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The Costs of Stopping Deforestation

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Abstract

Even though deforestation in tropical developing countries releases large quantities of greenhouse gases, the Kyoto Protocol does not include mechanisms for forest conservation. Nevertheless, deforestation and forest degradation has now taken centre-stage as the developed countries, having failed to convince their own electorates to bear abatement costs, have pledged large sums to stop it. It is in the interests of both donors and recipients that the costs of abatement are matched by compensation payments. The paper examines in detail the abatement in greenhouse gas emissions achievable in Papua New Guinea (a heavily-forested tropical country) by the reduction in deforestation and forest degradation (REDD), and the opportunity costs of doing so. Its methodology takes advantage of recent modelling of the emissions from deforestation in PNG and integrates this with financial models developed by the author for the logging and palm oil industries.[1] Indonesian results are also drawn upon to support an argument that the opportunity costs of REDD have been systematically underestimated. The analysis also helps to achieve a fuller understanding of the complexity of designing and implementing policies for REDD that not only adequately compensate for a country's opportunity costs but do so in a way that improves the welfare of regional communities.

[1] The spreadsheets containing the financial modelling are available from the author on request.

Introduction

The state of Papua New Guinea is made up of the eastern half of the island of New Guinea the main islands of New Britain, New Ireland and Bougainville, plus many smaller islands. The country's tropical forests of approximately 293,000 km^2 are subject to logging and conversion to agriculture (Filer at al. 2009) and thereby are the source of greenhouse gases emissions.

Papua New Guinea is classified by the World Bank (2009:353) as a 'low income country', with an average annual income per capita of $1,800.[1] The poorest sections of the community command a very small proportion of national income. Key social indicators such as life expectancy and literacy rates are very low; moreover HIV aids affects 1.8 per cent of the population (World Bank 2009: 353, 355). The population of about 6 million is predominantly rural and in semi-subsistence. An improvement in social indicators requires development and service delivery in regional areas.

The Kyoto Protocol omits the reduction in deforestation and forest degradation (REDD) from the suite of mitigation activities that attract credits under the Clean Development Mechanism, even though it was thought responsible for about 17 per cent of total greenhouse gas emissions.[2] After Stern (2006) reported that compensating for returns from logging and agriculture could abate emissions at relatively low cost there was a heightened focus at the 2007 Bali climate change conference on the pivotal role that REDD could play.[3] This notion was reinforced in the case of PNG and Indonesia, where abatement would be fast (Garnaut 2008a) and cheap (Garnaut 2008b).

Much effort and speculation followed on how REDD might be included in post-Kyoto arrangements for climate change mitigation under both market and funds approaches. Meanwhile, however, the major emitters, with the exception of the EU, had failed to adopt national emission targets and abatement schemes. As a consequence, the Copenhagen climate

change conference in December 2009 was unable to deliver a new protocol to mandate the cuts in emissions that would have stimulated the necessary investment needed for REDD credits to enter the global market. Nevertheless, the Copenhagen Accord (UNFCCC 2009: Clause 5) agreed on the need for positive incentives for REDD-plus through a funds approach[4,5] enabled by the mobilisation of financial resources from developed countries.

The Copenhagen Accord contains a collective commitment by developed countries to provide additional resources for climate change adaptation and mitigation in developing countries, including forestry, approaching $30 billion for 2010-2012, and rising to $100 billion a year by 2020 (UNFCCC 2009; Clause 8). At the same time, Australia, the United States, France, Japan, Norway and Britain pledged $3.5 billion to support immediate steps to implement the Accord (Reuters 2009).

Given the considerable financial resources being mobilised for REDD, this paper focuses on clarifying the costs of REDD to tropical developing countries and to potential investors, whether under international or bilateral arrangements.

Sources of emissions from land use change in PNG

PNG takes a national approach to reduction of emissions, including transport, power generation, and mining and fire as areas where mitigation actions can be taken (Conrad 2010:4). However, PNG is already a very low carbon economy and there is minimal potential abatement from these sectors.

In the case of PNG's forests, their carbon content has for the first time been the subject of a robust assessment of the above-ground carbon (C) stocks for PNG's tropical native forests: Fox et al. (2010: 7) estimated the above-ground carbon in lower montain forests in PNG at 121 T/HaC and in selectively logged forest at 90 T/HaC.[6]

The major causes of deforestation in PNG are commercial agriculture (both estate and smallholder) as well as logging and subsistence or shifting agriculture. In the case of logging and subsistence agriculture the forest regrows. The secondary forests that regenerate after logging may or may not be revisited by the logging companies that hold concessions over that area. The secondary forest that follows shifting agriculture will be cleared again, the length of the fallow interval depending, among other things, on population pressure (Bourke and Harwood 2009).

