for carbon sequestration without addressing these will be unsustainable, and will limit any livelihoods benefits.
- **Equity**. The same equity concerns arise as in forestry, but in addition better carbon management in agriculture may require inputs, and this raises specific questions.

[13] This possible integration has given rise to a new acronym: AFOLU, for agriculture, forestry and other land uses.

- Carbon potential may be **overestimated**. Farmers may implement agreed practices without achieving the projected gains; should they be held responsible?

3.1.1 The right technology?

Carbon funding may lead to economic or other pressures to adopt technology that is not right for the farm, and this can have livelihood consequences, especially where scarce labour is expended on measures the farmers themselves knew all along made no sense.

Historic experience with erosion control, in particular, bears this out. It could be adopted as a tactic to reduce carbon emissions from agricultural land against previous baselines. The IPCC's latest review, the Fourth Assessment Report, says relatively little about this (see Smith et al., 2007a); however, in previous years it has quoted Lal and Bruce's estimate that erosion displaces about 0.5 Gt of soil C a year, of which about a fifth enters the atmospheric CO_2 pool (Lal and Bruce, 1999: 179). In fact, Lal (2003: 437) later suggested that the amount of soil displaced was far greater and that the total emitted as CO_2 could be as high as 0.8-1.2 PgC/yr.[14]

But erosion control has an unfortunate history in the developing world. There can of course be benefits, as farmers well know; at least 40 different indigenous soil and water conservation (SWC) systems have been recorded in Africa and the Middle East (Pretty and Shah, 1997: 48; Ellis-Jones and Tengberg, 2000: 34) Despite this, *external* attempts to make farmers adopt techniques for sustainable management have often failed. These failures have often puzzled scientists and extensionists, who feel that the technology works and they just need to push the farmers into understanding them. However, farmers often understand them all too well. Hellin and Haigh (2002: 213) listed some of the reasons why they do not adopt; they included the following:

- *Technologies demand changes that are alien to the farming system*
- *No secure access to land*
- *Labour costs*
- *Technology may not stop soil loss, or increase yields*
- *Physical earthworks may not in themselves increase productivity*
- *Technologies force land out of production*
- *Farmers aren't convinced that erosion is a key problem*
- *Resistance to 'top-down' programmes*
- *Technologies exacerbate other problems – waterlogging, weeds, pests, diseases*
- *Farmers don't feel they own the technologies*

[14] He has always accepted that there is great uncertainty (ibid.; 2005, pers. com.).

- *Increases in risk or debt*

Source: Adapted from Hellin and Haigh (2002: 213)

Initiatives can involve technology that is inappropriate, or wrongly applied, or both. For example, Bewket and Sterk (2002: 197-198) looked at officially-sponsored soil conservation in the East Gojjam zone of Amhara Regional State, Ethiopia. Although farmers were aware of the need for soil conservation, only 35-40 per cent had participated voluntarily; the remainder said they had been under pressure. Part of the reason for this reluctance was that the bunds used cannot have followed the contours well enough; farmers stated that they simply concentrated water and then broke, causing more erosion than they prevented; in fact they referred to it as "erosion caused by the government"(ibid.). Similar patterns have occurred elsewhere. In an area of north-west Rwanda studied by Lewis (1992: 245), farmers were made to construct terracing on very shallow soils and an acidic B-horizon was brought close to the surface at the back of the terrace, where yields were reduced. Farmers compensated by hoeing down soil from the front of the terrace above, so that erosion was exacerbated, not prevented. In these cases, conservation measures were rejected and even dismantled because they did not work. In Ethiopia as a whole, about 40 percent of terraces constructed by the World Food Programme (WFP) were broken a year later (Pretty and Shah, 1997: 45, 1999: 9). This must not happen as part of emissions reduction as well.

But it need not. There many syntheses, in theory, between carbon-friendly management and on-farm sustainability, and if farmers decide measures are worthwhile they will keep them when the carbon funding is no longer there, providing a greater mitigation effect than they have been paid for. However, experience suggests that farmers prefer a basket of technologies to try out and, very often, adapt. Indeed, some would see this as part of a process by which farmers actually *develop* the technology (Sumberg and Okali, 1997).[15] In carbon projects, therefore, it will be better if farmers are compensated for carbon gains without specifying the technologies too closely.

