PROGRAMME ON FORESTS

Working Draft

Selling Carbon Storage

Background Paper for the Guyana Forest Partnership Initiative

PROFOR

SELLING CARBON STORAGE: BACKGROUND PAPER FOR THE GUYANA FOREST PARTNERSHIP INITIATIVE

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ACRONYMS

BAU	business-as-usual
CDM	Clean Development Mechanism
CO2	carbon dioxide
CH4	methane
CSERGE	Centre for Social and Economic Research on the Global Environment
DTI	Department of Trade and Industry, United Kingdom
EU	European Union
FACE	Forests Absorbing Carbon Dioxide Emissions, the Netherlands
FCCC	United Nations Framework Convention on Climate Change
FMP	forest management practices
FOB	free-on-board (a timber trade term)
GWP	global warming potential
HFC	hydroflourocarbon
N2O	nitrous oxide
PFC	Perflourocarbons
SF6	Sulpfur hexaflouride
US	United States of America
USIJI	United States Initiative on Joint Implementation
UN	United Nations
VAT	value-added tax
WTP	willingness-to-pay

Background

The world's forests remain under threat from commercial pressures such as clearance for agriculture, ranching, agri-business, logging, urban and infrastructure expansion, and general encroachment. While many complex factors contribute to forest loss, a dominant one is easy to identify and state. Compared to these alternative uses of forest land, sustainable and conservation uses of the forests do not pay, especially not to the owners of the forest and the forest dwellers. The economic returns from alternative land uses exceed the economic returns from conservation.[1]

To help slow the decline of forest cover, sustainable uses must be made economically more attractive. The way to do this is to 'capture' at least some of the environmental values of forests, in other words, identify those values and translate them into cash flows. It is widely acknowledged that rainforests have a myriad of ecological values that provide benefits both nationally and globally. Among these, carbon storage is a potentially large source of this encashable environmental value (Pearce, 1998).

Cashing-In on Carbon

The essential argument is simple. Forests are carbon stores[2]. The carbon dioxide that trees absorb from the atmosphere is fixed in perennial tissue. A logistic curve depicts the rate at which forests absorb carbon: quickly at first and slowing down as they reach maturity. As the wood starts to decay, the carbon dioxide is released so that fixation levels become matched by those of decay. Mature 'climax' forests thus do not produce a net gain in carbon fixing capacity, they take in (roughly) as much carbon (in the form of CO_2) as they emit. In their standing state, they therefore make no net contribution to atmospheric warming. However, if they are converted to other uses, carbon is released as CO_2, thus fostering global warming.

Due to population and commercial pressures, it is inevitable that some forest conversion takes place, but much of it depends on factors that are open to policy choice. The rate of conversion in a 'business-as-usual' (BAU) scenario is known as the *baseline rate of conversion*, and the carbon emitted under that scenario is the *baseline level of emissions.* Through policy intervention, this baseline emission level can be reduced to the *policy level of emissions*. The difference between the baseline and the policy level of emission is the *carbon benefit* of the policy intervention, measurable in tonnes of carbon per annum.

The policy intervention has a cost to the forested country, and a major component of that cost is the *forgone economic returns* from the alternative land use. The benefit of the policy intervention is the carbon emissions avoided multiplied by the willingness-to-pay (WTP) of some foreign agent to have the reduced carbon credited to them

[1] There are exceptions, of course, but the literature claiming extractive sustainable use values are higher than exploitative values, has been shown to be flawed (see Pearce, 1998).

[2] We ignore *afforestation* where net carbon sequestration occurs, as it is not relevant to the current context.

through a paper transaction. The motivations of those who may have WTP for the carbon are considered shortly.

From the host country's point of view, then, conservation for carbon is preferred to, say, leasing the land to forest concessionaires, if:

$$[WTP \cdot tC] - T > R_L$$

where WTP is willingness of some agent to 'buy' one tonne of carbon;
tC is tonnes of carbon;
T are the transaction costs of the credit;
R_L is the net revenue to the host country from leasing the land for timber extraction.[3]

What matters, then, is how much carbon is 'in store', how much can be sequestered through forest regeneration, and the price (WTP) at which it can be sold in an established market.

