3

Using international carbon markets to finance forest restoration

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3.1 Introduction

The rapid growth of the global economy during the last century, coupled with a tripling of the world's population, has taken a heavy toll on the natural environment. Although it is difficult to quantify the current extent of degraded land globally, some estimate this to include around one third of the total global land area (Eswaran *et al*., 2001). It is clear that land degradation has been occurring on a scale which makes it one of the most pressing environmental problems of our time. In the same way, the need for ecological restoration is not confined to isolated sites but applies to vast areas around the world.

Deforestation, often followed by soil erosion, is a key contributor to land degradation on a global scale. At the current rate, 13 million hectares of forest are lost annually, and this consists almost entirely of deforestation in tropical developing countries (FAO, 2006). There is thus an urgent need for active ecological restoration through reforestation in developing countries. A combination of factors, including poor environmental regulation and enforcement, limited governance capacity, constrained financial resources, and lack of scientific information, make the problem of land degradation in general, and deforestation in particular, especially pressing for developing countries.

Arguably, the majority of the degradation of natural ecosystems occurs because the environmental services they provide to the global community are not valued in monetary terms. There have been frequent calls by researchers, as well as politicians and activists for people to realize the value of these ecosystem services and ensure their protection; however, this has rarely led to the translation of these global benefits into tangible incentives for local actors who often face strong economic incentives to engage in unsustainable land-use practices. An international financial mechanism exists that could help enable the restoration of formerly forested lands through private sector funds. which is not the case for many other forms of land degradation. International carbon markets could, at least in principle, bridge the notorious gap

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between global climatic and conservation benefits and local opportunity costs of sustainable land use through the monetary valuation of the carbon sequestered by growing forests. Project-based mechanisms under the framework of the Kyoto Protocol and within voluntary carbon markets contain concrete opportunities for financing ecological restoration through reforestation. Such carbon forestry projects have been in the making for over a decade (Stuart and Moura Costa, 1998) and, despite temporary setbacks, they are now growing in importance in carbon markets.

This chapter begins by providing a brief background to existing carbon markets and mechanisms for funding carbon forestry activities in developing countries. This includes an overview of the current status of forestry in the regulatory and voluntary carbon markets. The main part of the chapter evaluates the match between the aims and mechanisms of carbon forestry and those of ecological restoration in theory and in practice. The impact of the requirements of carbon standards for forestry projects and the market incentive structure is analyzed with regard to their impact on ecological restoration aims. Potential synergies between carbon crediting and ecological restoration are explored and illustrated with practical examples, and these are contrasted with challenges posed by the economics of carbon markets, regulations under the Kyoto Protocol, and real-world limitations. The concluding section gives some considerations regarding the realistic potential for achieving ecological restoration goals through carbon forestry while suggesting ways to enhance synergies. Throughout, the focus is on carbon forestry under the Clean Development Mechanism (CDM), voluntary carbon markets and, where relevant, emerging non-Kyoto compliance markets. While most of the contents of this chapter would also apply to the use of carbon finance for avoided deforestation projects, or "REDD" (reduced emissions from deforestation and degradation), this is not the subject of this chapter.

3.2 Forestry and international carbon markets

This first section lays out the underlying principles and framework of international carbon markets. It then provides some background on how forestry has been integrated into these markets since they were first established, before summarising the current market status of the carbon forestry sector.

3.2.1 Background on carbon markets

There are two fundamentally different, yet related, types of carbon markets: voluntary and compliance, or regulatory, markets. Voluntary funding for carbon offset projects (not yet real "markets") has existed for about two decades, albeit on a small scale, and has provided companies and individuals with an opportunity to offset some of the greenhouse gas (GHG) emissions they produce. These markets are discussed below. Regulatory or compliance markets, on the other hand, have been created based on national law or international agreements.

The basis for the main international regulatory market for emission reductions was laid in 1997 when most of the world's nations signed the Kyoto Protocol (Figure 3.1) and became parties to it. This agreement established quantified emission reduction obligations for the industrialized countries which had previously signed the United Nations Framework Convention on Climate Change (UNFCCC), the so-called "Annex I countries" of that convention. Most developing countries are similarly Parties to the UNFCCC and the Kyoto Protocol. However, they do not have any emission reduction targets and are referred to as "Non-Annex I countries" (UNFCCC, 1998). The Kyoto Protocol also established three flexible mechanisms. These were intended to allow for the implementation of emission reductions where it is most economically efficient, which is often in developing countries with low levels of energy efficiency, while the ensuing carbon credits can then be purchased and used by Annex-I countries.

The most important of these flexible mechanisms is the Clean Development Mechanism (CDM), which allows projects implemented in developing countries to generate internationally tradable emission reductions (Certified Emission Reductions, or CERs). CDM credits, including from forestry projects, can be used by developed countries to meet their emissions reductions targets (UNFCCC, 1998; UNFCCC, 2005).

The CDM has proven to be successful in many ways since the Kyoto Protocol finally entered into force in 2005. With double-digit growth rates since that year, the CDM market reached about US$ 13 billion in 2007. At the same time, overall regulatory carbon markets transacted about US$ 64 billion, including the CDM and the European Emission Trading Scheme (EU ETS) (Capoor and Ambrosi, 2008). The respective numbers for 2008 markets are projected to be US$ 20 billion for the CDM and US$ 118 billion for overall regulatory markets (New Carbon Finance, 2009). The commodity traded on these markets is measured in tonnes of avoided CO_2 emissions, the main anthropogenic greenhouse gas, and they are therefore generally referred to as carbon markets.

Even before the Kyoto Protocol was signed, and in parallel with the creation of regulatory markets, voluntary carbon markets have emerged. Whereas Kyoto markets are fundamentally compliance markets, created and shaped by governmental regulation, voluntary initiatives are not driven by any legal obligation. Individuals, but also corporations and other organizations without reduction obligations, have the option to purchase carbon credits voluntarily through these markets and to use them as "offsets" for their own emissions. Growing awareness regarding emissions caused by individuals, particularly concern about individual air travel, along with a growing sense of corporate social responsibility (CSR) have fuelled the voluntary markets. There is now an ever increasing demand by organizations for reducing

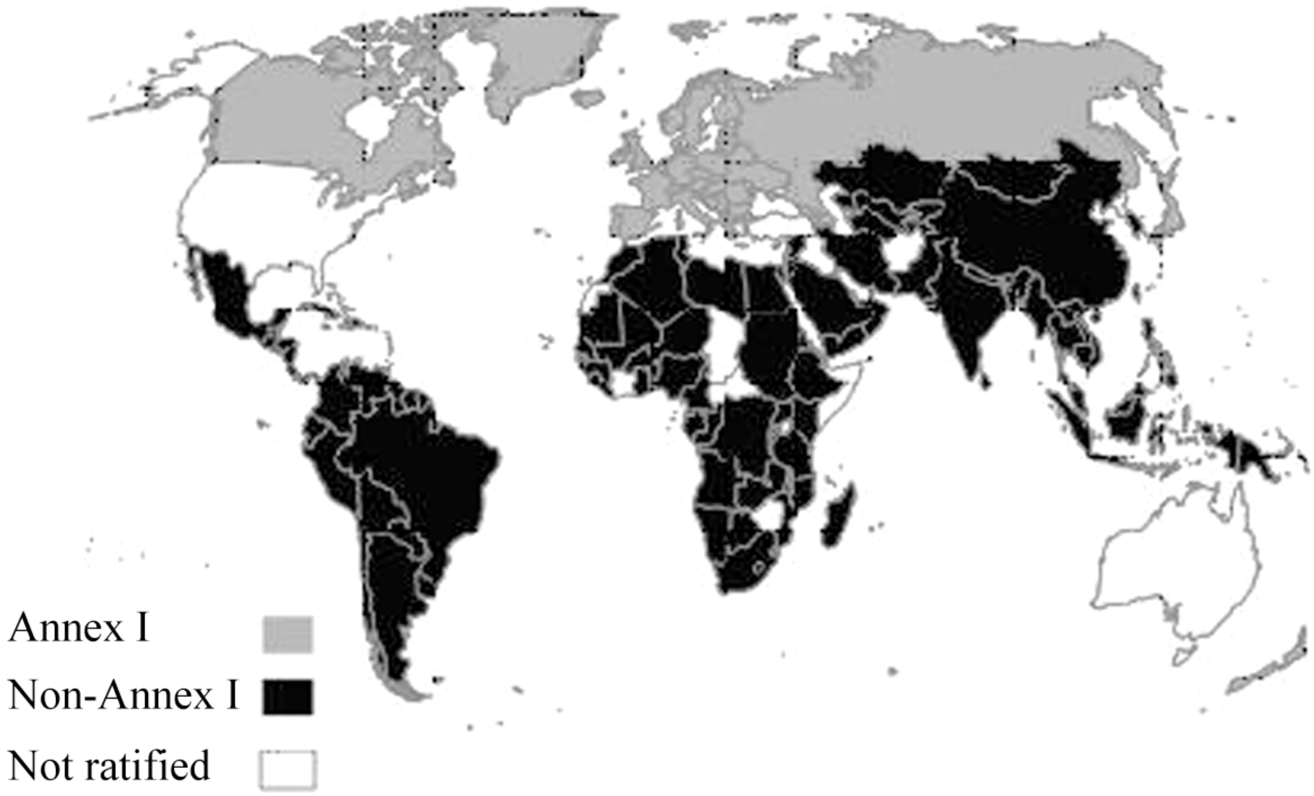

Fig. 3.1. Parties to the Kyoto Protocol, UNFCCC. Elaboration by EcoSecurities.