This would make monitoring and verification more dependent on actual measurement of carbon; this is problematic, as it is much easier to use stratified accounting based on the projected accumulation of a practice, and simply ensure that that practice has been adopted. The implication may be that national-level accounting is more practical than fixed project areas, so that carbon balances can be

[15] There is a large literature on this, and also some useful work by the World Overview of Conservation Approaches and Technologies (WOCAT), which has investigated farmers' own motivations for conservation-related activities.

extrapolated over wide areas using (for example) flux measurements and sediment loads.

3.1.2 Equity and agriculture

In the discussion on forest management, equity issues were flagged as a problem in community management. This would also apply to any community-based project in agriculture. As suggested above, the project-based approach is not the only way for agricultural sequestration, but even if farmers are offered incentives on a national basis, there are different equity issues specific to agriculture.

The Green Revolution illustrated them clearly. It unquestionably saved millions of lives, but the dwarf wheat cultivars with which it began did not spring to attention and deliver high yields to order. They were bred to respond to inputs. Fertilizer use in Pakistan's Punjab grew from 14kg/ha in 1966-1974 to 86kg/ha in 1985-1994. Water use also climbed rapidly, not least through private investment in tubewells (Ali and Byerlee, 2000). The poorest could not afford this. Inequalities both within and between regions increased, according to 80% of over 300 studies between 1970 and 1989 (Freebairn, 1995). That they could also appear in carbon projects is illustrated by the cost-benefit analysis performed by Tschakert (2004, 2007) in the Old Peanut Basin in Senegal. Tschakert looked at the profitability of "carbon-friendly" practices without as well as with carbon payments, which implies that her results are an indicator of sustainability; and her work in the Old Peanut Basin of Senegal is a rare field analysis of what a carbon-sequestration project in agriculture, as opposed to forestry, would actually do. She found that the costs of adopting a given practice tended to be higher for resource-poor farmers, to the extent that two-thirds were more profitable for better-endowed households and only one held more advantages for poorer ones (Tschakert, 2007: 78-79). Similar conclusions were reached from a very different agroecological zone when the possible impacts of carbon sequestration were reviewed in a slash-and-burn system in Panama (Tschakert et al., 2007).

This is a different sort of heterogeneity to that implied by the literature on technology adoption, but is just as significant, as it once again concerns Adger et al.'s contention that environmental policy must be equitable, as well as legitimate, efficient and effective (Adger et al., 2002: 1097). If a carbon initiative were to present farmers with inflexible alternatives that made carbon sequestration far more profitable for the richer ones, community tensions would be exacerbated and the project weakened (e.g. its lack of equity would make it less effective). It is hard to see how this can be completely eliminated, as "investing" in carbon will always incur opportunity costs from the foregone use of an asset, and as poorer households will have fewer assets, foregoing the income from any one of them will constitute a greater part of household income. But the impact can be reduced with a "basket" of technologies that permits diversity of asset use for sink management.

3.1.3 Unpredictable carbon tonnages and agronomic effects

The carbon that could be sequestered in agriculture by the technologies advocated for it is often uncertain, and it would be unfortunate if farmers were to incur costs in their adoption and "grow" insufficient carbon to cover them.

No-till, a technology widely promoted for carbon, is an example. Most tropical soils, it has been argued, need not be tilled; an easier strategy is to leave crop residues in the field, where they will encourage a build-up of soil biota that will – it is claimed – aerate the soil just as well. There is no doubt that no-till can often build up large amounts of soil carbon, and there is a further potential benefit from reduced mineralization through reduced erosion under CT.[16] The causative mechanism for C build-up under NT is that not ploughing prevents break-up of microaggregates, from which SOC would be emitted as CO_2.