The Motivations of Carbon Buyers

What the 'buyer' of carbon buys is, of course, not carbon as such, but a paper title to the carbon reduction, or a *credit*. Agents' motivations are primarily twofold:
(i) 'green image': the desire to *offset* carbon emissions from current activities so that a company or activity is *carbon neutral* (i.e. sequesters carbon or avoids emissions in amounts equal to its emissions); (ii) legal requirement: the need to comply with a carbon 'cap' that may be set by a local (state) or national government. National governments will set carbon caps in order to comply with the Kyoto Protocol of the United Nations' Framework Convention on Climate Change (FCCC).

The first point refers to existing carbon markets under voluntary schemes (such as United States Initiative on Joint Implementation, or USIJI) to satisfy consumers' demands for 'green' products. The second defines existing and potential markets arising from obligations under the 1992 FCCC (e.g., Forests Absorbing Carbon Dioxide Emissions, or FACE, in the Netherlands) and those that that will emerge under the Kyoto Protocol through pressures from the key players in Kyoto - the EU, the US, and Japan. The US took the lead in the establishment of three mechanisms for 'flexible' implementation of the Protocol: emissions trading, joint implementation, and a *clean development mechanism* (CDM). The CDM may hold the key to the Protocol's entry into force, as it is the only feature likely to engage 'key' developing nations in emission reduction projects. The CDM is a form of joint implementation; its purpose is to assist both developing countries in achieving sustainable development and Annex I parties in meeting their emission targets. The former are to "benefit from project activities resulting in certified emission reductions," while Annex I countries are entitled to use certified emission reductions to "contribute" to compliance with

[3] Strictly, R_L is the revenue from taxing forest rentals, i.e. the amount the host government can secure from logging companies. A broader concept would include any benefits from downstream activities, such as processing.

"part" of their targets (the Conference of Parties will decide at a later date exactly what those terms mean).

The Kyoto Protocol Carbon Reduction Obligations

Under the Kyoto Protocol, Annex I countries have the obligation, either individually or jointly, to "ensure that their aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases listed in Annex A do not exceed their assigned amounts." (Kyoto Protocol, 1997). The targets apply to a 'basket' of six gases - CO_2, CH_4, N_2O, HFCs, PFCs and SF_6 - weighted by their GWP (global warming potential). These targets are shown in Table 1.

Table 1 Target Changes in Carbon Emissions for 2010 (from 1990 levels)

Country	Change	Country	Change
Australia	+8%	Liechtenstein	-8%
Austria	-8%	Lithuania*	-8%
Belgium	-8%	Luxembourg	-8%
Bulgaria*	-8%	Monaco	-8%
Canada	-6%	Netherlands	-8%
Croatia*	-5%	New Zealand	0%
Czech Republic*	-8%	Norway	+1%
Denmark	-8%	Poland*	-6%
Estonia	-8%	Portugal	-8%
EC	-8%	Romania*	-8%
Finland	-8%	Russian Federation*	0%
France	-8%	Slovakia*	-8%
Germany	-8%	Slovenia*	-8%
Greece	-8%	Spain	-8%
Hungary*	-6%	Sweden	-8%
Iceland	+10%	Switzerland	-8%
Ireland	-8%	Ukraine*	0%
Italy	-8%	UK	-8%
Japan	-6%	USA	-7%
Latvia*	-8%		

* Countries that are undergoing the process of transition to a market economy.
Source: Kyoto Protocol (Annex B)

It is important to note that the 8 percent reduction for all EU countries ignores the fact that each of these countries will have *differential* targets. In other words, there will be a separate burden-sharing agreement within the EU.

The targets in Table 1 are expressed relative to 1990 emission levels. Since the underlying trend in emissions in many countries is for CO_2 to increase, the *actual* reduction targets should be expressed relative to the *baseline rate of conversion*, i.e.