their carbon footprint or even to become "carbon neutral." A growing number of project developers are implementing carbon projects, many of them in developing countries, to create offset credits for the voluntary markets. Voluntary markets have been rapidly growing in the last few years and are thought to have reached a volume of US$ 330 million in 2007 (Hamilton *et al*., 2008).

The other two flexible mechanisms are Emission Trading (ET), which allows for the trading of emission allowances between Annex-I governments, and Joint Implementation (JI), which allows crediting of emission reduction projects implemented in other Annex-I countries.

3.2.2 Brief history of forestry in international carbon markets

Forestry projects were very much at the focus of early carbon offset projects and climate change mitigation efforts. In many ways, they helped define the concept of carbon offsets as such and prepared the ground for the CDM. Indeed, the requirements for independent certification of carbon credits under the CDM is based on work done for forestry projects and schemes (Moura Costa *et al*., 1997; Moura Costa *et al*., 2000). Forestry offsets are still considered by many as typical offset projects. In 1989, years before the Kyoto Protocol or even the UNFCCC were agreed upon, AES Corporation, a US electricity supplier, initiated the first corporate carbon offset project (Faeth *et al*., 1994). The project, which focused on community forestry and agro-forestry interventions in Guatemala and was aimed at reducing deforestation pressures, helped set the stage for the development of forestry offset projects. Throughout the 1990s, forestry continued to play a central role in the development of the carbon offset concept. At least thirty Land-Use, Land-Use Change and Forestry (LULUCF) offset projects were developed during this period by a variety of companies under a variety of voluntary programs. The project types included forest conservation, reforestation/afforestation, reduced impact logging and forest management, biomass energy deployment, and projects involving agricultural soils and crops (Moura Costa and Stuart, 1998).

However, the history of forestry in international climate negotiations has been marked by many ups and downs with some proponents hailing its potential enormous co-benefits and others condemning its risks as a sound emissions reduction regime. The discussions which eventually led to the Marrakech Accords in 2001 (UNFCCC, 2001) included a controversial and heated debate about sinks (as opposed to sources) of GHG emissions in the land-use sector, irrespective of their merits. The main criticisms revolved around perceived risks of "market flooding," non-permanence and carbon leakage, as well as measurement and monitoring concerns, perverse incentives, and potential negative social impacts of carbon projects (Ebeling *et al*., 2008).

The suggestion to include sinks, mainly in the form of forests, was made when total emission targets had already been set by Kyoto Parties. This led to fears that forestry activities would simply dilute the focus on or displace some other mitigation efforts. Instead of leading to a net reduction in emissions, assigning carbon benefits to sinks would further delay the necessary restructuring of our fossil-fuel based economies. The concerns were poignantly expressed by the slogan adopted by the non-governmental organizations (NGOs) involved in the debate: "Don't sink Kyoto!" Projections of vast quantities of cheap forestry credits flooding the carbon markets and depressing the price of tradable emission permits led to similar concerns. Cheap credits, while commercially desirable, would decrease incentives to invest in energy-related emission abatement and crowd out such activities (Ebeling, 2008).

The risk of reversal, or non-permanence, of emission reductions if sinks were destroyed, e.g., by burning or cutting down forests, seemed difficult to tackle. Similarly, leakage, the displacement of emission-generating activities outside the project boundaries without actually reducing them, seemed very difficult to quantify or prevent. For example, leakage would occur if plantations were established on agricultural land and if farmers converted forests elsewhere to regain areas for cultivation (Schwarze *et al.*, 2002). Added to this were uncertainties in monitoring and measuring carbon fluxes from land-use and forestry.

Some stakeholders were also concerned that the CDM would create perverse incentives to cut down existing forests and establish plantations in their stead to gain carbon credits. Finally, sovereignty concerns and social impacts generated controversy: paying poor developing countries for keeping certain areas under forest cover for a long time and thereby restricting other development options on these lands was portrayed by some as a form of expropriation and neo-colonialism (see Fearnside, 2001; Dessai *et al.*, 2005). We discuss below how these concerns were addressed in the design of carbon markets.

3.2.3 Current market status of carbon forestry projects

The main distinction here again is between Kyoto regulatory and voluntary carbon markets, as well as forthcoming US and post-Kyoto carbon markets. After the Kyoto Protocol was signed in 1997, it took several years to define concrete rules for the CDM. Most of these were established by the Marrakech Accords in 2001; however, forestry-related rules were not finalized until several years later. This delayed regulatory clarity, the complicated methodological framework being established for forestry, and, perhaps most importantly, the refusal of the European Union to allow forestry CDM credits into its domestic emissions trading scheme contributed to the fact that forestry projects still account for a very small share of the overall CDM pipeline (Figure 3.2). At the end of 2008, only one forestry project had achieved CDM registration (the final step before the issuance of carbon credits), another

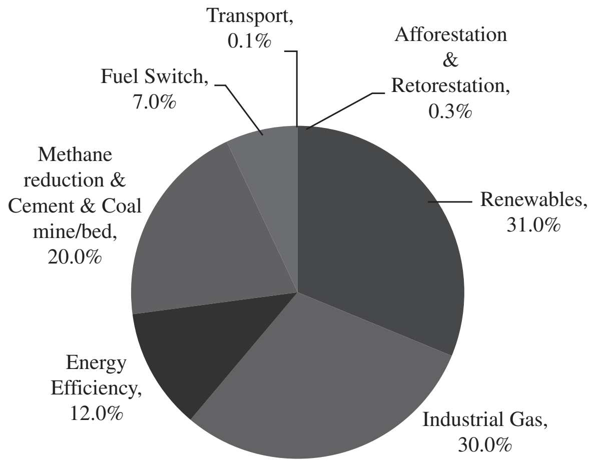

Fig. 3.2. Share of expected carbon credits until 2012 in each CDM project category
Adapted from UNEP, 2008.

seventeen projects had been submitted for validation by independent certifiers (the step preceding registration), and several dozen more projects were under development. The corresponding project numbers for the overall CDM pipeline were 1242 registered projects and 4151 projects at validation (UNEP, 2008). However, there are signs of increased activity in the CDM forestry sector as more experience is accumulated and carbon buyers become more interested in this asset class.

Most of the first CDM forestry projects in the pipeline were promoted by pilot funds administered by the World Bank, as well as by several large conservation and development NGOs. Overall, many of the existing projects rely at least partly on donor funding (Neeff *et al.*, 2007). This means that at this early stage in the development of the carbon market, much of the demand for CDM forestry credits is not actually created by buyers that have to purchase credits for compliance reasons but rather by multilateral and philanthropic organisations. The registration and validation of the first CDM forestry projects have lifted the sector beyond the pilot status and more and more commercial project proponents have started to become involved. However, interest is still subdued due to the restrictive attitude of the largest regional carbon market at present, the EU Emission Trading Scheme, towards forestry (Neeff and Ebeling, 2008). In terms of regional distribution of CDM forestry project development efforts, Latin America is currently the region with the highest credit potential in existing projects (with more than half of the estimated future credits coming from this region), followed by Africa (with about one third) (Figure 3.3). Similarly, the geographical distribution of projects in the World Bank's BioCarbon Fund includes a majority of projects being developed in Latin America, followed by Africa (World Bank, 2006).