Almost all of PNG's land and forests are under customary ownership and the bulk of the population still depends for its livelihood on indigenous farming systems. Some 23.5 per cent of PNG's total land area was found to be used by local farmers, 50 per cent being left in fallow for periods of more than 15 years, 43 per cent in fallow for 5-15 years and 7 per cent in fallow for less than 5 years. Tall secondary forest was the typical fallow vegetation cleared for cultivation, primary forest was being cleared at only a few sites (Allen et al. 2001). Where the fallow period has been too short in successive cycles, the land is converted to grassland or shrubs.

While Shearman et al. (2009) claim that subsistence agriculture is a major driver of deforestation, it is erroneous to assume that the logging and subsistence agriculture lead to permanent deforestation. At any one time there is a loss of carbon from newly logged concessions, plus that from previously logged-over areas and from new village gardens being created, but there is also a simultaneous and countervailing sequestration of carbon on most of the area previously used (Keenan 2005; Filer at al. 2009).

Government has little or no capacity to change local farming practices which are already characterised by a high degree of innovation, enabling food supply to keep pace with a growing population in most locations (Filer at al. 2009; Bourke and Harwood 2009). Therefore it is not profitable to speculate on the reduction in carbon emissions that might take place from changes in cultural practices in subsistence or smallholder agriculture. Production of oil palm, cocoa, coffee and rubber by smallholders has been growing over the

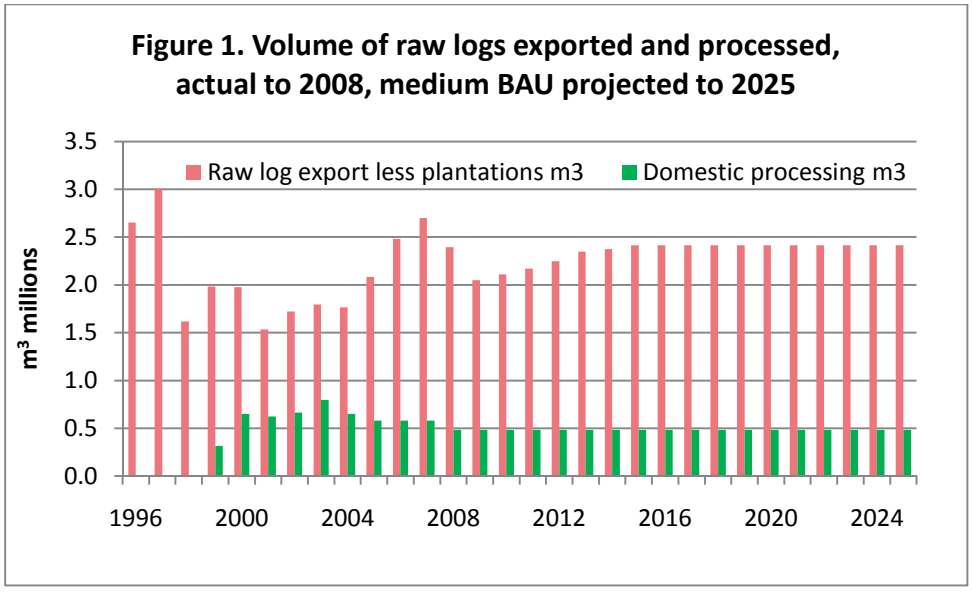
last two decades while estate agriculture has been contracting, except for oil palm and tea; but, again, there is no comprehensive information on impacts of these trends on the carbon cycle.

It is concluded (see Filer at al. 2009; Shearman et al. 2009) that logging is the only area in which deforestation can be readily avoided. In this case the PNG government can intervene in persuading landowners to surrender their rights to the carbon in their forests, in exchange for future rewards, rather than for logging. The analysis in this paper is facilitated by an assessment of the carbon contained in PNG forests (Fox et al. 2010) and by modelling of the loss of carbon due to selective logging[7], as well as the loss of carbon associated with the rapidly expanding area under oil palm (Fox et al. 2009).

