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Raising 'Kyoto Forests' in the Different Bio-geographic Zones of India - A Profitability Analysis

by

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Introduction

The Kyoto Protocol requires the industrialized countries to reduce their combined greenhouse gas emissions by at least 5.2 % compared to 1990 levels by the period 2008-2012. A number of flexibility mechanisms, including the clean development mechanism (CDM), have been incorporated in the Protocol in order to facilitate compliance. The twin objectives of CDM are to assist industrialized countries achieve compliance with their emission limitation and reduction commitments and help the non-industrialized countries move towards achieving sustainable development (Kant, 2004).

A normal afforestation project aimed at production of biomass involves the provision of land and planting of seedlings followed by their maintenance but a CDM carbon sequestration project must also fulfill the Protocol requirements of additionality, leakage accounting, sustainability, biodiversity conservation and a monitoring and verification system based on consistent, transparent and accurate methodologies leading to a credible certification of the carbon. These requirements can only be fulfilled at considerable costs enhancing the cost of production of carbon credits far above that of biomass.

This paper examines the underlying issues in details, reviews literature for the current and expected prices of carbon, makes an assessment of real costs and presents an analysis of the profitability of CDM afforestation projects in the different bio-geographic zones in India.

The carbon market

Carbon credit trading is a market-based mechanism for efficiently allocating emission reductions and sink enhancements among different sources and sinks with different marginal costs. It ensures that the actual emission reduction or sink enhancement is undertaken by sources/sinks that have the lowest-cost opportunities to reduce emissions or enhance removals by sinks. This mechanism thus reduces the total cost of the meeting the objectives of the Kyoto Protocol.

Prior to the adoption of Kyoto Protocol in December 1997 a number of forestry sequestration projects were initiated and, while the level of investment remained low at US$4.5 million per year, the price paid for carbon rose to $12 per tC (Maura-Costa, 2000). The contracted prices for 12 projects supported by the Prototype Carbon Fund of the World Bank for the year 2002 range from US$11/tC to $15/tC ($3-4/tCO_2) (PCF, 2002). Since these were some of the first such transactions and were carried out in times of great uncertainty about the rules governing CDM these have to be seen essentially as venture capital investments with high risk adjustment in the prices paid. As the first commitment period of 2008-12 approaches resulting in enhanced demands and the rules governing the trade become clearer, it is expected that the venture nature of the transactions would give way to a price trend that would not discount risks so heavily and the market should then show the volume and price predictability necessary in an industry with such long term investments.

Limited demand for CDM forest carbon credits may, however, continue into the foreseeable future and could prove to be a major factor in keeping the prices at their current low levels. The annual limit on the use of carbon credits earned through carbon sequestration projects under the CDM, the maximum amount allowed to be used in meeting the emission reduction commitments, equals only 1% of the base year greenhouse gas emissions of the investing country (Pohjola et al, 2003) thus limiting the demand for CDM sinks. The withdrawal of the USA from the Protocol, responsible for a quarter of the global emissions and thus the biggest market for carbon credits for abatement, has further severely restricted the demand for carbon credits.

The Upper Price Limit

The carbon sequestration offers a limited alternative to the abatement of carbon emission and it can be expected that the emitter, required to reduce emissions or abate equivalent amount of carbon in an approved sink, would opt for the cheapest option available at that time. The carbon prices are, therefore, limited by the marginal cost of abating carbon emission that ranges from US$15/tCO2 (or US$55/tC) in most industrialized countries to substantially higher in more energy efficient economies (PCF, 2002). This is then the maximum price range possible for the carbon sequestered. For cheaper options the buyer would go for other products or sources whose marginal costs of abating carbon emissions or sequestering carbon is lower.