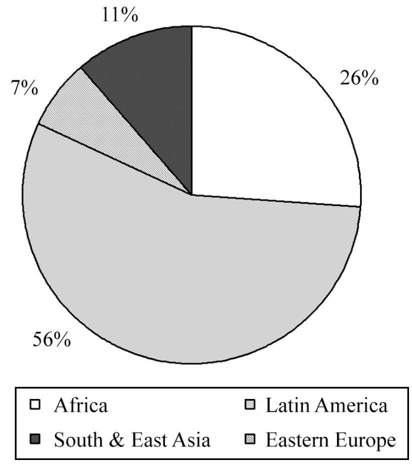

Fig. 3.3. Carbon credit potential of CDM projects in different regions (based on projected carbon sequestration of CDM projects currently under development). Modified from Neeff *et al*., 2007.

In addition to the maturing regulatory (Kyoto) carbon markets, the burgeoning voluntary carbon markets are fuelling demand for forestry-based carbon offsets. Indeed, forestry projects have constituted one of the largest sectors in the voluntary market, with about 18 percent of the volume of all transactions (Figure 3.4) (Hamilton *et al*., 2008). Forestry project types are split between protective and productive reforestation, avoided deforestation, and improved forest management. This high share may decrease somewhat in the future as more projects in other technology sectors are developed.

There are currently clearly more forestry projects under development for the voluntary markets than under the CDM (Neeff and Ebeling, 2008). In the medium term, voluntary markets are also likely to continue to dominate the carbon forestry sector because of their much greater flexibility regarding project types, standards and crediting approaches. In addition, with the United States being increasingly likely to impose cap-and-trade schemes for GHG emissions on a federal level (several US States have already started to implement such schemes), forestry credits may meet significant demand in this market. US buyers have always been very favorable towards carbon forestry in general, and most pre-compliance buyers in the country are likely to flock to the voluntary markets (Ebeling and Fehse, 2008; Hamilton *et al*., 2008). It is expected that any future compliance regime in the US will include a prominent role for forestry credits.

An additional push for the carbon forestry sector in general has been arising from the vigorous debate around the inclusion of Reduced Emissions from Deforestation and Degradation (REDD) under a post-2012 or post-Kyoto climate regime. Some

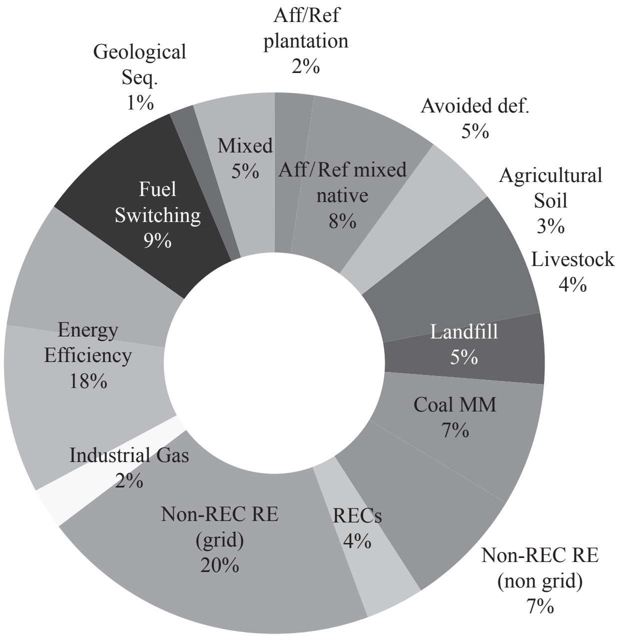

Fig. 3.4. Volume of credits sold by project type on international carbon markets (over- the-counter transactions). After Hamilton *et al.*, 2008.

clear indications that such a deal will be reached with a significant role for forestry in general since the announcement of the Bali Roadmap in 2007, have greatly increased the interest of project developers and investors in this activity (Ebeling and Yasue, 2008). Although the REDD discussion initially focused strictly on preventing deforestation, there are increasing signs that a future scheme may in fact move towards a sectoral forestry approach, including gains in forest cover and forest biomass, i.e., reforestation and the restoration of degraded forests (Ebeling *et al.*, 2008). Importantly, there are also signs that future regulatory markets may become more accessible for reforestation projects as such, not only in the US but also under a Kyoto successor agreement. The CDM as a whole is undergoing a review and reform process, and so is the European trading scheme, including current import barriers for forestry credits, which may be eased (Fehse, 2008b).

3.2.4 Relevance of carbon markets to the financing of forest restoration

Carbon markets are already transacting billions of Euros each year, and it is evident that they have the potential to bring unprecedented finance into emission reduction projects, including those in the realm of forest restoration. Although the share of carbon forestry in the current regulatory markets is very small, it can be expected to increase greatly in forthcoming international regimes, as well as in regional markets in the US and beyond (Neeff and Ebeling, 2008), and forestry already has a market share of one fifth of the rapidly expanding voluntary carbon markets (Hamilton *et al*., 2008).

In comparison, funding through Official Development Assistance (ODA) for forestry has been stagnating on a relatively low level for some time and there are few prospects for such funding to significantly increase. Although precise numbers are difficult to establish, current bi- and multilateral government funding for forestry seems to total about US$ 1.1 to 1.5 billion annually during the last decade (Tomaselli, 2006). This number includes investments into the forest industry, and direct expenditures for reforestation or even forest restoration are certainly much lower. Considering the long list of topics on the international environmental and development agenda that are competing for ever scarcer public funding, from poverty relief to fighting HIV-AIDS to providing education and basic sanitation, from combating desertification and biodiversity loss to mitigating and adapting to climate change, it is unlikely that international public funding for forest restoration will receive a major boost. Much hope, therefore, rests on private funding and market-driven initiatives to promote environmental causes (see Scherr *et al*., 2004). The land-use sector in developing countries includes some of the lowest-cost options for carbon emissions abatement on a very significant scale (Enkvist *et al*., 2007) (Figure 3.5). Against the backdrop of chronically insufficient international donor funding, carbon markets thus hold an immense potential to leverage funding for avoiding degradation and restoring of ecosystems on a global scale.

The Kyoto regime, as well as voluntary carbon markets, created a market value for a less than tangible product, carbon dioxide. The relative ease of measuring different GHGs and assigning a precise value of global warming potential in tons of CO_2-equivalent to them has been instrumental in the success of markets for emission reduction certificates. For no ecosystem service other than climate change mitigation has an easily convertible unit been defined to date, although numerous researchers and environmental organizations are attempting to achieve this. A number of local and national payment schemes exist for ecosystem services, such as the regulation of water quality (Jackson *et al*., 2005) and the provision of biodiversity (Pagiola *et al*., 2005; Bishop *et al*., 2008). However, most of these services are not tradable across or even within national borders at present. Even emerging markets for biodiversity offsets, which allow companies to compensate for development impacts in one area by protecting or restoring natural habitat elsewhere, for the most part rely on relative crude area measures without actually measuring their respective biodiversity value (Fehse, 2008a). Schemes such as the

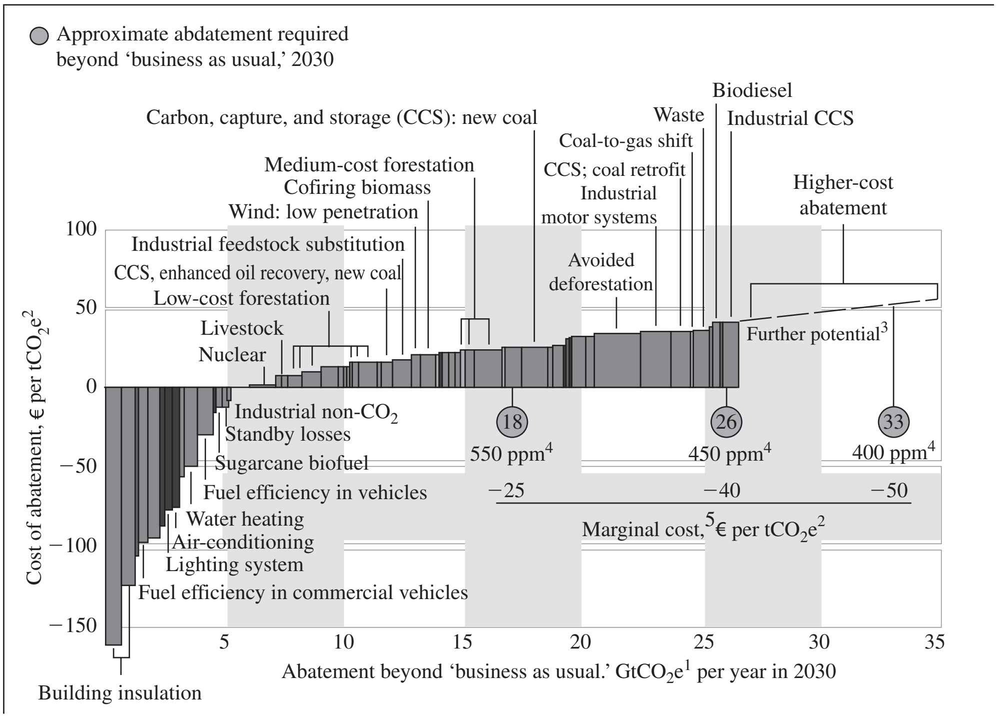

Fig. 3.5. Global cost curve for greenhouse gas abatement measures beyond 'business as usual'. Source: Enkvist *et al*., 2007.([1]$GtCO_2e$: gigaton of carbon dioxide equivalent; "business as usual" based on emissions growth driven mainly by increasing demand for energy and transport around the world and by tropical deforestation. [2]tCO_2e: ton of carbon dioxide equivalent. [3]Measures costing more than €40 a ton were not the focus of this study. [4]Atmospheric concentration of all greenhouse gases recalculated into CO_2 equivalents; ppm: parts per million. [5]Marginal cost of avoiding emissions of 1 ton of CO_2 equivalents in each abatement demand scenario).