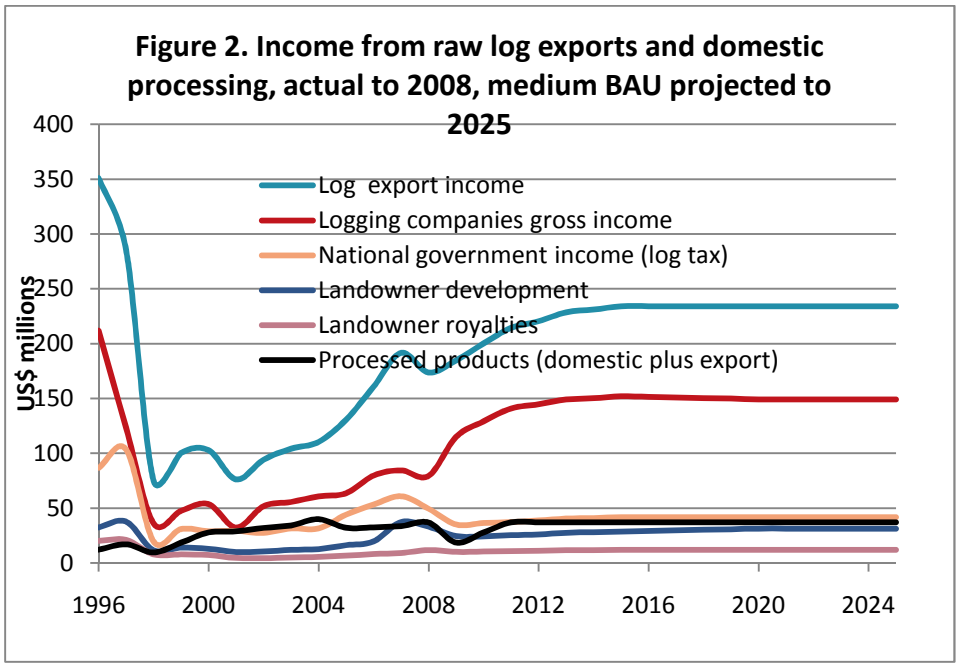
Methods

The aim is to derive the costs per tonne of CO_2 emissions avoided by reducing the removal trees for raw log exports, as well as the conversion of forest to palm oil plantations. In the case of logs and palm oil, PNG is a price-taker but no account has been taken of commodity price rises that would likely accompany widespread and successful efforts to halt deforestation.

In modelling the level of log extraction that would take place under a business as usual (BAU) scenario, it is necessary to take into account market conditions for raw logs and the availability of the resource for exploitation by logging companies. The market for raw logs has been impacted since mid-2008 by the global financial crisis, and PNG production under a business as usual (BAU) scenario is expected to recover and plateau at almost 3 million m^3. Of this, 2.5 million m^3 is raw logs extracted for export and 0.5 million m^3 is for domestic processing.[8] Total log volumes extracted are in Figure 1.



The free on board (fob) value of log exports and the shares to stakeholders, logging companies, landowners and government, both historically and under a BAU scenario, together with the value of processed product, are show in Figure 2.



Fox et al. 2009 estimate that, on average, selectively-harvested forest has 50t C/ha less above ground live biomass than primary forest immediately after harvesting.[9] The Fox et al. (2009) model of carbon dioxide CO_2 (the main greenhouse gas) emissions takes account of not only the removal of biomass in the form of logs, but also the $CO_{2\ emitted}$ by the decomposition of smallwood and largewood resulting from collateral damage, emissions from timber harvesting and transport operations, together with the rate of carbon sequestration on areas of successful forest regeneration and the storage of carbon in wood products.

Actual and modelled abated emissions under the medium BAU scenario are in Figure 3. The decline in actual and abated emissions after 2014 is caused by the cumulative impact of carbon sequestration in successful regeneration. Emissions abated under the high, medium and low projections are in Figure 4.

Figure 3. CO_2 emissions from logging, actual to 2008, medium BAU projected to 2025 and abated from 2012

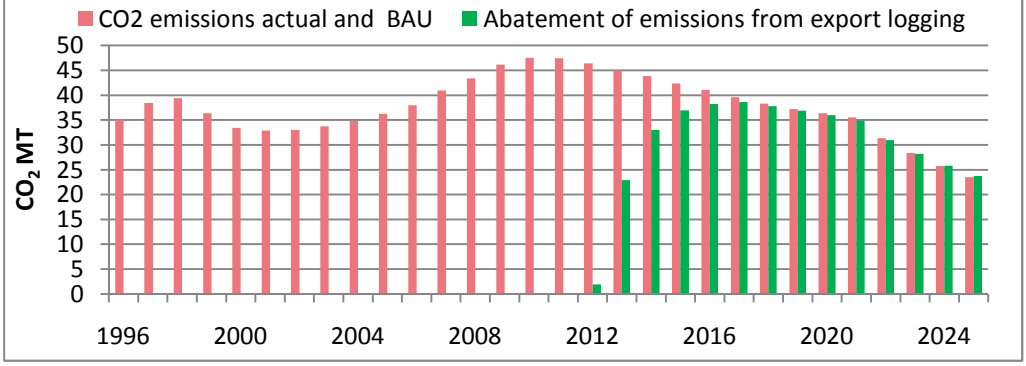
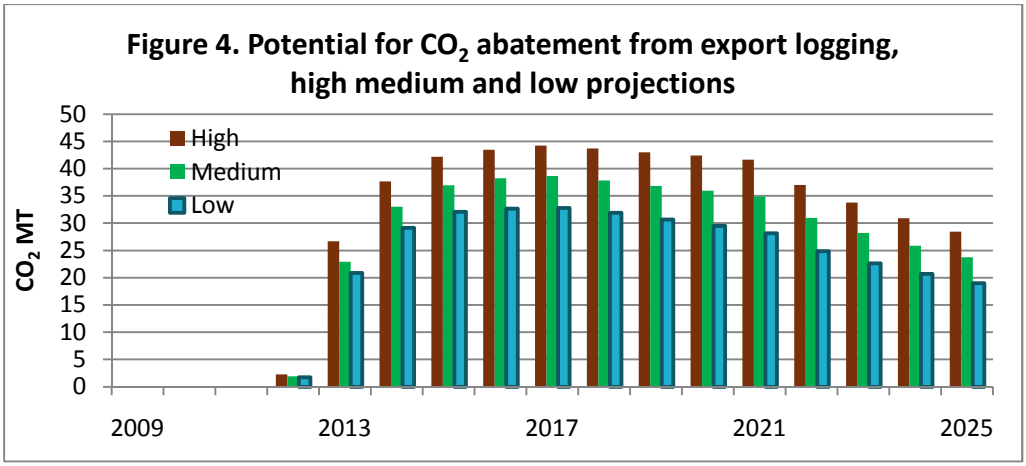