Review of carbon sequestration costs in some CDM hosts

Benitez et al (2003) have reviewed the literature on costs of carbon sequestration in some of the major potential CDM host countries. Their review findings are given in the table below:

Country	Practise	Cost US$/tC[1]	C-pool[2]	Remarks[3]
China	Reforestation	10	n/a	Ex OC&T
China	Plantations	0-2	n/a	n/a
India	Reforestation	15	n/a	Ex OC&T
India	Plantations	0-1.1	n/a	n/a
Malaysia	Reforestation	5	n/a	Ex OC&T
Indonesia	Plantations	0-1	n/a	n/a
Tanzania	Plantations	0-3	n/a	n/a
S. Africa	Reforestation	9	n/a	Ex OC&T

The basic assumptions as well as carbon pools included in these assessments vary widely with most studies including only the initial cost of planting and exclude the land opportunity costs, the transaction costs and the timber and other environmental costs and benefits that may accrue. In the following paragraphs an attempt has been made to make a realistic estimate of the total costs incurred in earning carbon credits in the various bio-geographic zones of India.

Cost of reforestation in India

The cost of raising a plantation for reforestation over 1 ha of public land in India under the reforestation schemes of the National Afforestation & Eco-restoration Board of the Indian Ministry of Environment & Forests (MoEF, 2003), is as follows:

Planting and 3 years maintenance costs (for raising 1100 mixed trees, bushes and herbs per ha) = Rs 17100
Soil & moisture conservation activity around plants per ha (15% of planting cost) = Rs 2565

The total cost of planting and maintenance and taking up the requisite soil and moisture conservation measures would thus be Rs 19665 (US$ 425) per ha. This excludes the land cost or the opportunity costs for using lands for tree growing and the plantation maintenance costs are only for the first

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[1] US$/ tC = costs in US currency per ton of carbon sequestered
[2] B = biomass, S = soils, P = products, n/a = not available
[3] Ex = excluding, In = including , OC = opportunity cost, T = timber benefits, n/a = not available

three years. The requirement of raising a mix plantation of both timber trees and non-timber bushes and herbs fulfils a key requirement of bio-diversity conservation under the CDM.

Land productivity in India

India has 10 different bio-geographic zones and 26 biotic provinces (WII, 2000). There is a huge variation in land productivity and many attempts have been made to categorize these lands in terms of their potential forest productivity. One of these is the Paterson's productivity Index, also called the CVP (Climate, Vegetation, Productivity) Index. Paterson argued that the optimal productivity is a function of light, temperature and moisture conditions. His formula estimates forest productivity in ideal sites under ideal conditions of management (Champion & Seth 1968, Lal, 1992)

CVP Index $X = (T_v/T_a) \times P \times (E/100) \times (G/12)$

And $Y = 5.20 \log X - 7.25$

where

T_v is the mean temperature of the hottest month in degree Celsius
T_a is the difference between the mean temperatures of the hottest and the coldest months
P is annual precipitation in millimeters
E is the evapo-transpiration intensity
G is the growing season in months, and
Y is the ideal ecosystem productivity expressed in cubic meter per hectare per year

Applying Paterson productivity index to the 10 bio-geographic zones in the country the following scenarios emerge:

S. No.	Bio-geographic zone	Description	CVP index	Potential Ecosystem Productivity	Suitability for C sequestration
1	Trans-Himalayan	Ladakh and high altitude zones abutting Tibet, very cold and arid, sparse alpine vegetation	< 25	Unproductive	Unsuitable
2	Indian Desert	Thar and Kutch in western India, sandy deserts, seasonal marshes, sparse thorn forests	< 100	1-3 m^3/ha/yr	Largely unsuitable
3	Semi-arid zone	Plains of Punjab, Haryana, Gujarat, Eastern Rajasthan, west-central UP, western MP. Most lands under agriculture, limited forested area	100-300	3-6 m^3/ha/yr	Mostly suitable for agro-forestry, small opportunities for reforestation