US wetland mitigation program have been widely criticized by environmentalists for failing to accurately reflect the habitat value of wetlands that are affected by developments or restored through compensatory measurements (Robertson, 2004). Although far from mature, carbon markets for now remain a uniquely successful attempt at creating an internationally tradable commodity for an environmental service, and they are unrivalled in the scale of resources they leverage.

Apart from payments based on carbon sequestration achieved by growing trees, carbon markets can also be used to monetize other aspects of reforestation activities (Aukland *et al*., 2002). Wood is receiving increasing attention regarding its potential use as a renewable energy source. The international market for biofuels is expanding rapidly and the CDM and voluntary markets allow for forestry-based bio-energy projects that replace the use of fossil fuels. Such projects can rely on wood residues from timber harvesting and processing or they can directly use wood sustainably harvested from natural or planted forests (Moura Costa and Tippmann, 2003). This significant opportunity has so far received very limited attention from the forestry community and is worth exploring in parallel with more conventional carbon forestry as an additional income source for reforestation projects.

3.3 How do forestry projects work in carbon markets?

Tapping into carbon markets to finance environmental projects can provide resources on a scale far beyond what is available through public financing. However, using carbon finance also means that the requirements of carbon markets have to be met. This refers to eligibility criteria (market entry), as well as buyer preferences (demand). It also means that projects need to consider how to maximize those goods and services that are valued on these markets, i.e., CO_2. In this section, we first give an overview on the requirements that carbon forestry projects need to meet in order to be able to receive carbon finance. We then discuss the economics of the creation of revenue generation for forestry through carbon markets and how these relate to the implementation of projects.

3.3.1 Requirements of carbon forestry projects

Forestry has been a prominent but also one of the most controversial sectors in the design of climate change mitigation schemes and carbon markets. We outlined the main issues in Section 3.2.2, namely concerns around risks of market flooding, non-permanence, leakage, measurement and monitoring, social and environmental impacts, and additionality. All or most of the concerns have been addressed in the meantime, sometimes through painful concessions from the supporters of carbon forestry, and at the price of severely curtailing the potential of forestry to help mitigate climate change. These safeguards are discussed in the following paragraphs, but an overriding limitation of the Kyoto markets is that projects that conserve tropical forests or improve forest management practices cannot gain carbon credits. Instead, only the planting or assisted natural regeneration of forests qualifies under the rules of the CDM, severely reducing the potential that carbon finance could have in reducing the large amount of emissions created by land-use change.

The main requirement of any credible carbon offset projects of any sector is that it needs to be "additional." All carbon projects are in a sense designed to offset emissions that take place in countries with emission reduction targets, in the case of CDM, or emissions from companies or individuals adopting voluntary commitments, i.e., they lead to emission reductions in developing countries *in lieu* of achieving the same result at a higher cost in industrialized, Annex I countries. Each carbon credit issued for a carbon project thus translates into decreased mitigation obligations in developed countries, companies, or households. It is therefore crucial to ensure that offset projects are additional and would not have happened in the absence of carbon finance or other incentives provided through the CDM or voluntary carbon markets (such as visibility and marketing benefits, or political support). If a project were to receive carbon credits but would in fact have gone ahead even in the absence of carbon finance, the net result would be fewer emission reductions globally (Ebeling, 2008).

There are several ways to demonstrate additionality under the CDM framework, and the same approach is part of the voluntary carbon standards. The main approach is to demonstrate that some barrier exists that prevents the proposed project from taking place. For example, project developers can demonstrate that a project would not be sufficiently financially profitable for investors without the added carbon income. Institutional, cultural, technological, or investment barriers could also exist for the CDM or offset activity and plausibly prevent its implementation under a business-as-usual (BAU) scenario. For example, reforestation on a sizable scale may be a novel land-use practice in a region, there may not be any local expertise or desire to reforest, and banks may be unwilling to lend money to such ventures. All of these barriers could prevent the implementation of a reforestation project. Carbon finance helps overcome these barriers.

There are other requirements that are specific to carbon forestry alone. One of these is to address the risk of non-permanence, i.e., reversal of carbon benefits, for example through the felling or burning of trees. Different approaches have been proposed to deal with the issue of non-permanence in forestry projects (Fearnside *et al*., 2000; Moura Costa and Wilson, 2000). Under the rules of the CDM, for example, forestry projects can only receive temporary carbon credits. Forestry is thus the only project sector in which no permanent credits are issued, and this has proven to be a major bottleneck to creating significant market demand for CDM carbon forestry. Under the temporary crediting approach, the actual carbon stocks in reforested areas have to be reverified periodically, and if a project does not retain the formerly stored carbon, existing temporary CDM forestry credits have to be replaced with emission reduction or sequestration credits from elsewhere (Chomitz and Lecocq, 2003; Pedroni, 2005). Voluntary carbon markets have adopted a different approach and, under the most established standard, the Voluntary Carbon Standard (VCS), a buffer reserve of credits has to be retained. Buffer reserves have been used in some schemes since 1997 (Moura Costa *et al*., 1997), and under this approach credits from such a pool can be used to compensate for any potential future reversal of carbon benefits. This translates into a powerful financial incentive for project proponents to address non-permanence risks in order to keep the percentage of credits that need to be retained in a buffer reserve low (Ebeling *et al*., 2008; Voluntary Carbon Standard, 2008).

Another key requirement for forestry activities is accounting for leakage. As mentioned before, activity shifting, i.e., the simple displacement of agriculture or logging to another land area, may lead to deforestation in other areas. This would significantly reduce the carbon sequestration benefits from a carbon project. In the worst case, such emissions may completely offset the climatic benefits achieved through the afforestation or reforestation project. A second type of leakage, market leakage, occurs independently of the direct land-use actors, i.e., does not involve their physical displacement. Rather, changes in supply or demand of products affected by the project leads to increases in production elsewhere (Chomitz, 2002). If agricultural production in an area decreases because of reforestation activities, the diminished supply may lead to increased production elsewhere in order to meet market demand. The reduction in available agricultural land could therefore induce land-use conversion in other, still forested areas (Schwarze *et al*., 2002; Aukland *et al*., 2003).

In order for a reforestation project to qualify as a CDM activity, lands to be reforested must not have been forested in 1990. In the language of Kyoto, afforestation, as opposed to reforestation, refers to the establishment of plantations on lands that have not been forested for at least 50 years. The 1990 base-year requirement acts as an efficient safeguard against perverse incentives which might otherwise lead project developers to cut down natural forests before establishing carbon plantations. The corresponding requirement under the Voluntary Carbon Standard is a rolling ten-year threshold, meaning that areas must have been deforested (or not forested) for at least ten years before being reforested (UNFCCC, 2003; Voluntary Carbon Standard, 2008).

Finally, CDM forestry projects (and forward-looking voluntary offset projects) need to seek confirmation by the host government stating that they contribute to sustainable development as defined by that country. This requirement frequently includes a form of social and environmental impact assessment and project developers have to document that the proposed project will not lead to negative environmental impacts, such as ground-water depletion, soil degradation or biodiversity loss. For voluntary offset projects, buyers usually prefer documentation that lays out how a project improves environmental and social conditions apart from climatic benefits. The need to demonstrate how their purchase of offsets will enable such benefits may in fact be the chief motivation of buyers to choose a well-designed forestry project with clear co-benefits (Ebeling and Fehse, 2008).