Figure 4. Potential for CO_2 abatement from export logging, high medium and low projections



The opportunity costs of a cessation of logging in 2012 to 2025 in PNG

A REDD scheme in PNG could be expected to be designed to reduce the export of raw logs in preference to a reduction in the production of logs for the domestic market; the latter would have greater consequences for employment and supply of timber in the domestic market.

Government revenues benefit from log taxes and landowners benefit directly from royalties and indirectly from development funds set aside from export revenues based on the volume and fob value of logs. Logging company's benefits are their net profits earned, but logging company annual reports of the twenty or so mainly foreign-based companies are not accessible. Net profits are therefore estimated at 30 per cent of gross incomes. It is likely that the compensation paid to logging companies would be based on net profits expected to be earned from their concessions by 2025.[10] It is unlikely that there would be a cessation in logging before 2012 given that arrangements would need to be in place, not only for compensation for government and landowner revenues foregone and logging company profits foregone, but also for REDD-plus monitoring, reporting and verification.

The first method of assessment of the total opportunity costs per tonne of carbon dioxide (CO_2) through the cessation of logging from 2010 to 2025 is based on the expected revenues of government and landowners, plus 30 per cent of the gross revenues of logging companies.

The second method focuses on the opportunity costs of a cessation in logging in terms of reduced national income. Logging companies, government and landowners are assumed to spend half their incomes from the export of logs on goods, services and wages in PNG. In applying the multiplier, the propensity to spend is assumed to be 0.5.

Estimation of national income opportunity costs is in (1).[11]

$$AD=(EX+T+R+D)*0.5*1/(1-P) \quad (1)$$

Where:

AD= Aggregate demand=National income

EX=logging company expenditure in PNG

T=Government log export tax receipts spent in PNG

R=Landowner royalties spent in PNG

D=Landowner development Spent in PNG

P=Propensity to spend= 0.5

The present cost per tonne of emissions avoided, in the case where government tax receipts, landowner royalties, landowner development benefits and profits to logging companies are foregone, is in (2).

The present cost per tonne of emissions avoided, in the case where log export income is the opportunity cost, is in (3).

The present cost per tonne of emissions avoided, in the case where national in the economy is the opportunity cost, is in (4).

$$\sum_{n=1}^{16}((T_n+R_n+D_n+(L_n*0.3))/(1+r)^n/\sum_{n=1}^{16}CO_2/(1+r)^n \quad (2)$$

$$\sum_{n=1}^{16}ET/(1+r)^n/\sum_{n=1}^{16}CO_2/(1+r)^n \quad (3)$$

$$\sum_{n=1}^{16}AD/(1+r)^n/\sum_{n=1}^{16}CO_2/(1+r)^n \quad (4)$$

Where:

n=years 2012-2025

T=Government log export tax receipts

R=Landowner royalties

D=Landowner development

LNP=Logging companies net profit

CO_2= CO_2 emissions avoided

ET=Export income

AD=Aggregate demand= National income

r= 0.1

Results for opportunity costs of logging

The quantity of CO_2 emissions mitigated, and results for the opportunity costs per tonne of CO_2 emissions avoided by the cessation of export logging for stakeholders (companies, government and landowners) is US$3.85 and for export income is US$6.65 per tonne and for national income is US$8.20 (see Table 1). These results are for the medium projections of BAU; forecasts are made for high, and low fob prices and export volumes of logs, as well as for the consequential high and low incomes to stakeholders, and high and low emissions avoided. Appendix Table A.2 shows the results of the sensitivity analysis.