4	Himalayan bio-geographic zone	Four distinct biotic provinces of north, west, central and eastern Himalayas. Sharp altitudinal differences. Well forested and also degraded in places, rich biodiversity. Tea cultivation in eastern part.	300	6 m^3/ha/yr except on very high elevations. Tree productivity of *Cryptomaria japonica* upto 39 m^3/ha/yr	Suitable for sequestration through reforestation but bio-diversity conservation requirements enhances costs. Also suitable for tree planting in agriculture and tea plantations
5	Deccan Peninsula	Raised land covering 40% of India; bound by Satpura, western ghats and eastern ghats; elevation ranges from 300 to 1000 meters in east; covered by tropical dry and moist forests	300-1000	6-9 m^3/ha/yr	Good opportunities for both agro-forestry and reforesation
6	Gangetic Plains	Plains of UP, Bihar, West Bengal; most fertile alluvial soils, mostly under crop; very little forest cover	300-1000	6-9 m^3/ha/yr	Large opportunities for agro-forestry but little for reforestation
7	Northeastern bio-geographic zone	Brahmputra and Barak river valleys and north eastern hills; evergreen and moist deciduous forests, heavily subjected to shifting cultivation and encroachment	1000-5000	9-12m^3/ha/yr Tree productivity for *Gmelina arborea* upto 35m^3/ha/yr	Lands under shifting cultivation and encroachment present opportunities for reforestation. Also good for agro forestry.
8	Coastal region	Coastal belts of west and east coasts, higher rainfall in west, exposure to cyclones in east, extensive casuarinas plantations on eastern coast	>5000 on west coast, 1000 – 5000 on east coast	>12m^3/ha/yr on west coast, 9-12 m^3/ha/yr on east coast	Suitable for bio-fuel plantations, also for reforestation and agro-forestry
9	Western Ghats	Moderately high hill range along west coast, eastern side under rain shadow, very rich in bio-diversity and forest cover; large extent under tea, rubber, coffee, cardamom, tapioca; significant area under protected areas for wild life	>5000 on west side, 1000 – 5000 on east	>12m^3/ha/yr on west side, 9-12 m^3/ha/yr on east	Few opportunities for reforestation under CDM; but good opportunities for agro-forestry under tea, coffee etc;

10	Indian Islands	Group of 325 islands in Andaman sea and also Lakshadweep along west coast; heavy rainfall, warm and humid climate, extensive forest cover	> 5000	$>12m^3$/ha/yr	Already well forested, no opportunities for reforestation or agro-forestry

Source: Champion & Seth (1968), Kant (2004), Lal (1992), WII (2000)

Opportunity costs

Placing lands under tree cover has the opportunity cost of the benefits foregone from other uses of land. The owners of lands do not always act in pursuance of a single objective; they often have multiple objectives and their relative priorities change with changing macro-economic environment. If there is a contract with punitive provisions for enforcement as would be the case in a carbon sequestration project, the landowner loses his freedom to change course and use his land assets in some other more productive venture even when his losses only increase with every passing year in the changed environment reflected in the lowered market prices (Kant, 2003). The monetary liquidity of these land assets also gets affected adversely because these can then be sold only to buyers interested in honoring the CDM agreement conditions. This restricted access to the market would result in lowering land prices. This can have serious implication in countries like India where land possession provides easy asset liquidity and is often seen as an excellent market tool of investment providing both good returns and an easy exit.

Land rental for agricultural lands taken up for carbon sequestration

The market would respond to these risks and restrictions by increasing rentals of the lands put under carbon sequestration. In India two methods of assessing market rentals for lands are in vogue (Kant, 2004). One very commonly used for fixing lands rented out for agriculture is seeking one half share of the crops produced by the tenant. This has the advantage of linking the land rent to its quality but has an accompanying disadvantage of inability to separate the incompetence of the tenant from the rent since the returns from the land reflect not only the land quality but also the inputs and the competence of the cultivator. The average annual revenue from one hectare of poorer quality rain-fed agriculture lands, in India being in the range of Rs 6,000 (US$ 130) the annual rental would amount to US$ 65. But this cannot be compared with renting land for carbon sequestration as the period of renting is only 4 months to 3 years at a time as against practically giving up the ownership for one to two generations in the case of carbon sequestration.