This reflects mainstream scientific opinion, but it is not universal. Indeed Baker et al. (2007: 1-5) have suggested that no-till does not sequester SOC and that its distribution between soil horizons has clouded the issue. Even if one accepts the majority view on no-till, some cropping systems might require inclusion of a legume to sequester SOC. Sisti et al. (2004: 50) report such a case; the soybean's capacity for biological nitrogen fixation (BNF) was insufficient to compensate for the N exported with the crop. The green-manure legume, however, provided BNF and resulted in sufficient biomass production for carbon derived from crop roots to accumulate. At the same time, there may soon be evidence emerging that no-till may sequester considerably *more* C at lower soil horizons than had been thought. (Boddey, 2007: pers. com.). There are big uncertainties here and farmers might do well not to give concrete undertakings in terms of tons of carbon.

Organic agriculture is another technique sometimes advocated for carbon sequestration, but whether or not it mitigates climate change is a difficult area, in which strong opinions are sometimes held. In theory, it should have inherent mitigation potential because of the link with organic matter. Kotschi and Müller-Sämann (2004) say that organic agriculture "is a systematic strategy, which may reduce GHG emissions and may enhance the sequestration of carbon, the most important green house gas" (op. cit.: 18).

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[16] Reduced emissions from soil erosion under NT do not seem to have been much discussed, but the gains might be spectacular. Boddey et al. (2003: 606) report that: "In a recent review of the literature…[it was] estimated that where ZT [zero tillage] had been introduced in Brazil there was a mean reduction of 75% in soil loss and a 25% lowering in water run off" (Boddey et al., 2003: 606). If Lal's 2003 estimates of emissions from soil erosion are anything like correct, this represents a big reduction in carbon emissions.

Some of their arguments in favour of organic agriculture as a mitigation strategy are open to question, not least their contention that reliance on and quantity of nitrogen fertilizer have become the main reasons for reduced SOM (op. cit.: 19). One could also argue that more is lost following *insufficient* use of nitrogen fertilizer.[17] Of course, conversion to organics would not normally be done solely to mitigate climate change; but again, farmers would be wise not to make carbon-related commitments on the basis of it.

3.1.4 The macroeconomic environment

Before attempting to subsidise on-farm carbon sequestration, it might be as well to ask why farmers themselves have depleted soil carbon in the first place; the answer may indicate that they have livelihood problems too great for carbon funding to make a serious difference, and that the real problems lie elsewhere.

The Atlantic Forest region of Brazil is an example. Despite centuries of deforestation, stands remain even in Rio de Janeiro State. However, GEF (2003: 5-6) reports that the State had a deforestation rate of 16.7% in 1990-2000, far above any other.

Dairy cattle are the main activity, and on-farm land-use is largely pasture – 77.3% of farm area according to a project document of the Global Environment Facility (op. cit.: 122-126). This is the result of the invasion of exhausted coffee plantations by cattle over the last 70 or 80 years; the organic matter, and therefore soil organic carbon, content of these pastures is low. There is good potential for increasing it. But when the writer visited the area in 2005, the pasture covering the low hills of the northern part of the State was usually unimproved. On conducting a survey with farmers to see what the perceived constraints would be to implementing such practices, it became clear that they included both a shortage of capital for investment and a serious shortage of labour. The latter seemed unsurprising, as it was assumed that there had been considerable rural-urban migration.

But much of the labour lost from agriculture in Brazil over the last 30 years has not travelled that far. Da Silva et al. (2002: 44) give figures showing that although the overall economically active urban population increased by a massive 43 million between 1981 and 1991, the rural population has not declined by more than a fraction of that amount, and in the 1990s it actually grew, albeit slowly. The urban growth has come from elsewhere. What has stripped available labour from the

[17] Equally open to challenge is their argument that organic agriculture can prevent emissions through deforestation because of its sustained productivity (op. cit.: 21). Cowie et al. (2007: 340) put things the other way round, suggesting that lower yields under organic agriculture could cause leakage by inducing conversion of additional land to arable.

farming sector has been the growth of non-agricultural rural occupations, referred to by Da Silva et al. by their Portuguese acronym of ORNAs. Yet according to Da Silva and del Grossi (2001: 447), the majority of people in ORNAs "are working in poorly paid jobs that demand few skills and little schooling, even in the most developed regions of the country." Neither should this be seen as a solely Brazilian phenomenon; Reardon et al. (2001: 395-396) reviewed studies in 11 Latin American and Caribbean (LAC) countries and their findings suggest a similar picture of rural labour.