3.3.2 Economics of carbon forestry plantations

When trees grow, they convert atmospheric carbon into biomass which may be stored for decades or centuries. This is referred to as carbon sequestration and it is one of the services valued in carbon markets. In order to maximize income through emissions trading, project developers face an incentive to maximize the rate of carbon sequestration and eventual volume of carbon in their plantations. The growth rate and biomass of mature trees are therefore important factors in the choice of species for carbon reforestation projects. The net carbon benefits of a carbon project, for which credits can be issued, can be calculated as follows:

$$ER_{net} = (ER_{project} - ER_{baseline} - EO_{project}) \bullet (1 - L) \bullet (1 - BD)$$

where:

ER_{net}	=	net emission reductions
$ER_{project}$	=	project emission reductions
$ER_{baseline}$	=	baseline emission reductions
$EO_{project}$	=	other project emissions (e.g., fuel use)
L	=	leakage (as a fraction of 1)
BD	=	buffer discount (as a fraction of 1) (some standards only)

The project's sequestration benefits through the growth of planted or regenerating trees ($ER_{project}$) has to be adjusted by what would reasonably be expected to occur on the land in the absence of the project, *i.e.*, the baseline or business-as-usual scenario ($ER_{baseline}$) (IPCC, 2003; Pearson *et al.*, 2006). For example, abandoned agricultural lands may regenerate even without any assistance through a carbon project. In addition, it needs to be considered whether the project itself generates emissions such as through the removal of pre-project vegetation ($EO_{project}$). For example, preparing the ground for planting may involve burning or cutting down of existing shrubs or grasslands that would otherwise impede the growth of tree saplings. Similarly, fuel use by machinery or project staff may generate measurable emissions.

Any emissions created through carbon leakage (L), the displacement of activities from the project area, will have to be subtracted. These three latter aspects help explain why it may be easier, and potentially more lucrative, to carry out CDM forestry projects in areas that are in a degraded or degrading state and that are not currently used for agriculture, grazing or collection of wood for fuel.

In order to account for the risk of non-permanence, i.e., the reversal of sequestration benefits through subsequent degradation or destruction of reforested areas, some high-quality carbon standards require the retention of a portion of credits in a buffer reserve (BD) (see Section 3.3.1). The percentage of credits retained in this pool will depend on the apparent risk of non-permanence and these may later be reclaimed if stable carbon stocks can be demonstrated. In contrast, the CDM issues temporary credits for forestry projects which need to be replaced periodically, and there is no buffer discount.

For an indication of the potential carbon revenue reforestation projects can achieve, it is useful to consider the sequestration rates of regenerating forests. Depending on hydrological conditions naturally regenerating tropical and sub-tropical forests typically increase their above-ground dry biomass by approximately 1 to 13 tonnes per year. Assisted regeneration, e.g., through active replanting and removal of weeds, can further increase this unassisted natural sequestration rate, especially in initial years, and so can the choice of faster growing species. The corresponding values for tropical and sub-tropical planted broadleaf forests and assisted natural regeneration are 5 to 18 tonnes per year (IPCC, 2003). Below-ground biomass in roots may add another 27 to 42 percent. Assuming a carbon content of 50 percent in dry biomass (IPCC, 2003), this corresponds to roughly 0.64 to 12.8 tonnes of carbon sequestered per year in above-ground biomass, i.e., 2.6 to 46.9 tonnes of CO_2, obviously a wide range. Assuming a forestry project achieves an annual growth rate of 13 tonnes of CO_2 and valuing this at US$ 2–5 per tonne, carbon finance could then generate US$ 26 to 65 per hectares per year, or US$ 260,000 to 650,000 for a 1000-hectares project over a ten-year period. Any emissions created through leakage, baseline sequestration benefits, etc. still need to be deducted in order to obtain the net carbon credit potential. In most cases, carbon finance is likely to cover only a small part of the costs of a good quality forest restoration project, at least at today's relatively low carbon prices. However, it can provide a significant additional income and can enable projects that would otherwise not have been feasible.

A full account of a project's gross sequestration potential would consider the different species used in reforestation and each species' typical above- and below-ground biomass, determined by wood density (determining the relative carbon content in the biomass), the biomass extension factor (indicating the ratio of biomass stored in branches as opposed to the trunk of a tree), and the root:shoot ratio (pointing to the biomass and carbon contained in roots as opposed to the visible parts of the tree). All of these are of course influenced by local climatic, soil, and other growth conditions, as well as management practices. The CDM regulations furthermore stipulate that project developers take into account other carbon sink components which may be affected by the reforestation activities. Besides the biomass components of a standing tree elaborated above, these sinks are deadwood, litter, and soil carbon.

3.4 Opportunities for ecological restoration through forest carbon markets

This section explores how the financial opportunities presented by carbon markets, as well as the particular economics of forest carbon projects, may be harnessed to provide synergies with ecological restoration objectives. This includes an overview of the potential overlap of ecological restoration needs and carbon forestry and also a discussion of settings in which synergies between the aims of ecological restoration and carbon sequestration are particularly evident. Furthermore, this section lays out how the requirements of carbon forestry projects can actually be utilized towards designing robust restoration projects. To illustrate potential synergies, we give examples from existing CDM forestry projects that try to promote ecological restoration. Ecological restoration can be described as an “intentional activity that initiates or accelerates the recovery of an ecosystem to a self-sustaining state with respect to structure, species composition and function, as well as being integrated into the larger landscape” (Clewell *et al*., 2005). The restoration of formerly forested lands is becoming an increasingly pressing need considering that an estimated 350 million hectares of forests have been lost between 1950 and 2000 and an additional 500 million hectares of forests have been degraded in the same timeframe, both particularly in developing countries (ITTO, 2002). In this context, it is not difficult to see that reforestation, carried out with the help of carbon finance, has the potential to contribute significantly to the aims of global ecological restoration. Most areas of deforestation and severe land degradation (Plate 3.1) can be found in countries that are signatories to the Kyoto Protocol (Figure 3.1), and most carbon offset projects similarly take place in developing countries, simply because these do not have any international emission reduction targets. The potential contribution of carbon finance to global ecological restoration aims is even clearer when considering the very limited public funding and implementation capacity for forest restoration in the developing world.

Carbon finance could support ecological restoration needs mainly in two ways. Firstly, additional funding could enable the restoration of larger areas than might otherwise be possible. Secondly, the added income from carbon finance could make it more feasible to use a wider mix of native species in restorative planting, which can be very expensive. Both aspects, large areas and mixed native species, are attractive also from a carbon market point of view. In the former case, this is because larger areas make it easier to cover non-area dependent, fixed transaction costs. In the latter case, mixed species reforestation projects can be much more attractive to voluntary market buyers of offsets because of their higher biodiversity value and marketing appeal.

Large areas of formerly forested lands remain unused and unproductive in the tropics and do not recover due to a range of factors, including soil degradation, depletion of nutrients, recurring fires, and large distance from intact forest which could otherwise act as seedbanks. A report by the World Bank suggests that with ongoing trends entire ecosystems and countless species in the tropics may be lost, together with the occurrence of widespread changes in water flows, the proliferation of pests, and a decrease in important pollinators (Chomitz *et al*., 2007). Carbon reforestation projects, either through active planting or through assisted natural regeneration, can support the recovery of a forest ecosystem and generate ecosystem services beyond the sequestration of carbon. Realizing such co-benefits of carbon offset projects is also a near-term opportunity to bring finance towards restoration projects which so far cannot count on any meaningful international markets for biodiversity or water-related services (Ebeling and Fehse, 2008).

Although most existing CDM and voluntary carbon forestry projects have been developed primarily with a view to generating carbon revenues, many do contain design elements to deliver further, non-carbon ecosystem services (co-benefits). Indeed, some of the first carbon forestry projects worldwide aimed at providing a wide range of ecological benefits. No up-to-date review of these multiple benefit projects exists, and the last comprehensive assessment was carried by Landell-Mills and Porras (2002) who, even at this very early stage of carbon markets, identified twenty-eight projects with "bundled" approaches. Such projects combine multiple ecosystem services either into one product or market these services separately. Fehse (2008a) shows that there is great scope for project developers to optimize such synergies in carbon forestry, particularly regarding the restoration of the vegetation cover on degraded and degrading sites that have lost their water and soil retention capacity.

CDM forestry projects need to demonstrate that they achieve a net climatic benefit compared to a baseline situation in which the project activities would not have been implemented. If there are uncertainties about the baseline scenario (e.g., how much carbon would be sequestered in naturally occurring, non-assisted recovery of vegetation), the most conservative outcome, resulting in the lowest carbon benefits, is usually assumed. Indeed, the first methodologies and projects to pass the forestry CDM approval process were based on reforestation of degraded and further degrading soils. This is not due to the co-benefits of these projects but rather to the simplicity of their baseline scenario in which it can be easily demonstrated that there would be no positive changes in the carbon balance if the projects did not take place (Fehse, 2008a). Nevertheless, these projects make a clear contribution to preventing and reversing land degradation.