The other method for fixing land rentals is by ensuring that the net present value of the land assets at the time of entering into contract is recovered in 25 years (one generation) time. The rental in the first year would thus be one twenty-fifth of the land value and in subsequent years it would be increased by the monetary discount rate. In India the average costs of agricultural lands, away from urban areas and not legally available for other commercial purposes, ranges from Rs 100000 to Rs 600000 per ha depending on the land quality, access to markets, labor availability and irrigation facilities. Assuming that only the poorer quality of agricultural lands would find preference in the CDM carbon market the land rental in the first year of planting would be about Rs 4000 (US$ 87) /ha and Rs 100000 (US$ 2174) over a rotation of 25 years (Kant, 2004).

Choosing low rental lands may not lower cost of production:

The land rentals are decided on the basis of other uses of the land in the prevailing macro-economic environment. The opportunity costs can be brought down by (i) choosing lands unfit for agriculture like saline and alkaline soils or (ii) by choosing extremely remote lands. In the first, while the rentals could be very low, the trade-off would be with both the production costs and productivity and the costs per unit carbon may actually go up. In the second case of extremely remote lands the opportunity costs could be a fraction of that in more accessible area but here the compromise would be on the returns from associate products like timber and the minor forest produce which would not fetch the same rates as in more accessible areas. Also the production costs and the transaction costs would rise sharply due to increased costs of accessing labor and human expertise in remote localities. The drop in costs due to remoteness of land chosen would, therefore, be significant but a point would soon be reached where the remoteness would not reduce costs further. Further, it would not be easy to find many remote lands which are not already forests as defined (0.05 – 1 ha lands with tree cover of 10-30% crown density) since remoteness, and consequent absence of biotic interference, would itself encourage forestry growth and Kyoto forests can not be raised on lands which are already forested. Also, most remote areas are catchments of important rivers and government policies often do not encourage enhancing accessibility to these areas that would accompany large scale planting efforts.

Increased demand for carbon credits from sequestration will not reduce costs:

Land is the unavoidable and the most important factor of production in carbon sequestration and is a limited resource. It cannot be reproduced and, therefore, its supply curve is inelastic from the society's point of view. A particular type of venture, though, may find the land supply curve somewhat elastic because greater rent given by it may attract lands currently under other uses. When an input is limited the entry of new investors seeking more of the same resource will drive the resource towards becoming even more limited in availability and ultimately scarce. Thus the entry of a large number of investors in carbon sequestration projects will make land scarcer and new investors would find it costlier. Since land is the costliest factor of production contributing to more than half the cost of production in carbon sequestration ventures attempts to reduce costs through increased cost efficiency measures related to other factors of production would have only marginal effect. Carbon sequestration is, therefore, an industry that cannot be expected to have a reducing, or even constant, cost of production but will have to bear greater costs of production with increasing demands.

Opportunity costs for government forests lands taken up for C sequestration

The government forests lands in India have an actual average productivity of 0.7 m^3/ha/year (Lal, 1992) under the current systems of management and has the attendant non-monitory, but very significant, benefits of biodiversity conservation, protection of soil and moisture regimes and wild life conservation. Reforestation under CDM would ensure the continuation of these non-monitory benefits and, therefore, the opportunity cost would only be the direct earnings from the sustainable utilization of forest biomass before the sequestration projects was taken up (Kant, 2004).

Opportunity costs for encroached government forests lands taken up for C sequestration

Since eviction of encroachment of over 0.75 million ha of government forests lands currently estimated to be under encroachment in India has not been possible in spite of several efforts, a realistic view of the situation would be that these lands have provided a temporary opportunity for settlement of people and the opportunity cost thus should be measured by the costs incurred in settling these people elsewhere which would involve purchase of land, construction of houses and infrastructural facilities and transportation of people and their assets to the new sites. These are prohibitive costs, and going by current norms it would cost about Rs 300000 per ha which would make even the most attractive C-credit project economically unviable. A low cost alternative could be to involve these people through the mechanism of joint forest management in which case the opportunity cost would be value of benefits from cultivation foregone and this category could then be clubbed with the non-forest lands under agriculture taken up for sequestration project discussed below for the purpose of assessing the opportunity costs (Kant, 2004).