Why could they not be brought (back) into agriculture? The answer seems to be that farmers cannot pay even the wages demanded. Da Silva and del Grossi (op. cit.:: 449) report that, taking all rural incomes as 100, non-farm employees earned 134% and farm employees just 61% – just US $58.68 at the 1997 exchange rate.

The implication is that farms are not being prevented from intensifying – and increasing their carbon sink – because there is no labour; they are just not making enough profit to employ it. It may be that competition from a globalized food market is partly responsible. Cassel and Patel (2003: 1) say that trade liberalization has driven down world prices for Brazil's major crops. Dairy farming is not exempt from this. Lopes et al. (2004) looked at the profitability of 16 dairy farms elsewhere in the Atlantic Forest region. Some farms were covering their operating costs but they were not, in the main, covering the long-term costs of replacing capital. Moreover the capital goods reviewed in their analysis, although including animals, tools, vehicles and machinery (op. cit.: 884), did not appear to include natural capital in the form of soil structure, biodiversity, invasive species or any other of the factors that would affect both carbon content and long-term productivity. In effect, the farmers are subsidizing urban milk consumption.

This does not mean that there should not be a scheme to pay farmers to sequester carbon in the region. But carbon trading might not be the only way to pay for it. For sustainable pasture improvement, a milk levy might do instead, as supermarkets and consumers appear to be getting their milk and meat – and, by implication, using soil carbon – at way below its real cost. What a carbon scheme would do, in effect, is make the world subsidise milk and meat for local consumers. This might or might not be a bad thing, but is not the real intention of carbon funding, and may delay dealing with the underlying livelihoods problems of low-income farmers in the region. In the long term, confronting imbalances between the price and real cost of agricultural produce may have better livelihood outcomes for farmers than carbon schemes that might leave farmers with a more intensive and diverse farming system that, despite being more sustainable in agronomic terms, was inappropriate when they found themselves back in the real world.[18]

4 Managing drylands

Drylands vary in nature from true desert, supporting only a little native vegetation in depressional sites, up to areas with a rainfall of 200-250mm, where agriculture is possible but may be marginal.[19] Most of the carbon potential in dry areas lies in steppe – the land 'between the desert and the sown' – that lies between the two. Vast amounts of this cover the Middle East and especially Central Asia, stretching across into China and Mongolia. In terms of the developing world, it is this semi-arid or arid rangeland that is the most important. According to Rango et al. (2002: 550), arid and semi-arid lands account for 33 to 43% of the total land area depending on classification.

Rangelands in general support about half the world's livestock (Allen-Diaz, 1996: 134). As de Haan (1997: 3) has pointed out, this proportion could decline, but it could also grow; in Europe concern for animal welfare and the environment could drive some animal production out of the industrial sector and back onto grazing land, while rising feed-grain prices could have a similar effect in the former Soviet Union and in Africa. Global demand for meat was expected to nearly double between the 1990s and 2020 (op. cit.: 1). So the economic significance of the steppe will increase.

Two important facts should be noted. First of all, these areas are a huge carbon sink. Second, they are subject to degradation, often from grazing, and this sink is subject to loss through wind erosion and species degradation.

It is as hard to be precise about the potential for grassland carbon as it is to estimate that for arable farming. Ni (2002: 205) highlights wide variation in estimates of China's grassland carbon storage, and ascribes them to differences in classification and estimation. But there is general agreement that grassland is a significant sink. Allen-Diaz (1996: 134) states that rangeland contains about 36 percent of the world's total carbon in above- and below-ground biomass. Other estimates vary; Sathaye and Meyers (1995: 13-1) quote estimates of 417 Pg C, mostly below ground. FAO (2001b: 7) suggest a figure of anywhere between 200 and 420 Pg C – again, mostly below ground and stable; it adds that grassland contains about 70 t/ha of soil C,

[18] This will not be the only case of on-farm carbon being emitted by trade imbalances; Robbins (2004: 32-34) uses the example of olive subsidies that skew production towards the northern side of the Mediterranean and lead indirectly to carbon emissions on both sides.