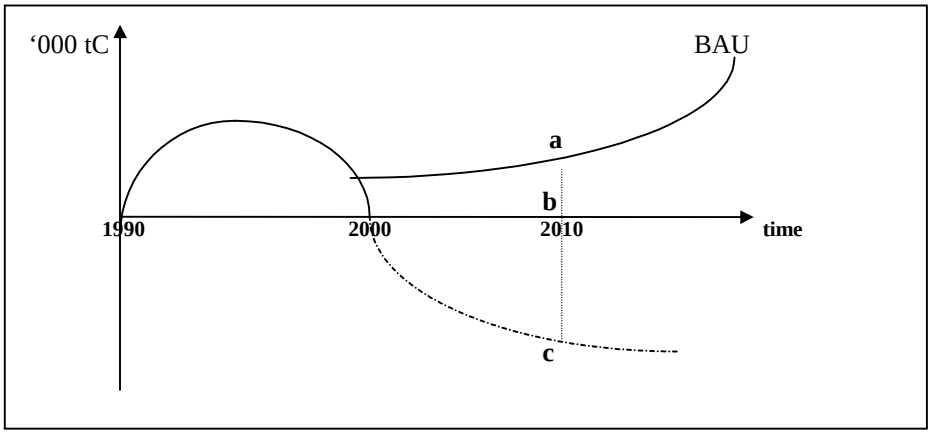
the ‘business-as-usual’ emission level. This level is counterfactual, as it describes what *would* happen if the policies designed to meet the Kyoto targets were not in place (see Figure 1). Of course, the *actual* reductions in emissions will be different for each country (or groups of countries like the EU).

For example, the UK’s CO_2 emissions in 1990 rose to about 158 million tC. The UK’s Department of Trade and Industry (DTI) projections of CO_2 emissions reveal that overall emissions are expected to fall between 1990 and 2000, meeting the original target of returning 2000 emissions to 1990 levels. However, on current trends, the DTI maintains that emissions will rise again to between 3 percent under and 5 percent over 1990 levels by 2010. Thus the total *actual* emissions reduction level for the UK (noting that the Kyoto target is minus 8 percent by 2010) will be between 5 percent and 13 percent.

There are many disputes associated with this claim, as it is likely that UK carbon emissions would be even greater under current trends, due to:

- the liberalisation of energy markets;
- the present government’s stance on VAT on energy; and
- the present government’s defence of British miners vis-à-vis gas.

Figure 1 Carbon Emission Levels 1990-2010



The distance **bc** depicts the *policy level of emissions*; in this case being the emission reduction level as specified under the Kyoto Protocol. The emission reduction level, **ac**, then defines the true target for domestic policy and trading, for a given Annex I country. Thus it is this distance which measures the *carbon benefit* of the policy intervention.

Estimating the Global Carbon Market

The maximum conceivable extent of likely global *purchases* of carbon credits can, in principle, be estimated by calculating **ac** for each country with a target under the Kyoto Protocol[4]. Clearly, the distance **ac** depends on:

(i) the year for which it is estimated;
(ii) the BAU projection for that year;
(iii) the extent to which trading will be employed as a means of reaching target **c**; and
(iv) the target.

The least known variable is the extent of trading. This might be estimated in two ways:

- as a residual: the distance **ac** in Figure 1 *minus* domestic policy measures designed to reduce emissions or sequester carbon; or
- as a deliberate policy variable: governments might declare that they will meet X percent of their target by trading.

Little is known about these two issues, and estimates are only likely to emerge as domestic policies are developed. For current purposes, we could take a rough guess that European countries will meet only 5 percent of their reductions by the purchase of credits, while the US, which is considerably more keen on carbon trading, may meet 15 percent of their emissions reduction target by trading.

With precise data on the carbon emission levels since 1990, and more importantly, BAU emissions projected to 2010, we could obtain a 'first cut' estimate of *carbon demand*. The necessary information includes the estimated *carbon benefits* for the key players of the Kyoto Protocol (i.e. the distances **ac** for each of the parties), which comprises the BAU growth rate in carbon emissions. Detailed estimates will be provided in the full report.

Using the US as an example, the analysis to be conducted will be as follows:

The projected carbon emissions for 2010 will be estimated. Trexler provides a figure of 40 percent above 1990 levels, so that:

$$E_{2010} = 1.4\ E_{1990} \qquad (1)$$

where E_{2010} are the projected emissions under the BAU scenario,
E_{1990} are the carbon emissions for 1990.