The apparent contradiction between the need for restoration of natural ecosystems with naturally occurring mixes of species on the one hand and the incentive to use fast-growing species for carbon sequestration on the other hand can be turned into an advantage by drawing on experiences gathered by restoration ecologists.

There is an innovative approaches in which certain types of fast-growing, non-invasive species are used to create the required initial conditions for colonization by (other) native species in a way that does not compromise the aims of ecological restoration (Feyera *et al*., 2002; Lamb *et al*., 2005). For example, in South Africa, ecological restoration projects are using exotic, fast-growing tree species to either act as nurse trees, adding nutrients to the soil, or to provide shade and thereby facilitate natural succession on degraded land. These exotic species are ultimately shaded out by the formation of a secondary native forest or they are actively removed (Geldenhuys, 2004). In this way, fast-growing species sequester carbon before being replaced by non-pioneer, slower-growing species. Removal of the exotic species does not affect the sequestered carbon stocks because they are replaced by secondary vegetation. Obviously, the success of this approach depends on the ability of native species to reach the site during natural succession and on the careful selection of non-invasive species for nurse trees. The replication of this approach in other carbon project will thus depend on the availability of particular ecological expertise and adaptive management practices.

Interestingly, although the requirements for projects regarding eligibility as carbon projects as well as the calculatation of their carbon credit stream may seem very restrictive (see previous section), they can actually be turned into an advantage in the context of ecological restoration. This relates in particular to requirements regarding the accounting for leakage and non-permanence risks. These and other stipulations can greatly enhance risk management and the net ecological benefits of restoration projects.

For example, leakage is not simply a technical requirement with relevance only to carbon crediting. Instead, leakage refers to the general and very real risk that protecting or restoring a piece of land can increase degradation pressures on other areas. Certainly, restoring particularly vulnerable or ecologically valuable land may well be justified even if this takes agricultural land out of production; however, ecologists need to address the fact that reducing land available for agriculture will facilitate degradation and land-use changes elsewhere, unless targeted counter-measures are put in place. In this way, the net benefits of many successful on-site restoration activities may be diminished through harmful off-site effects. In contrast, leakage mitigation measures that are carried out primarily because of the requirements of a carbon forestry project can enhance overall ecological restoration benefits at a landscape level. Proactive measures to reduce leakage include agricultural intensification in neighbouring areas, and the creation of other income-generating activities for rural communities (Schwarze *et al*., 2002), reducing land-use pressures not only in the project area.

Similarly, the need to assess and improve the risk profile of carbon forestry projects regarding non-permanence risks can be an advantage for ecological restoration projects. Determining non-permanence risks is a systematic way of identifying threats to the long-term success and resilience of forest restoration endeavours. Once risks have been identified, systematic response strategies, i.e., risk mitigation measures, can be developed and incorporated into the project design (Ebeling, 2008). This can entail direct financial advantages from a carbon crediting perspective (e.g., because of lower discounts if a risk buffer approach is applied), and it can also help to identify and address risks from an ecological restoration point of view early on.

Synergies between ecological and carbon-market oriented restoration aims can also arise regarding the integration of local livelihood benefits. The first CDM forestry projects have been implemented on degraded lands (Fehse, 2008a), partly because degraded agricultural lands and pastures are not very productive, posing a low potential for leakage. As more and more carbon forestry projects are implemented on lands which are at least partially in use, there is an increased risk of leakage, requiring that leakage mitigation measures become an integral part of the project design. In some cases, such measures can directly enhance local livelihoods. For example, existing cattle grazing in an area that is proposed to be reforested by an offset project could generate a substantial leakage risk because local people may be forced to encroach on neighbouring woodlands. Instead, including tree species that produce suitable fodder for animals, devising silvo-pastoral schemes that allow for continued grazing, reserving a portion of the project area for the production of food and fodder crops, or providing alternative employment and income sources are measures that can diversify livelihood options and prevent leakage.

Ecological restoration practice is also increasingly looking at supporting sustainable livelihoods and is thereby extending its focus beyond purely conservation goals. So far, ecological restoration projects have unfortunately had limited success in compensating for local opportunity costs in the form of land being lost for agricultural production or grazing (Lamb *et al.*, 2005). Integrating approaches devised for carbon forestry projects may help improve this situation.

Although there certainly are a number of challenges in linking the restoration and climate agendas through carbon forestry (discussed in the following section) the potential co-benefits for biodiversity and human development make to the exploration of synergies in the design of projects worthwhile. Instead of merely trying to prevent negative social and environmental impacts, carbon forestry projects can be designed to focus on the enormous potential positive outcomes of restoration (see Table 4.1 in this book). For deliveries of these potential benefits, it is essential that carbon forestry takes into account multiple stakeholders' perspectives. For example, local communities may have an interest in restoration programs using certain types of trees to provide building materials, fruits, firewood, or animal fodder. Ensuring the support and engagement of local land-users is also critical to securing the long-term sustainability and ecological goals of restoration and similarly their carbon benefits.

Finally, it remains important to recognize that carbon finance alone cannot provide all the funding for the multiple benefits of restoration projects. Establishing plantations is generally so costly that in most cases only a small portion of this can be financed through carbon crediting. This is even more so for high-quality restorative tree planting or assisted regeneration. Targeted non-carbon related financial support for the biodiversity and development benefits of reforestation projects can enhance these co-benefits. This could involve direct donor-driven and charitable funding, as well as tapping into markets for other, non-carbon based, ecosystem services that are emerging (Ebeling and Yasue, 2008). There is some indication that forestry projects in voluntary carbon markets that provide clear co-benefits achieve higher prices or meet larger demand (Hamilton *et al*., 2008). Standards such as the Climate, Community and Biodiversity (CCB) standards aim at providing reliable assurance that projects are designed to deliver measurable net positive benefits to local communities and biodiversity, in addition to credible greenhouse gas reductions (Ebeling and Fehse, 2008).

3.5 Restoration through carbon forestry in practice

Carbon forestry can directly contribute to restoration aims by preventing and reversing degradation of arid and semi-arid lands. An initiative that seeks to secure additional rewards for such projects is the Global Mechanism-EcoSecurities Partnership (Global Mechanism, 2007). The Global Mechanism is a subsidiary body to the UNCCD and is charged with mobilizing finance for implementing that convention. EcoSecurities is a private-sector carbon project developer and environmental finance consultancy. The partnership strives to adopt a synergistic project approach to support the aims of the climate change and desertification conventions (UNFCCC and UNCCD).

One concrete example of the work of the Global Mechanism-EcoSecurities partnership is the Julcuy project in the province of Manabí in coastal Ecuador, as described by Fehse (2008a). This arid region has been suffering for decades from deforestation of the native dry forest and subsequent degradation from overgrazing by goats. This has led to significant soil erosion and contributed to water scarcities in the region. The project seeks to restore around 5000 hectares of the original forest vegetation. In a first step, a mix of seven native tree species will be planted; they were selected to also provide non-timber products to local communities, including fodder for the goats, e.g., the algarrobo (*Prosopis juliflora*) and the palo santo (*Bursera graveolens*). It is envisioned that in the long term the reforested areas will provide the local communities with a sustainable source of timber and fuel wood. The project area also fulfils connects two important coastal nature reserves in the larger Chocó-Manabí Conservation Corridor and will benefit both of them.

Furthermore, the project area is of importance for the hydrological supplies of a number of urban centres, which have seen steep population growth in the last three decades. The initially established mix of tree species will create the structural and microclimatic conditions to allow a broader suite of native plant species to colonize through dispersal from nearby forests. In a partnership with Conservation International, EcoSecurities will seek to quantify and market the project's biodiversity benefits and market hydrological benefits to the municipal water companies of nearby cities.

Further examples are carbon projects that rehabilitate degraded mining sites. Legal obligations for companies to rehabilitate decommissioned sites are rarely enforced in most developing countries. Sites therefore often continue to degrade after mining operations have ceased, leading to erosion and related problems of sedimentation or aeolian dust. Any rehabilitation efforts that are made usually only establish a grass cover, even in areas that would naturally be forested. However, although not rehabilitating clearly saves costs in the short term, it can severely damage a company's image, and this is becoming an increasingly important factor for business decisions, especially for international organizations. The additional income obtained through a carbon forestry project can tip the balance in corporate decision-making by turning an environmental cost into an asset. Likewise, without the underlying rehabilitation aims, a carbon project might not take place because carbon credits alone could not provide sufficient financial incentives for restoration.