[19] There is no need to define drylands precisely for the purposes of this paper, but where definitions are required, they vary. It has been understood here as land that is marginal for settled agriculture due to inadequate rainfall.

similar to the content of forest soils. "But the majority (close to 70 percent)…is degraded," it states. Views on the extent, and definition, of grassland degradation are also bound to differ but again, there is a general consensus that it is a problem. Batjes (2004: 134) quotes Oldeman's estimate that about 31 percent of the permanent pastureland in Africa is affected by anthropogenic soil degradation. Preventing overgrazing on these vast areas of semi-arid rangeland is therefore an important climate mitigation strategy.

However, there are reasons for caution, as there will be serious livelihoods consequences for those who rely on these regions to support livestock, and for the urban people who rely on their products. There are also good reasons why protecting the livelihoods of livestock owners would not necessarily be incompatible with rangeland maintenance.

4.1 Potential for sustainable grazing

The first is that, although livestock are responsible for much of the degradation, the evidence suggests that soil C in grassland can be maintained and built up without eliminating grazing and indeed that some grazing is required for optimum C content, encouraging a species mix that produces more biomass. Schuman et al. (2002: 7) discuss studies that found an increase from 1321 to 1983 g m^{-2} in the top 15 cm of soil through grazing shortgrass steppe, and a rise from 6.3 to 11 percent soil C through grazing sheep in an alpine meadow. This work concerned North America, but there is evidence that limited grazing pressure also maintains species diversity and grazing potential in arid or semi-arid environments (Rae et al., 2001: 7; Mearns, 1997: 1). This extra biomass, and the prevention of degradation implied by better rangeland condition, implies not only better forage but also more soil carbon. It is thus widely accepted that well-managed rangeland can be enhanced as a sink and as a grazing resource at the same time. It therefore makes no sense to limit animal numbers below a certain level; that will not produce or preserve organic carbon.

Second, there has been a certain orthodoxy in thinking behind rangeland preservation. Policymakers appear to have made the classic error with regard to such systems, perceiving steppe and rangeland degradation as a consequence of the 'tragedy of the commons' (Banks et al., 2003: 132-33), although the real cause may be a policy of encouraging conversion of grassland to agriculture that was only abandoned relatively recently (Bruce and Mearns, 2002: 51-52), or the breakdown in traditional systems of grazing control due to outside interference. In one of the most important semi-arid carbon sinks, the vast grasslands of Western China, the reaction to overstocking has been to allocate tenure for a given area to specific households or groups of households, on the grounds that they will then practice better land husbandry.

But it may be that pastoralists need more, not less, freedom in such fragile environments. The reason for this lies in their non-equilibrial nature. As Sathaye and Meyers (1995: 13-4-5) explain, rangeland response to grazing and rainfall has normally been predicted on a successional model, embodying the assumption that that there will be a linear response to grazing pressure and that the ultimate productivity potential is a constant. But the crossing of small thresholds in (say) species composition may greatly affect this. In these relatively disequilibrial systems, the number of animals is only loosely related to vegetation dynamics (World Bank, 2003: 3). Bruce and Mearns (2002: 39) explain that "Opportunistic means of 'tracking' fodder availability from natural grazing and browse, usually through mobility, are typical management adaptations to such spatial and temporal variability."

Historically, pastoralists have functioned this way. But this has led outside observers to assume that traditional clan-based mechanisms for grazing control have broken down, and they are seeing an open-access system – a 'tragedy of the commons' – implying an urgent need to impose controls; a reaction that has been seen regarding the Bedou groups of the Middle East (Rae et al, 2001: 13). Indeed there are few countries in which the legislative framework permits such mobility (Bruce and Mearns, 2002: 21). This runs counter to the real needs of pastoralists, and may impede traditional grazing controls that had, in fact, still been functioning to some extent.