Using the same notation, the US target emissions (noting that it must reduce emissions by 7% by the year 2010) will be:

$$E^*_{2010} = 0.93\ E_{1990} \qquad (2)$$

[4] In practice, most of the distance **ac** will be met by domestic emission reductions.

where E^*_{2010} are the target emissions under the Kyoto Protocol.

Consequently, it is estimated that the US will 'buy':

$$0.15\ [E_{2010} - E^*_{2010}]\ tC$$

Actual Carbon Trades

Two joint implementation initiatives that will shape the United Nations' (UN) final decision on joint implementation are the USIJI and the Dutch FACE deals. Table 2 sets out preliminary estimates of the prices at which carbon has traded under the USIJI and FACE programmes. It examines fifteen projects from USIJI rounds one and two, as well as the five FACE projects. These projects are being undertaken in a joint implementation pilot phase when no 'official' credits are awarded for emission reduction and where monitoring is weak. Most of these are 'anonymous' due to commercial confidentiality requirements, but CSERGE has access to the full database for these trades[5].

The results reveal the very wide range of costs, from $2-3/tC to nearly $400. The average cost of carbon capture for these twenty projects is $64.9/tC. The average forestry project cost is $18.5/tC (eleven projects), the average fuel switching cost is $136.6/tC (eight projects). Carbon capture in forestry projects ranges in price from $2.8/tC to $81.0/tC (in the Netherlands).

A useful benchmark is given by available estimates of *marginal damage* from climate change. These cluster around $25-30/tC[6]. From a cost-benefit standpoint it makes little economic sense to pursue trades that cost more than the $25-30/tC. Fifty percent of the trades in Table 2 exceed this benchmark.

Table 2 Costs per tonne of Carbon in Existing Trades

Number	Method	Country	Cost in $/tC
FACE 4	Carbon planting	Malaysia	4.0
FACE 5	Carbon planting	Czech Republic	47.7

[5] These estimates will also be checked, as they are preliminary.
[6] Full details will be supplied in the full report.

FACE 6	Carbon planting	Ecuador	2.7
FACE 7	Carbon planting	Uganda	4.4
FACE 8	Carbon planting	Netherlands	81.0
A	Carbon planting	Russia	4.6
B	Carbon plant & protect	Costa Rica	13.4
C	Carbon plant & protect	Belize	2.8
D	Carbon protecting	Costa Rica	3.2
E	Fuel switching (Wind)	Costa Rica	120.5
F	Fuel switching (Gas)	Czech Republic	62.0
G	Fuel switching (Solar)	Honduras	35.6
H	Carbon planting	Costa Rica	24.4
I	Carbon planting	Costa Rica	15.5
J	Fuel switching (Wind)	Costa Rica	157.7
K	Fuel switching (Hydro)	Costa Rica	173.1
L	Fuel switching (Wind)	Costa Rica	120.5
M	Fuel switching (Biomass)	Honduras	47.3
N	Fuel switching (Geothermal)	Nicaragua	376.3
O	Supply side energy efficiency	Russia	0.07

The actual range of prices is seen to be very wide, so much so that they offer an inadequate guide to future prices. In large part, this is because existing trades carry no incentive to be least-cost trades. Least-cost trades would emerge only if markets 'scan' a large range of potential deals and select from among them. Thus, in a full, working, and competitive market, demand and supply forces would interact to adjust for price and quantity levels. In practice, most of these deals are for 'demonstration' purposes--for example, to show that carbon trades can be carried out, and to learn from the experience about *how* carbon trades are conducted, rather than least-cost options. Existing trades are therefore likely to be a very limited guide to the future.

Guyana's Carbon Supply

The main threat to Guyana's forest area is the rent-seeking behaviour of logging companies during timber extraction, behaviour that disregards the damage done to the 'non-commercial' part of the forest. This disregard is owed to the design of forest mechanisms (i.e. policies, legislation, and incentive schemes), which discourage logging companies from adopting more sustainable forest management practices (FMPs). If there is no incentive to keep the forests intact, large areas will be logged down, as has occurred to date. The baseline scenario to consider is thus unsustainable timber extraction (this is what would follow from the BAU scenario).

Two alternative scenarios arise:

- the first involves preserving the forest; and
- the second implies overcoming the economic, technical, and institutional barriers that prevent more sustainable FMPs to be undertaken. This latter case will be discussed in more detail below.