3.6 Challenges for integrating carbon forestry and ecological restoration

There are, of course a number of challenges to obtaining the benefits of the synergies between carbon forestry and ecological restoration described in the previous section. Many of the potential challenges arise from the very economics of carbon forestry, outlined above. On the other hand, some apparent challenges are simply the result of exaggerated expectations vis-à-vis the carbon markets. We discuss here issues arising from the incentive to maximize carbon sequestration over other ecosystem services, restrictive regulations of the Kyoto framework, weak sustainable development requirements of regulatory carbon markets, ecological constraints, disincentives for fire management and invasive species control, and high transaction costs.

Reforestation projects are probably the carbon project category with the slowest returns on investment in terms of carbon credits produced. This is because trees sequester carbon and thereby reduce emissions relatively slowly compared to the emission reductions achieved more quickly in energy-related or industrial gas project types. Forestry project developers, therefore, often face significant problems in bridging the gap between the necessary upfront investments, ongoing management costs and eventual generation of credits. This explains the popularity of fast-growing, often exotic, species such as *Pinus* and *Eucalyptus* in commercially oriented carbon forestry projects. Their high growth rate allows for carbon credits to be obtained relatively early after plantation establishment. In addition, timber can be produced from such plantations, in itself an attractive revenue source. However, the introduction of exotic species, in many cases, may clearly not meet the requirements of ecological restoration or may not appeal to carbon buyers concerned with the ecological impact of their investments.

Early carbon forestry activities, usually promoted by not-for profit NGOs and development organizations, tended to put greater emphasis on providing multiple environmental and socioeconomic benefits as opposed to maximum carbon sequestration rates. Now, after the successful implementation of many of these initial projects, commercial project proponents have started to become increasingly interested in carbon forestry. What this means will partly depend on the kind of carbon markets these projects target. In regulatory markets, carbon benefits may be the main or sole consideration, whereas in voluntary markets, there may be significant financial advantages to the promotion of ecological co-benefits (Ebeling and Fehse, 2008).

It will remain important to find ways to ensure that the economics of such projects work. Therefore, private project developers in a market-driven environment have to consider carefully both the direct costs of pursuing non-carbon benefits and any potential indirect costs due to reduced carbon sequestration rates, e.g., through planting a mix of slower growing species.

CDM regulations demand that there are no negative environmental and social impacts of afforestation and reforestation activities. The assessment of such impacts is based on the interpretation of the CDM's sustainable development requirement by the respective host countries where such projects are implemented. National regulations may in fact contain concrete stipulations for ecological improvements and many do demand comprehensive environmental impact assessments for proposed projects. Nevertheless, unintended negative impacts can occur in reforestation projects even if such assessments have been carried out. For example, there is a long history of reforestation programs using exotic tree species with negative impacts on the local ecology (Richardson, 1998), although not necessarily in the context of carbon forestry; some of the traits that make these tree species highly suitable for productive forestry (i.e., speed of growth) can also make them potentially invasive. Frequently, negative hydrological impacts of forest plantations are also quoted by organizations opposing carbon forestry.

It is clear that some afforestation and reforestation programs have had undesirable consequences for soil erosion, groundwater levels, biodiversity and local livelihoods (Cossalter and Pye-Smith, 2004). However, it is also important not to associate the shortcomings of poorly designed forest plantations as such with the potential outputs of carbon offset projects. The latter usually involve a careful planning phase and regular environmental monitoring (Ebeling,). It remains true, however, that the economic incentive to maximize sequestration rates presents certain risks. Ecologically desirable reforestation is more costly to manage and may have a lower carbon credit potential.

In general, forest restoration can be conducted in any of the following three main contexts (Clewell *et al*., 2005):

(a) Recovery of a degraded system
(b) Replacement of a forest system that was entirely destroyed with the same system
(c) Transformation or substitution, i.e., conversion of an ecosystem to a different kind of ecosystem.

The current rules of CDM forestry projects, however, contain severe shortcomings in relation to their potential application to ecological restoration. For example, the restoration of degraded remaining forest (option a) is not allowed under CDM rules since they demand that the area to be planted has been depleted completely of forests since 1990. In this way, Kyoto regulations preclude the possibility of financing the recovery of the more than 500 million hectares of degraded primary and secondary forests that exist worldwide. Restoration of these areas, which may still hold significant biodiversity, provide hydrological services, and support local livelihoods, could be highly beneficial for achieving multiple conservation and sustainable development goals, as well as greatly contributing to mitigating climate change (Ebeling, 2008). Furthermore, restoration of degraded forest is generally more cost efficient and may have a higher success rate than the reforestation of bare lands. This is because degraded forests may still be ecologically functioning i.e., these sites may have sufficient topsoil, nurse trees, and pollinators for successful regeneration and succession. Restoration practitioners can only hope (and lobby) for a reform of pertinent carbon crediting rules in forthcoming post-Kyoto climate regimes. Fortunately, the rapidly growing voluntary carbon markets are much more flexible and do not have such restrictions in place. The restoration of degraded forests as well as sustainable forest management are both eligible under these voluntary schemes. Similarly, preventative actions can be credited, e.g. reducing degrading activities such as extensive logging or collection of fuel wood, or assisting natural regeneration through reducing recurrent disturbances caused by man-made fires, all of which are not eligible for participation under the CDM.

A further Kyoto stipulation is that no CDM forestry project can be implemented on areas deforested after 1990, also severely limiting potential ecological reforestation activities (option b). The 1990 requirement acts as an efficient safeguard against perverse incentives which might otherwise encourage the cutting down of natural forests in order to establish carbon plantations (see Section 3.3.1). However, this restrictive regulation excludes a vast number of potentially beneficial reforestation projects on deforested, degrading lands. This applies to roughly 180 million hectares of land that were deforested from 1990 to 2005 (FAO, 2006). Again, voluntary markets provide a useful alternative here because they have much more flexible eligibility requirements. For example, the Voluntary Carbon Standard uses a rolling 10-year threshold (see above), although even this can still be very restrictive.

Apart from the reforestation of lands deforested before 1990, CDM afforestation projects can also occur in areas that have not been forested at any point in time, or at least not for the last fifty years. This could include sites that once supported functioning non-forested ecosystems, such as grasslands and savannahs, although they may have become unproductive and degraded. Afforestation in these areas could involve substituting one previously existing ecosystem with a very different one (option c). Substitutions, used for a transitional period, can sometimes be useful for restoration aims. For example, certain exotic plant species can be extremely efficiently employed for bioremediation, removing toxic chemicals from soils on mining sites, which then allows the natural systems to recover (Cooke and Johnson, 2002). However, permanent replacement of vegetation cover can be questionable from an ecological restoration point of view, especially if this occurs over large expanses of land, and in systems which could have potentially recovered to their natural ecological state. In these cases, afforestation could interfere with natural succession, especially if non-native species are used that may then dominate the system and change both its physical and biological attributes (Versfeld and van Wilgen, 1986; Richardson, 1998).

In the previous section, we discussed how CDM and voluntary carbon forestry projects can be carried out in regions heavily affected by degradation and desertification (Plate 3.1), including those in arid and semi-arid climatic zones. In practice, however, carbon finance may be easier to obtain in certain environments than in others. Forests planted in the tropics, particularly in humid zones, achieve much higher growth rates and absolute carbon densities, resulting in higher revenues from carbon sales. For example, according to FAO estimates, the average carbon density of forests in Sudan is approximately 6 tons of carbon per hectares, whereas the average value for Malaysia is 102 tons (equalling 374 tons of CO_2) and can be three times this value even in lowland *Dipterocarp* forests (FAO, 2006). Most arid regions may therefore struggle to attract carbon finance because they cannot support high forest biomass levels or growth rates. However, these regions are among the areas most affected by soil degradation and desertification. Managers of restoration projects in these regions may therefore have to rely to a greater extent on additional, non-carbon market-based finance or entirely on public and philanthropic funding.

Another issue that does fit easily into the current carbon forestry framework is fire management. Some tropical dry forest systems require a regime of occasional fires for maintaining natural processes for the regeneration of certain species. This, however, leads to temporary reductions in the level of carbon stored in a sequestration project and also to lower average carbon densities in the long term. A similar example relates to the impact of controlling invasive plant species, often an integral component of restoration programs and considered by some to be one of the "big five" environmental issues of our times (Sala *et al*., 2000). Removing biomass, while ecologically necessary, would negatively impact the carbon balance of a project at least in the short term.