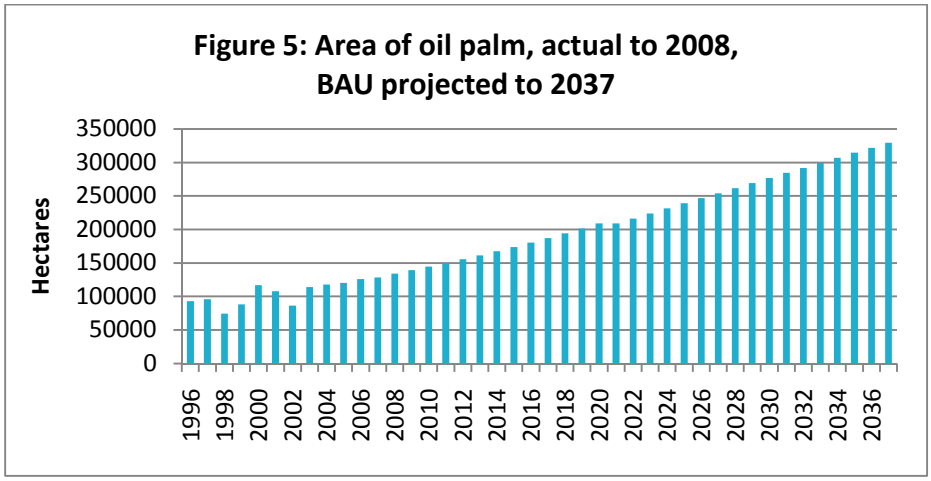
Table 1: Quantity of CO_2 emissions abated and opportunity cost per tonne of CO_2 by cessation of export logging 2012-2020, medium projection of BAU

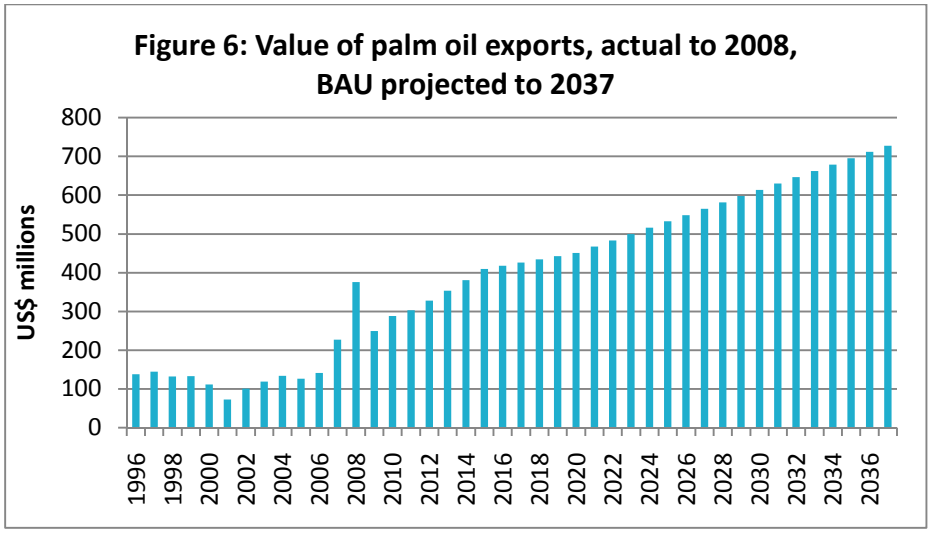
Abatement CO_2 TM		Opportunity Cost (NPV) US$/TCO_2	
Total	426.0	Loggers	1.11
Average per year	26.6	Government	1.41
		Landowners	1.34
		Total stakeholder income	3.86
		Export Income	6.65
		National income	8.20

The opportunity costs of a cessation of conversion to oil palm in PNG

The production of fresh fruit bunches is by company plantations surrounded by smallholders. Company mills, at the operational centres of the nucleus estates, process production from the estate and the peripheral smallholder plantations.

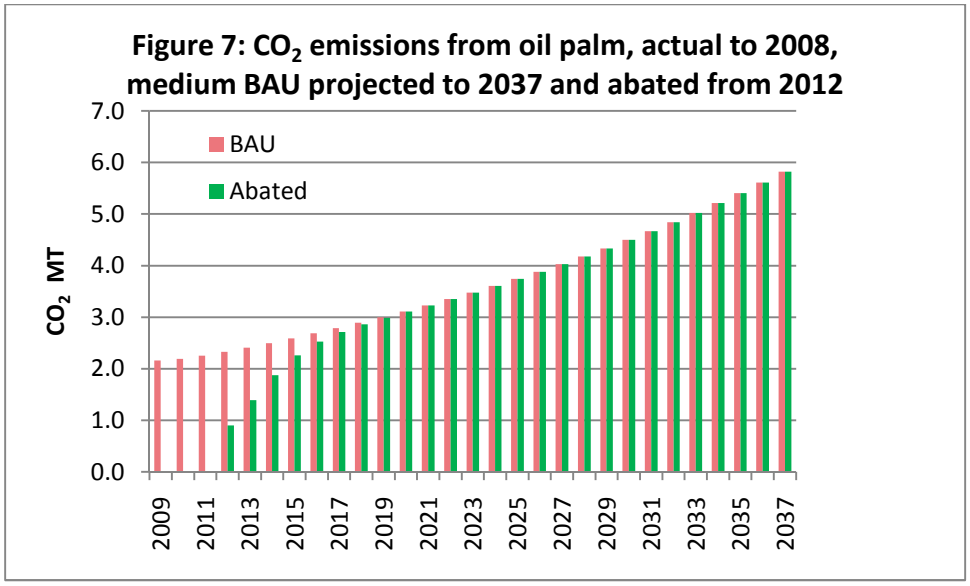
Figures 5 and 6 show the area of oil palm and export value of palm oil, actual and projected, respectively, for PNG. Expansion of the industry is expected to continue for the foreseeable future, given the strong demand for palm oil and palm oil products.