Opportunity costs for non-government lands taken up for C sequestration

On these lands, usually under excessive harvesting when under forest cover, the opportunity costs, from the point of view of the owner(s), would be the monitory equivalent of the benefits foregone irrespective of the sustainability of the process. The non-monitory benefits that would accrue from reforestation are often not valued by the owner(s) and, therefore, would have to be ignored in the assessment of opportunity costs unless these convert into direct monitory benefits to him in the short run. Similarly, the opportunity cost of planting trees on agricultural lands would be seen by the land owner as the entire amount of income foregone from crops that would be replaced by the trees and he would expect the income from trees to be higher than the amount thus foregone (Kant, 2004).

Costs caused by leakage

The CDM rules make the accounting of all negative leakages mandatory for earning carbon credits. Leakages can take place in the shape of activity displacement, demand displacement, supply displacement or investment crowding (IPCC, 2000). *Activity displacement* would occur when an activity (say, use as a grazing or play ground) on a land taken up for carbon sequestration shifts to another land in the neighborhood and causes a certain loss of carbon on the new land. Usually, the land taken up for raising a Kyoto forest would either be a forest land, grazing land or farm land and, except when the activity is grazing or farming, the activity being displaced to an alternative land would not require extensive lands and bringing it within the project by sparing a small extent of land for the purpose would not pose too serious a problem. In the case of agro-forestry the impetus to shift to tree growing from farming usually arises from lowered economic returns from agriculture crops due to oversupply and, therefore, it would be rare for new areas being brought under cultivation because of loss of cropland to agro forestry elsewhere. Displacement of grazing, however, by a large number of cattle to an alternate site would constitute a major leakage and may even render the project unviable on this count.

Demand displacement occurs when carbon removal through, say, fuel-wood collection going on over a land taken up for carbon sequestration shifts to another accessible land. In developing countries like India it could pose a serious problem because both agriculture and forest lands provide the fuel, small timber and livelihood needs of many people who may not figure as owners of the lands. *Supply displacement* is when cheaper forest products from a plantation supported by, say, CDM makes costlier forest products from existing forests unviable and lead to conversion of the existing forests in to agricultural lands due to economic pressures. In India the gap between the supply and demand of forest products is so large that for quite sometime to come we cannot produce enough in India for supply displacement to cause any serious leakage. *Investment crowding* could occur when the incentives to invest in plantations for carbon sequestration are so high that the funds meant for other economic activities, like solar power generation for replacement of fossil fuel, are also diverted for the former. Certainly there is no danger of it happening in India because of land for afforestation would limit the investment even if funds were available without any constraints.

Leakage avoidance and leakage limiting involve costs and it is not sufficient to only prevent leakage treating it as a case of theft. Alternatives will have to be provided within the physical and economic reach of the erstwhile users of the lands put under plantations. These entail costs on the proponent and the state that have to be added to the cost of carbon sequestration and storage. Murray et al (2002) estimated that leakage in afforestation projects for the US show leakages ranging from about 20% in the Lake states to over 40% in the southern states and that smaller project sizes did not necessarily have smaller leakages. The study also concluded that at higher carbon prices the leakage declines since there is wider participation under the promise of higher returns.

Since leakage is often considered synonymous with licit or illicit removal of biomass for fuel wood and timber or for earning livelihood it is easy to identify it with poverty. It then becomes logical to adopt the higher range of 40% leakage in the US for a developing country like India. But this need not be the case since the nature of leakage in these two societies is essentially different. In a poorer country like India leakage would be driven by the scarcity of biomass whereas in a rich country like the US the driving force would be the investments that would have been made in enterprises increasing biomass under the BAU scenario going to activities that either do not result in carbon sequestration or do it in smaller measure. In other words, leakage in poorer countries is generally the loss of biomass whereas it is mostly the reduction in the production of biomass in the developed countries. The underlying factor not being poverty in all the cases it would be wrong to conclude that the leakages in developing countries would be higher compared to the developed countries. Since no figures are available for India we would adopt the lower range of leakage of 20% and treat the leakage costs at 20% of the total production costs.