Under the first option, the donors would be investing in the forest as a carbon store. Deforestation would not occur at all, which implies a carbon *gain* relative to the baseline. The initial carbon density for forests in Guyana is, on average, 125 tC/ha[7] (Trexler et al., 1995). Guyana's forest covers an area of approximately 16 million hectares (ha) (Sizer, 1996). The maximum supply of carbon by Guyana is estimated as follows:

125 tC/ha * 16 million ha = 2 billion tC

It has been estimated that 1 percent of the total forest land area has been deforested (Guyana NEAP). A rough estimate for the amount of carbon present in Guyana's forest is thus 1.98 billion tC.

An area of 3.6 million hectares of forested land is accessible for exploitation, and approximately 2.4 million ha. has already been allocated for harvesting. This accounts for 15 percent of Guyana's forests. Assuming that all of this area would ultimately be 'lost' to logging (which is arguable), Guyana's carbon supply would be reduced to 1.70 billion tC (125 * 13.6 million). The point of the carbon deals will be to *prevent* further logging from taking place, so the area *avoided* would be 1.2 million ha, which accounts for 0.15 billion tC. It is this amount that would be traded in the market.

However, the forestry sector is poised for an expansion of production. 10.4 million ha of forest are *potentially* exploitable (infrastructure has to be constructed to access these lands) and the BAU scenario indicates that 65 percent of this area (6.4 million ha) could eventually be harvested (it is currently *leased* for exploitation). Again, it is this area that could be potentially traded as carbon to prevent it from being exploited, so the tradable carbon would amount to 0.8 billion tC.
Therefore, the *total* amount of carbon that could be potentially traded is 0.95 billion tC. Actually, it is less since logging would not release all this carbon. The crucial questions here are *how* logging takes place, what kind of FMPs (if any) are followed in Guyana (or which could be put into practice), and how much carbon is left in the forest once the area has been exploited for timber.

Potential Carbon Sequestration from Sustainable FMPs in Guyana

As described in Section 2, pristine rainforests absorb as much carbon as they emit, thus fulfilling their role as carbon stores rather than as carbon sequesters. However, when sustainable logging takes place, allowing for forest regeneration, carbon is

[7] Low-density forest in Guyana has an estimated carbon storage of 100 tC/ha, while high-density forest has a carbon content of 150 tC/ha.

accumulated in the biomass. Again, taking the BAU scenario (i.e. exploitation of the forest) as the *baseline rate of conversion*, we can consider the option of undertaking more sustainable FMPs, not only as an opportunity to fix carbon from the atmosphere, but also as an operation whereby more trees would be left standing as carbon stores.

The aim is to estimate the current and potential value of the carbon store in one hectare of the Guyanese rainforest under sustainable and unsustainable management options. Thus the *net carbon gains* can be estimated by establishing a baseline for the unsustainable logging scenario, and comparing this with the estimates of how much carbon could be sequestered and 'locked in' by introducing more sustainable logging practices.

In this situation, donors would be investing in carbon as a mechanism to *offset* their own emissions. Previous studies have shown that under sustainable FMPs, more carbon is accumulated in the forest than that which is lost via logging, thus proving *beneficial*, in carbon terms, *not* to leave the forest undisturbed. A more detailed analysis of the extent to which sustainable logging can realistically take place in Guyana is necessary, together with logging cycles, the density of carbon stocks before and after logging, the damage incurred to the other parts of the forest when exploiting certain areas, and carbon sequestration rates.[8]

The Conditions for Guyana to Engage in Profitable Carbon Trade

We now establish the broad conditions that must prevail for Guyana to benefit from carbon trades covering some or even all of its 'carbon store', and its carbon sequestration potential. These will, of course, be traded in the same market, in the quest for simplicity, because a tonne of carbon stored is equivalent to a tonne of carbon sequestered.

Guyana's Willingness to Sell Carbon Credits

Guyana's choice can be characterised in terms of the alternative uses of its forest land. These are:

- concessions for timber extraction; and
- sustainable use, including carbon storage.