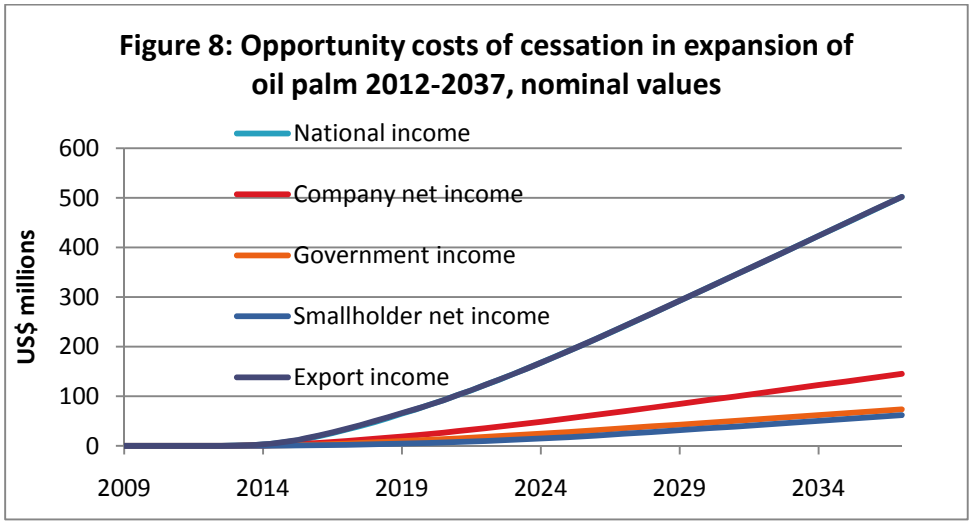




The annual reports for only one of the five companies producing palm oil in PNG, New Britain Palm Oil, are publicly available. The annual reports of the four other companies, three owned by Minneapolis-based Cargill, are not accessible. However, New Britain Palm Oil is responsible for half PNG's production and export. Production, income, government tax and expenditure by PNG-based palm oil companies can thus be estimated with a reasonable level of confidence.[12] Expenditure on goods and services and wages, much at regional level in a decentralised industry, is estimated to total $370 million in 2008. There are thus large regional and multiplier effects of oil palm company expenditures.

Figure 7 shows the emissions from oil palm and the abatement achieved by a cessation of the establishment of new plantations from 2012. Figure 8 shows the nominal values of the opportunity costs and the incidence of costs.





Note: National income and export income appear as one line.

The same methodology is followed as for logging in estimating opportunity costs. Estimation of national income is in (5)

AD=(CE+T)*0.5*1/(1-P) (5)

Where:

AD= Aggregate demand=National income

CE=Palm oil company expenditure in PNG

T=Government income tax receipts spent in PNG

P=Propensity to spend= 0.5

The costs to stakeholders, in this case the palm oil companies, and to the stakeholders, are identified.

$$\sum_{n=1}^{16}(C+S+T)/(1+r)^n/\sum_{n=1}^{16}CO_2/(1+r)^n \quad (6)$$

$$\sum_{n=1}^{16}EPO/(1+r)^n/\sum_{n=1}^{16}CO_2/(1+r)^n \quad (7)$$

$$\sum_{n=1}^{16}AD/(1+r)^n/\sum_{n=1}^{16}CO_2/(1+r)^n \quad (8)$$

Where:

n=years 2012-2020

C=Palm oil companies

S=Smallholders

T=Government income tax receipts

CO_2= CO_2 emissions avoided

EPO=Export income

AD=Aggregate demand=National income

r= 0.1

Results for the opportunity costs of palm oil

The present value of the opportunity cost per tonne of CO_2 abated in the case of a cessation in the conversion of forest to oil palm is much higher than for logging. The opportunity cost in terms of export income and national income is $36.54 and $36.39 per tonne of CO_2

respectively, in terms of stakeholders $19.84, made up of palm oil company net profit $10.57, smallholder net profit $3.93 and government tax $5.34 (see Table 2).