Transaction costs

The transaction costs can be broadly defined as the costs incurred in linking goods and services produced with their prospective consumers. These have also been defined as all costs incurred in reaching a product to the consumer except the production and transportation costs. Cacho et al (2002) have adopted a modified version of classification of transaction costs by Dudek and Wienar (1996) that includes the search costs, negotiation costs, verification and certification costs, monitoring costs, enforcement costs and the insurance costs under the overall transaction costs. *Search costs* are incurred as the investors and hosts seek partners for mutual benefits and *negotiation costs* are incurred, after the search is over, in reaching an agreement over the terms of partnership. *Verification and certification costs* are incurred when the negotiated contract parameters require the approval of an accredited agency. For example, GHG abatement contract between an investor and a host under the CDM would require verification of the claims of carbon sequestration and fulfillment of the conditions of cut-off date of 31.12.1989, biodiversity conservation etc by an independent body before the carbon credit certificates are issued.

The *implementation costs* refers to the costs incurred in implementing the provisions of the negotiated contract like keeping records, making payments and dealing with discords. Large projects often require establishment of an office for this purpose. *Monitoring costs* are the amounts expended to observe and measure the intermediate milestones, progress indicators and achievements made in real time as the project takes off and test them against the forecasts. Projects that fix less than 2-3 tC/ha/year cannot be monitored in a cost effective manner because the cost of measuring these quantities is similar to the cost of measuring 10-15 tC/ha/year (Macdicken (1997) quoted in Cacho et al (2002).

Enforcement costs are incurred when monitoring reveals deviation from the agreed terms of the contract. In complex multi-layered agreements among partners belonging to different political, legal and administrative environments, as would be the case under CDM, disputes arise frequently because same words often carry different meanings to different partners. Also the very nature of the long term contract between the host/seller and the investor/purchaser is prone to be more adversarial than co-operative as both try to maximize their benefits, the host by relaxing standards in order to spend less and the investor insisting on even harder standards as markets start discounting severely even minor flaws in the carbon credits earned. The litigation costs incurred in enforcing such contracts can be very high.

Insurance costs arise from the risks that the ventures face. Tree growing locks up the land resource used for a long time and in the case of planting for carbon sequestration it would be even longer. Long-term investments face high risks of drop in prices far below expectations on account of changed market preferences, policies and the technological development. Forestry also faces the risk of fire and damage by insects and pathogens and the risks factor varies from activity to activity and the environment under which the activities take place. A pine plantation has higher risks of fire compared to an oak plantation in the Himalayas. In long gestation forestry crops market uncertainties raise risks of lowered prices at the time of harvesting and policy uncertainties of a government given to experimentation can lead to serious risks of miscalculation of both the cost of inputs and expected prices of the output. Over and above this, the stringent CDM requirements for the award of carbon credits and uncertainties arising out of the enormous complexities of the rules laid down for this purpose, enhance the chances of failing to satisfy the accredited agency authorized to issue carbon credit certificates.

Estimates of transaction costs in forestry projects

In her detailed work on transaction costs involved in obtaining carbon credits through carbon sequestration, Milne (2002) has examined six large afforestation and reforestation projects in Latin America and Russia and reported it to be in the range of US$ 0.57 to 2.96 per ton of projected sequestration of carbon in these projects and estimated the transaction costs to range from 6% to 45% of the total project costs. The small data does not give any correlation between the project size and the transaction costs.

Detailed examination of some of these transaction cost estimates reveals them to be underestimates. For example, Milne (2002) had estimated the transaction costs for the Russian afforestation project RUSAFOR to be US$ 0.84/tC but this did not include enforcement and insurance costs.