On a very practical level, transaction costs for designing CDM forestry projects, passing external validation and verification, and obtaining final approval from the CDM Executive Board can be quite high. Similarly, applying high-quality voluntary standards currently under development is likely to entail transaction costs comparable to those of the CDM. Considering that such transaction costs can easily surpass US$ 100,000 per project and do not vary significantly with project size, larger reforestation projects have a definite economic advantage over smaller ones. It may be difficult for many smaller projects to generate carbon revenues that are significantly higher than the transaction costs involved. Given that ecological restoration activities are often carried out in relatively small and patchy areas, they may incur disproportionately high transaction costs, possibly hampering their viability as carbon projects. Some adjustments in documentation required have been made under the CDM in order to lower transaction costs to encourage small-scale projects, defined as having a maximum sequestration potential of 40,000 tons CO_2 per year,. However, costs for validation and verification are still expected often to be high. Although the CDM allows the bundling of small projects (the implementation of reforestation on multiple sites under one project), this increases the administrative complexity and may make it difficult to apply consistent baseline and leakage scenarios because the ecological and socioeconomic land-use context on a very local level may vary. Efforts are ongoing to find ways to lower carbon market transaction costs for smaller projects, for example through "programs of activities." These would allow for the addition of further project components to an existing, approved carbon project with a much less costly statistical sampling approach conducted for verifying compliance. Transaction costs should also decrease as local expertise becomes available in developing countries, reducing the need for often expensive international consultants. Moreover, regulatory reforms could rid instruments like the CDM of cumbersome requirements that do not contribute significantly to ensuring climate benefits or broader environmental integrity.

Finally, one should not forget that carbon finance is still a very young and comparatively immature instrument with uncertain and evolving prospects.

Although recent market growth rates have been impressive, with both regulatory and voluntary market segments almost doubling in size every year for several years, the overall size of these markets is closely correlated to emission reduction targets adopted by countries and companies. Furthermore, changes to regulations may impact the ability to use international offset projects for compliance or generate credits from certain project types. It would in any case be naïve to expect carbon markets to solve all financing challenges that have plagued conservation and restoration ecology for the last decades.

3.7 Conclusions and outlook

Deforestation, desertification, and other forms of land degradation are among the major environmental challenges the planet faces today. Climate change is directly linked to these in several ways because it contributes and exacerbates ongoing degradation and because it is itself fuelled by emissions from land-use change. There are thus many ways, in principle, to integrate the mitigation of both climate change and land degradation. International carbon markets linked to international climate mitigation efforts have evolved extremely rapidly and now transact many billions of dollars a year. It needs to be kept in mind that carbon markets have only reached a meaningful scale in the last few years and are still very much developing. It would be too much to expect such a new instrument to effectively address several complex global problems at the same time and without contradictions. Nevertheless, their pure financial volume but also the great flexibility they offer through their project-based mechanisms (CDM and voluntary offset projects) offer great potential for combining different environmental agendas. The land-use sector in developing countries includes some of the lowest-cost options for carbon emissions abatement at a very significant scale (Enkvist *et al.*, 2007) (Figure 3.5). Against the backdrop of chronically insufficient and stagnating international donor funding, carbon markets thus hold an immense potential for leveraging funding both for avoiding degradation and for restoration of ecosystems on a global scale.

While carbon credits alone may not be sufficient to cover the costs of forest restoration projects at today's market prices, they can provide a crucial additional income for restoration projects. Using carbon finance effectively can allow restoration activities to be implemented on a larger scale. Although carbon forestry projects value primarily only one ecosystem service, the sequestration of carbon, this does not have to translate into a conflict of goals with restoration aims. Well-designed projects can avoid many of the risks identified in our discussion and focus on integrating non-carbon oriented elements. In many cases, multiple income sources will have to be tapped and there are increasing opportunities to evaluate the multiple benefits of forests. For example, alongside the UNFCCC, various innovative financing mechanisms for other ecosystem services are being explored under the Convention on Biological Diversity (CBD) and the United Nations Convention to Combat Desertification and Land Degradation (UNCCD) (Ebeling and Fehse, 2008). Furthermore, the international community is also exploring potential funding mechanisms for the adaptation of natural ecosystems to expected climate change. Such adaptation funding, together with carbon finance directed at climate change mitigation, may be used to establish the necessary conditions for ecosystems to adapt and for restoring vulnerable systems in a way that makes them more resilient to forthcoming climatic changes and land-use pressures.

Apart from such non-carbon based finance sources, carbon markets themselves are increasingly distinguishing between different types of credits and projects. In particular, projects with clear development and biodiversity co-benefits can often command a price premium, especially on voluntary carbon markets (Ebeling and Fehse, 2008; Hamilton *et al*., 2008). Whether such "gourmet carbon" will be restricted to niche markets remains to be seen, but forestry projects with an ecologically sound restoration approach are in many ways ideally positioned to monetize on their non-carbon co-benefits and will always have a potential advantage over projects based on single objectives (e.g., energy related projects purely focused on emissions abatement).

It is obvious that carbon sequestration reforestation does not share the multiple goals of ecological restoration and that there are some goals and elements of restoration which carbon forestry will not be able to fulfil optimally. At the same time, a sober analysis should compare the risks and benefits of carbon forestry with a realistic baseline scenario – i.e., what would have happened in the absence of an offset project – instead of an ideal one (Ebeling, 2008). For example, reforestation on degraded lands with non-invasive exotics or a small number of native species is certainly less desirable from a restoration perspective than using a mix of several dozen native tree species. In many cases, however, the realistic alternative is no restoration at all, a much less beneficial outcome by any measure.

Ecologists and restoration practitioners can play an important catalyzing role in realizing synergies through carbon forestry. CDM projects do need to credibly prevent negative environmental and social impacts but they do not as such gain in monetary terms from a focus on valuing and enhancing co-benefits. The emphasis on climate change mitigation may well be appropriate considering that the CDM and voluntary carbon projects are primarily instruments to offset greenhouse gas emissions. However, settling for this outcome could mean that significant opportunities are missed. To fully realize the potential of carbon forestry to contribute to global restoration aims, restoration ecologists need to become more involved in carbon forestry and offer and apply their in-depth knowledge and experience. In many cases it is difficult for carbon project developers to design carbon projects to fit ideally into the local ecological context. They might, however, place great value on such co-benefits in order to ensure good local stakeholder relationships, to sell a good project story to potential carbon buyers, out of a genuine personal conviction, or to design resilient and robust projects from a carbon sequestration perspective. In order to fully realize synergies and avoid conflicts, the goals and design aspects of carbon forestry projects need to be set and mediated by local land-users as well as carbon project developers, restoration ecologists, and funding organizations or carbon buyers.

Carbon markets are still in the process of becoming a more mature and more effective environmental finance instrument. They exist mainly as a result of political agreements, and some uncertainty therefore arises from the limited commitment time-frame of the Kyoto Protocol, which ends in 2012, and its less than global coverage. However, it is virtually certain that climate change will rise in importance as an issue of international concern and that carbon markets will exist beyond 2012. In addition, it is very likely that the land-use and forestry sector will gain much greater prominence in forthcoming climate regimes. Importantly, reforestation could move away from having a single project focus under suggested sectoral mitigation approaches (Boyd *et al*., 2007). Under such a sectoral approach, any increase in forest cover or carbon stocks in a country could become eligible for receiving carbon credits. The earliest opportunity for realising this may be through the inclusion of "avoided deforestation," or "reduced emissions from deforestation and degradation" (REDD) into a post-Kyoto regime (Ebeling and Yasue, 2008). Although REDD started out as a discussion focused on reducing deforestation, some countries favor the inclusion of carbon benefits through carbon sequestration in a prospective scheme and a recent UNFCCC decision does include this possibility (Ebeling *et al*., 2008). At the same time, various regulatory carbon markets are taking shape in North America and beyond, and these include forestry much more prominently than the current Kyoto framework.

Forestry, including forest conservation and restoration, is thus firmly anchored in the evolving international climate change agenda. Carbon markets are set to expand alongside growing international efforts to reduce greenhouse gases, and they are bound to focus on the vast mitigation options in the land-use and forestry sector. The main challenge and opportunity for global ecological restoration will thus be to create an effective link with these markets in order to allow for a potentially unprecedented flow of finance into restoration efforts in developing and developed countries.

It is important for conservationists and restoration ecologists to be well aware of the existing challenges of using carbon finance for restoration aims. There are many exaggerated hopes attached to carbon markets, which are partly the result of an imperfect understanding of existing market mechanisms and the surrounding regulatory framework. However, significant opportunities exist to derive multiple restoration benefits from carbon forestry. Ecological restoration is a global challenge and it needs solutions financed on a global scale and implemented locally. Tapping into the largest existing environmental markets can be an important part of this.

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