Table 2: Quantity of CO_2 emissions mitigated by cessation of conversion to oil palm and opportunity costs, 2012 to 2020

Mitigation CO2 TM		Opportunity Cost (NPV) US$/T CO_2	
Total	95.5	Smallholders	3.93
Average per year	3.4	Government	5.34
		Companies	10.57
		Total Stakeholders	19.84
		National income	36.39
		Export income	36.54

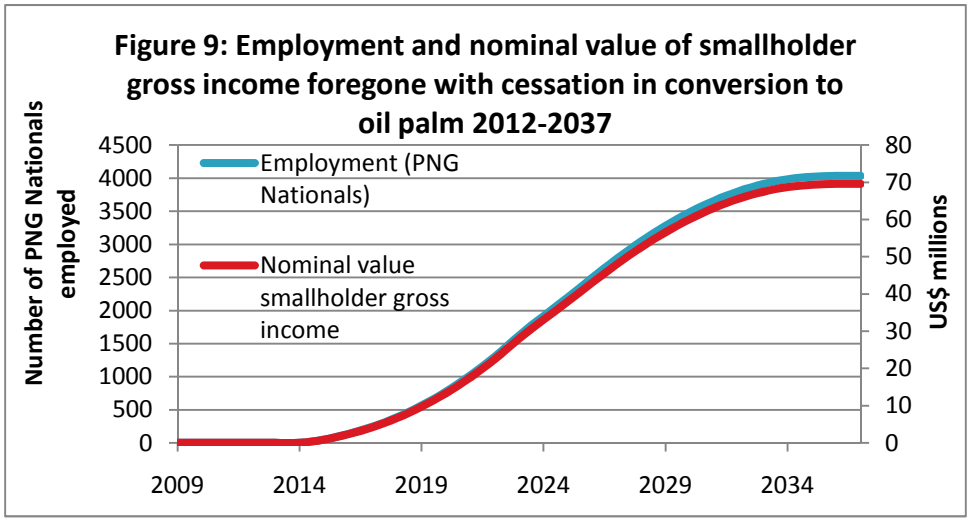
The industry will be reducing its cabin footprint by establishing third on new oil palm plantations on already cleared land (Ian Orrell, Director of the PNG Oil Palm Research Association, personal communication). This will increase the opportunity cost of a cessation of new plantings from 2012, as shown in Appendix Table A3.

Socio-economic opportunity costs

Regional employment and incomes would be affected by a cessation in logging and new oil palm establishment. It has been estimated (FAO 2005) that 8,000 landowners at any one time receive monetary benefits through the provision of wage labour to logging companies.

In 2008 there were almost 14,000 PNG Nationals employed in the industry as well as 52,000 smallholders supplying the mills (Ian Orrell, Director of the PNG Oil Palm Research Association, personal communication). An illustration of the social costs incurred by the cessation of new oil palm in 2012, is the estimation that the loss in employment by PNG nationals would peak at 4,000 and the loss in smallholder gross receipts at over US$70 million, as a result of the cessation in new oil palm plantings (see Figure 9). (No estimate is

made in the increase in number of smallholder as this will depend on the expansion in area planted by existing smallholders.)



Results of other studies

Grieg Gran (2006) in a report to Stern (2006) estimated the opportunity costs of a cessation in logging in PNG at $5 per tonne of CO_2 abated; Busch at al. (2009) suggested a cost of 2.24/T CO_2 for PNG, while a survey by Olsen and Bishop (2008) found the financial cost of logging in South-east Asia and the Pacific to be $3.44/T CO_2.[13] A survey by Boucher found similar levels of average costs for at $2.90/T$CO_2$.

In the case of palm oil, Grieg Gran (2006) estimated the cost at $17/T CO_2 for estates and $5 for smallholders;[14] this study was undertaken before the rises in palm oil prices in 2007 and 2008. According to Olsen and Bishop (2009) most palm oil production generated returns of $3.00 to $7.00/ T CO_2. Boucher found intensive agricultural costs to average $2.83.

A recent study by Venter et al. (2009) on the opportunity costs of stopping deforestation in Indonesia, based on the after-tax profits of palm oil companies, arrives at a cost per tonne of

CO_2 emissions avoided of $10-33. Butler et al. (2008) found a before-tax cost per tonne of CO_2 avoided in Indonesian palm oil of $22-56 (the tax foregone was not quantified). These latter two estimates included costs of administration of a REDD compensation scheme. [15,16]

In these latter studies, the profit earned by the smallholder growers attached to the private palm oil companies' estates and by the independent smallholders, who supply the processing mills of the private companies, is ignored as an opportunity cost. Smallholders production is profitable with internal rates of return from 12 to 21 percent (Zen et al. 2005: Table 4) and constitutes about a third of total production and palm oil palm area (Kadin-Jetro, 2006: Table 1).

Opportunity costs are likely to rise appreciably if smallholder profits and government income are included in estimates. The PNG case study estimates the opportunity costs of smallholder oil palm and government income at $3.93 and $5.34/$TCO_2$ abated almost equalling the opportunity costs of company net profits of $10.57/TCO2 (Table 2).

Issues in compensation

The incentive for stakeholders to accept REDD is the receipt of income at least comparable with that which they would have received under BAU. The national government must be concerned that compensation matches not only its tax revenue foregone but is also paid at a level, and designed to be in a form, that generates a similar level of national income.[17] A developing country such as PNG might take the stance that export income, necessary for funding imports, is an important indicator of compensation.

In PNG, the likelihood is that the multinational companies involved in log and palm oil exports would move their investment and business offshore.[18] This would result in not only the loss of export income but also the cessation of the considerable spending by the companies on wages, goods and services that contribute to national income.