Enforcement costs, incurred mostly on litigation, was a non-issue because this was essentially an agreement between five Russian government organizations including the Russian Federal Forest Service on one side and the US Environmental Protection Agency and the Oregon State University on the other, all more eager than the other to ensure the success of the project to assess the possibilities of the vast Siberian land mass to sequester carbon. Insurance was not considered necessary for the project, as it was essentially a non-commercial venture. Further, since the Russian Federal Forest Service was the primary participant with in-house availability of high-grade technical skills in all aspects of the project, these were not costed lowering the transaction costs significantly.

The situation in most other projects examined by Milne appears similar underestimates when viewed in the context of the transaction costs that the host/seller and the investor/purchaser are likely to face in the CDM forestry carbon sequestration projects. The best scenario for comparison with the CDM projects is presented by the Chilean afforestation project with transaction cost estimates of US$ 2.96 /tC is which thousand of farmers are co-participants and almost all the categories of transaction costs are covered including the insurance costs lacking in all the other five projects studied by Milne. It would thus be reasonable to adopt this transaction cost of about US$ 3/tC for the purpose of our cost estimates.

Production of associate and rival products

A complex production system like the forests is capable of producing several associate products and a few rival products that would influence the costs significantly. Some of the associate products of carbon sequestration in forests would be water conservation, soil conservation, bio-diversity conservation, non-timber forest produce, firewood and small timber from thinning etc. Timber on harvest becomes a rival product because increase in its production reduces the amount of carbon stored. However, even timber production can also become an associate product, or at least exhibit a reduced rivalry, by its end use since timber meant for furniture and building material would continue to store carbon for a long time. The venture would be successful if the net present worth of the returns are higher than the costs. But the market trends today are far lower and the demand scenario does not give much hope for increase in demand for carbon credits and, therefore, market by itself is unlikely to help raise carbon prices to levels above the production costs.

Analysis of the real costs of carbon sequestration

There would be sustained interest in taking up CDM forestry projects only if benefits exceed costs (B > C) by a significant margin

C = R+ O + P + L, where

C = Total production costs
R = Total land rental discounted to the base year
O = Total opportunity costs (except those accounted for in land rental) including non-monetory benefits to the extent felt by the project proponent
P = Total planting and maintenance costs discounted to the base year
L = total leakage costs to the project proponent discounted to the base year

and B = (Bcc- T) + Bap + Bnm

B = Total monitory value of benefits
Bcc = Total carbon credit values discounted to the base year
T = Total transaction costs discounted to the base year
Bap = Total monitory value of the associate marketable products discounted to the base year
Bnm = Total value of the non-monitory benefits accruing and appreciated by the project participants

Profitability of a typical reforestation project

Let us now take an example of reforestation by government forest department in eligible degraded government forests lands in the North Eastern bio-geographic region (where the potential productivity lies between 9 to 12 m^3/ha/year) at a site with potential productivity of, say, 10 m^3/ha/year. Here there would be no land rental (R = 0). Also, since the land has become degraded there is no harvesting except what is removed by people of the neighborhood by way of fuel wood and grasses which would constitute leakage which, as in the previous case, is assumed to be 20% of the production cost. The opportunity cost would be the non-monitory benefits foregone by the society but since the reforestation for sequestration would ensure at least the same measure of non-monitory benefits we would assume O = Bnm. The total production cost per ha over a period of 25 years, with the cost of reforestation having been already assessed above at $ 425 per ha, would thus be

C = 0 + Bnm + 425 + 0.2 x 425 = $ 510 + Bnm

and assuming no associated products (Bap = 0) the benefit values would be

B = 15 x 3.5 x 25 - 3 x 3.5 x 25+ Bnm + 0 = $ 1050 + Bnm

Thus B > C even without any associated products at this carbon productivity and price. But if the productivity falls to half of the projected value or the carbon prices drop below $ 8 /tC the benefit value would no longer be above the costs unless associated products add value.