Any hectare of land issued as a logging concession will be worth *to Guyana* the share of forestry charges that Guyana would collect through its forest revenue system. A variety of forest fees, harvest fees, and government taxes compose a complex revenue structure. Let A be an area-based fee which is issued on a per hectare basis, Y is the yield (measured in m^3/ha) that is multiplied by the other variables to give a per hectare revenue. R is a royalty levied on timber once it has been extracted from the forest, r_e is an export tax levied on the FOB price of timber (given by P_t) and r_g is a corporate tax (usually of about 45 percent). Some large concessions have been exempt from this tax

[8] A theoretical framework for carbon accumulation will be presented in the full report.

in the past, although Guyana is presently restructuring its forest revenue system. Thomson (1994) suggests a number of reforms to Guyana's forest tax system to make it "fair to both the GFC[9] and to forest operators." Then Guyana's revenues from *one hectare* of a forest concession will be:

$$R_h = A + Y\,[R + r_e \,.\, P_t\,(+\, r_g \,.P_t)] + B$$

where h refers to the host country, Guyana.

B includes any secondary benefits (e.g. downstream processing) that Guyana may secure from forest logging. It is measured in per hectare terms by expressing the profits per m^3 of timber, and hence per tonne of carbon.

Guyana will sell credits if:

$$P_c \,.\, tC/ha > R_h$$

where P_c is the market price of one tonne of carbon, and tC/ha refers to tonnes of carbon per hectare[10]. From a cost-benefit standpoint, the highest possible revenues that Guyana can capture from its forest sector must be used, in order to keep the estimates conservative when comparing these revenues with those that can be attained from selling the carbon in a global market.

Similarly, if Guyana decided to introduce more sustainable FMPs in its logging system, the revenues that would accrue to the country would be *both* the carbon benefits *and* the revenues from sustainable timber extraction (accompanied, of course, by the appropriate taxes and fees from the leased areas - call these revenues R^1_h). In this case, Guyana would sell credits if:

$$(P_c \,.\, tC/ha) + P_t \,.\, Y + R^1_h > R_h$$

where P_t is the price of timber in m^3.

The Willingness to Buy Guyanese Carbon

Those 'donor' countries with an obligation to reduce carbon emissions can do so by:

(i) reducing emissions in their own country;
(ii) sequestering carbon in their own country;
(iii) reducing emissions in a third party country; and

[9] Guyana Forestry Commission.
[10] We are ignoring transaction costs for simplicity.

(iv) sequestering carbon in a third party country[11].

The choice between domestic, *d*, and host, *h*, activity will depend on the cost differential, $(C_d - C_h)$ and on any associated differential risk between domestic and host country activity, call it L.

The *maximum* WTP (for each tonne of carbon) by the donor for activity in *h* will be:

$$max\ WTP_d = [C_d - C_h - L]$$

where C_d, C_h and L are all measured per tonne of carbon. C_d and C_h are the costs of reducing one tonne of carbon in the donor country or in the host country respectively. *Actual* WTP, i.e. P_c will be determined by supply and demand in the market, and will be less than WTP_d. Let α be the ratio of actual to maximum WTP, then:

$$P_c = WTP_d = \alpha.\ max\ WTP_d$$

Is it Worth Guyana Forgoing Logging to Sell Carbon?

The expression WTP_d gives us the potential demand for carbon (measured per tonne of carbon), while R_h gives us the potential supply of carbon (measured per hectare of Guyanese forest). For it to be worth Guyana to sell carbon, we require:

$$P_c\ .\ tC/ha > R_h$$

or, receipts per hectare must exceed the opportunity costs of conservation for carbon storage.

Requirements for a Full Analysis

We now have an idea of the information required to engage in a full analysis. Ideally, the whole process needs to be modelled and this should be an aim. However, the following information is required:

(a) total carbon reduction required for the EU, the US, and Japan under the Kyoto targets;

[11] We do not discuss here the extent to which this is permitted under the FCCC.

(b) total carbon stored in Guyanese forests that could potentially be traded, expressed as carbon per hectare;
(c) accurate data on forest rents in Guyana;
(d) proportion of rents collected by Guyanese government;
(e) a 'guesstimate' of the proportion of rents that *would* be taxed;
(f) costs of carbon reduction in donor countries;
(g) costs of carbon reduction in host countries; and
(h) judgement on the risk premia for storage projects in Guyana.

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