What happens when herders lose their mobility can be seen from the Mongolian example. Mongolian pastoralists have traditionally been highly mobile; collectivization, perhaps surprisingly, maintained and enhanced this mobility, as the *negdel* (collective) trucked herds between pastures as required (Fernandez-Gimenez and Batbuyan, 2004: 151-152). The *negdels*, however, were dissolved in the early 1990s. At the same time, the economic upheavals that affected Mongolia, like other former socialist countries, led to large-scale urban-rural migration as people turned – or turned back – to pastoralism as a livelihood strategy.

Between 1990 and 1997 the number of herding households doubled, and livestock numbers reached their highest level in Mongolia's history (Mearns, 2004: 108). Herds have become less mobile on an increasingly crowded steppe. Many older Mongolians regard the resulting loss of productivity as a sign that the earth is dying. Others, however, do perceive the need for mobility (Fernandez-Gimenez and Batbuyan, 2004: 151-152). The situation is compounded by the 1994 Land Law, which has given local officials the impression – apparently erroneous – that they have no authority to ask herders to move (op. cit.: 156-158).

If grazing control in itself does not work, what can be done to preserve the semi-arid carbon sink? Does carbon funding have a role, and need there be livelihoods consequences?

Evidence from Mongolia suggests that the reduction in mobility may have been in part caused by a need to access scarce services (veterinary, perhaps, or medical) and markets. Another challenge in Mongolia has been the cessation of the annual autumn offtake, which greatly reduced animal numbers before the harsh winter. These may be better strategies than restricting herder mobility, and there is no reason in theory why they should not be paid for with carbon.

4.2 Interaction with settled agriculture

There may also be unpredictable livelihood effects if settled farmers on the steppe margin adopt no-till. Reduced-tillage systems demand retention of crop residues. In subsistence farming, especially in arid or semi-arid areas where overall biomass production is low, such crop residues may have other uses. In particular, they provide feed – to the extent that in an integrated crop/livestock system the grazing of livestock on cereal stubble may be economically more significant than the grain production itself. In some regions lentil straw can be worth more than the grain, and Saudi Arabia has actually imported it (FAO, 2002: 1).

Even where farmers do not graze livestock on their cereal stubble, they may permit others to do so, or sell the straw off-farm. This is in fact an important safety net for pastoralists on nearby steppe land, who are vulnerable to year-on-year variations in rainfall. In their study of Syria's Khanasseer valley, which is marginal for arable farming and borders the steppe, Nielsen and Zöbisch (2001: 144) comment that land-use systems in dry regions are "generally characterized by the coexistence and interaction of agriculture and pastoral activities." In this case, if settled farmers retained crop residues instead of selling them, this could cause pastoralists to overgraze fragile steppe, or even attempt to grow barley or other cereals on it. This is unsustainable use of the steppe, as the cultivation fails and causes loss of the native species needed for regeneration; the resulting degradation will cause substantial mineralization of SOC – that is, leakage. The classic case is the Virgin Lands Scheme in Central Asia, but lesser incursions of this sort by individuals are also seen, especially in the Middle East (Robbins, 2004: 28). So the flow of biomass through the farming system would need to be modelled carefully when planning any project.

5 Conclusions and policy recommendations

This paper has reviewed some of the livelihood implications of carbon sequestration. Some policy suggestions can be made.

First, REDD is likely to be linked to national-level accounting. This means the governments in developing countries will have a greater incentive than before to put pressure on forest users. That does not mean that they all will, especially in democracies with strong media and civil-society institutions. But some sort of provision needs to be written into any treaty. Saying that forest conservation must be compatible with sustainable development is unlikely to help; governments will insist on the right to decide for themselves what that means, as they did with the CDM. Provisions must be more focused; for example, that while governments may insist on preservation of sinks, forest users themselves must decide how it is to be done. CFUGs/VPs would be the best blueprint. There also should be an insistence that a minimum portion of compensation for sink conservation should go to the users themselves, and that it should be through structures that address local inequities.