Profitability of an agro-forestry sequestration project

For an understanding of the above let us take an agro-forestry project in Darjeeling hills in Eastern Himalayan biotic province of the Himalayan bio-geographic zone in which *Cryptomaria japonica*, which has a productivity potential of 39 m^3/ha/year (Lal, 1992), is planted on a 25 year rotation basis. With a wood density of 0.6 and biomass - carbon conversion factor of 0.5 the productivity in terms of carbon amounts to 13 tC/ha/year. Assuming a carbon value of US$ 15 per tC and assuming further that over the next 25 years the increase in carbon prices would keep pace with the current monitory discount rate of 5% the total benefits that accrue to the project participants would be
B = US$ (15 x 13 x 25 - 3 x 13 x 25) + 0 + 0 = US$ 3900

In arriving at this we first assume that there are no associated products (Bap = 0) either during the 25 years or at the culmination of the project. Also, that the non-monitory benefits hold no attraction for the project participants (Bnm = 0).

The production costs would be

C = 2174 + 0 + 425 + 0.2 x (2174 + 425) = US$ 3119

Here we assume opportunity costs O = 0 as all such costs to the project participants have been accounted for in the land rental ($2174) itself. Further, the reforestation cost at $425 per ha has been assumed to fairly represent the tree planting cost in agricultural lands also. Also the leakage costs is assumed to be 20% of the production costs. Final harvesting would occur beyond the crediting period of the project and would be accounted for by the non-permanent nature of the carbon credit issued.

Thus at the carbon prices of US$ 15 per tC the perceived benefits are larger than the production costs and the venture would be economically viable. But if the prices fall below USD 13/tC the venture would no longer be profitable unless the project participants earn from associated products also. These leads us to the possibility of using the resource produced as a fuel resource to displace fossil fuel or as a replacement for cement or steel in construction and thus displace fossil fuel that would have been used in producing that quantity of cement or steel. Alternately the harvested wood could be utilized in a manner that stores carbon over a long period. It may be noted that the accounting methodology for carbon stored in harvested wood products has not yet been agreed upon and is likely to be taken up in the forthcoming Conference of Parties.

Conclusions

The true cost of sequestering and storing carbon in trees is the sum of the land rental, planting and maintenance costs, transaction costs and the costs on account of leakages. In India the land rental or the land use opportunity costs are the biggest constituent of these costs and, land being a limited resource, greater requirement for land for carbon sequestration would drive its prices up. At present the negotiated price range of carbon for projects supported by responsible multilateral bodies is US $ 15/tC and, while at this price range the carbon sequestration projects are marginally economical in lands of high potential productivity, even a slight reduction in real prices (when adjusted against inflation) would render these projects unviable. The very low prevailing prices in the international markets, and a demand induced price rise for carbon credits being unlikely in the near future, point towards such a possibility. Since individual project developers may have no influence on the prices a useful strategy would be to rely on high productivity to reduce the cost of producing carbon credits even though it would limit the choices to only the warmer and more humid lands of higher productivity and to a few species in agro-forestry.

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Abstract

The cost of carbon sequestration under the Clean Development Mechanism (CDM) of the Kyoto Protocol is far higher than the normal afforestation costs as it includes the opportunity cost of the land and the costs of project formulation, regeneration, maintenance, monitoring, measurement, verification, baseline construction, leakage accounting, accessing markets and the costs incurred in ensuring additionality, biodiversity conservation and the credibility of the certification system. For purposes of reforestation of degraded forests the ecosystem productivity of the bio-geographic zones in which these forests lie also influences the costs to a very high degree. In India the land rentals alone exceed the current tentative price range of carbon. The withdrawal of the USA from the Kyoto Protocol, the very real possibility of trade in 'hot air' and the limitations on the use of carbon credits earned through carbon sequestration under the CDM would make a demand induced price rise for carbon credits unlikely. Also, demand for higher volumes of carbon sequestered in forests may also drive the costs up, as greater requirement for land would enhance its rental, notwithstanding the advantages of the economy of scale. The high transaction costs, arising out of the stringent Kyoto conditionalities and monitoring quality expected of the CDM projects, present another formidable barrier to the profitability of such sequestration projects.

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