That is probably as specific as such provisions can be made if an agreement on REDD is to be reached. All parties, developing countries in particular, have been sensitive about sovereignty issues throughout the UNFCCC process, and REDD will raise especially sensitive questions in that regard.

Second, any Kyoto II should continue to accommodate unilateral and multilateral, as well as bilateral, models for carbon funding, despite the suspicions some parties have of this. It would also be helpful if there were more investment available for countries that need to find money up-front for unilateral projects. Official development assistance (ODA) cannot be used to fund CDM projects, for the all too good reason that countries might divert it into such projects instead of other types that do not pay back. The answer may lie partly with bodies like the Global Environment Facility (GEF), which could act as an agricultural bank for carbon. Again, getting agreement might be tricky; the GEF in particular has been a political football, with developing countries on the one hand suspicious of its management and wanting more control, while donors such as the USA have wanted to see its funding criteria as tight as possible. However, other multilateral institutions (the African Union, the Asian Development Bank) might share this role.

Third, there is a need for capacity-building to reduce transaction costs in carbon projects involving the poor. This has been realized from the beginning, but the more funding that is available for it, the better. ODA *can* be used for this. Areas in which it is urgently needed include forestry conservation; the inclusion of forest degradation as well as deforestation in REDD means that monitoring will require data on size, age and species composition of trees, not just the extent of the forest canopy. Moreover user groups need to understand their rights and obligations in carbon-funded projects. The case in Ecuador described by Granda was a commercial plantation, not a carbon project, but the difference could narrow and the same abuses appear.

Fourth, carbon activities in agriculture must be based on farmer-selected and, if possible, farmer-developed technologies; if they are not, farmers may not adopt them, or may do so for the carbon payments only and drop them later. This has several implications. One is that accounting will be more difficult than it would if one were able simply to insist on adoption of a fixed practice, and then multiply the hectares by a notional sequestration value for that activity. Instead, accounting may have to be done on national or regional bases using remote sensing of vegetation cover and flux measurement. Another implication, however, is that selection of appropriate technologies must be non-ideological. Agricultural development is a divided business; one insists on the utility of chemical fertilizer, or on small-scale technologies, or organics, depending on one's preferred model of development or ecology. In fact, farms, especially small, low-income ones, are so heterogeneous that coming at technology selection like that is not good for the farmer, and will sequester no carbon. The writer can endorse this from experience of researching possible models for carbon sequestration in Brazil.

Fifth, farmers should not be encouraged or funded to adopt practices that would otherwise make no sense in the macroeconomic context. If there is (for example) no affordable labour because farm-gate prices are low, it is pointless making them construct labour-intensive terraces; they will not be able to maintain them afterwards, and the carbon will be lost. This is another good argument for farmer-developed technology; the farmer may, for example, reject terraces for that reason but devise simple trash strips instead, and there have been such cases.

Sixth, carbon-funded initiatives should be careful of providing inputs or other assistance that benefit some farmers a lot more than others.

Seventh, initiatives to conserve large areas of dryland steppe should not impose controls that limit pastoralists' mobility more than necessary, and might sometimes achieve more by actually increasing it. Funding of (for example) veterinary services may also help make best use of grazing. It is also important that any controls to not supersede and nullify long-standing traditional grazing arrangements that might have been more effective.

Eighth, initiatives in dry areas should be designed with an eye to the much lower production of biomass and to the multiple uses for which it is needed in some areas.

Funding farmers to retain crop residues for cover, for example, might deprive pastoralists of feed. The existing use of biomass in a system should always be modelled first to prevent unforeseen livelihoods effects (and possible leakage) if one of these multiple uses is withdrawn. In connection with this, it is also worth noting that there are complexities and, quite often, serious tensions in the relations between pastoralists and settled farmers at the desert margin; no carbon initiative should exacerbate these. Doing so could have dangerous consequences in parts of the Middle East and around the edges of the Sahel.

The above recommendations address some of the livelihoods challenges that could arise for some low-income groups as a result of carbon sequestration. But only experience can really show how best to safeguard their interests.

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