In addition to issues of national economy there are also imposing development issues in relation to REDD. The industries targeted for REDD, logging and palm oil, are both decentralised, contributing to regional employment and smallholder income generation, which are otherwise scarce, and to regional aggregate demand. The industries would appear to have an important role in restricting the drift to urban centres where there is high unemployment and a high level of crime.

A benefit of compensation to landowners for REDD is that it would be in the form of an annuity rather than as a one-off payment, as for logging royalty. In PNG, in the case of REDD compensation for logging, some $40 million (in nominal terms) would be available annually for landowners. It is not immediately apparent that there are regional development alternatives available that do not use the forest resources or land converted from forest. (An alternative is to pay the REDD annuity in cash to each landowner. But cash annuities would be in small amounts, relative to log royalty, and would likely to be consumed.)

As in PNG, Indonesia palm oil production is decentralised and contributes to wealth distribution to some of the poorest parts of the archipelago. Some 500,000 smallholders making profits (and directly affecting a total of approximately 2 million people) plus 1.2 labourers are beneficiaries (Zen et al, 2005:2). It can be argued that, on socio-economic grounds, such regional wealth creation and distribution would need to be matched by a REDD scheme.

In the case of PNG, if compensation were to be paid at the rate of $5.00/T CO_2 (a rate between total stakeholder and export income opportunity cost) for the cessation of logging between 2012 and 2025, the nominal outlay for the 426 million tonnes of CO_2 abated would be $2.13 billion, which has a present value (10 per cent discount rate) of $855 million.

The discussion would be incomplete without reference to forestry activities that might increase as a result of a cessation in industrial export logging. These include illegal logging

and small-scale forestry, emissions from which would go unrecorded and would undermine abatement under a REDD initiative.

While the administration of REDD scheme faces challenges in the negotiation of adequate national compensation that is also equitable for stakeholders, it also faces a challenge of ensuring that that REDD payments by donors to government actually reach the stakeholders. The risk is broadly illustrated by the ranking of PNG at 154 out of 180 countries in the Transparency International (2009) corruption index.

Issues in biodiversity conservation

There is asymmetry in the availability of funds for environmental services. Funds for carbon retention are not matched by funds for biodiversity conservation and REDD funds will tend to be deployed where abatement is cheapest regardless of the biodiversity value of the forest protected. This bias needs to be corrected by incorporating in REDD schemes strategies that maximise biodiversity conservation, see for example Laurance (2008) and Venter et al. (2009).

Baselines and moral hazard

Tropical developing countries will be tempted to inflate their BAU projections of deforestation in order to maximise their compensation. A case of this seems to exist in PNG. In the country's "Preliminary Inscription", forwarded to the UNFCCC under the Copenhagen Accord, PNG claims that its CO_2 emissions from forestry are 50-52 MT in 2010 and that this will increase to 53-64 MT by 2030, and the abatement that can be delivered by 2030 is 50 per cent of this is, i.e. 26-32 MT. Agriculture is also expected to expand greatly, creating large abatement potential of 15- 27 MT by 2030 (Conrad 2010:4).

While present emissions from logging are estimated by Fox to be 46.5 MT, which is roughly in line with the government's own figure, the increase in logging to 2030 is highly unlikely

given that as mentioned above, the accessible resource is likely be exhausted by 2025 at current rates of exploitation (Fox et al. 2010:1). Moreover discussions with industry (Personal communication, Bob Tate, Executive Officer, Forest Industries Association Inc (FAI) and members of the FIA Board, December 2009) indicated that, because of increasing costs of logging and diminishing profitability, the volume of log exports is likely to recover but only to a modest level, similar to that modelled in Figure 1. This paper suggests that emissions from forestry, and abatement opportunities, will peak at 37 million tonnes, decline subsequently and then cease in 2025, as illustrated in Figure 3.

In the case of agriculture no accurate data on emissions exists for the bulk of agricultural production. Oil palm, which is by far the fastest growing agricultural crop, is estimated to rise to 4.5 MT CO_2 by 2030 (see Figure 7). Only one third of new plantings are expected to be accommodated on already cleared land, which delivers abatement of 1.5 MT CO_2 tonnes in 2030. The proposition that emissions from subsistence agriculture can form part of the massive abatement proposed by PNG to the UNFCCC has already been addressed in this paper. It was concluded first, that subsistence agriculture is already efficient and, second, the government has no control over subsistence agriculturalists tilling their own land.

Summary and conclusions

Influential economists have asserted that reduction in greenhouse emissions can be had quickly and, relative to the cost of abatement by developed countries, cheaply in tropical developing countries. Recent studies have reinforced the notion that REDD will be a relatively low-cost way of abating greenhouse emissions.

In PNG robust models have recently become available for CO_2 emissions generated by logging of primary forest and palm oil establishment on selectively logged forest. The models enable the estimation of opportunity costs in terms of the present value of income foregone per tonne of CO_2 emissions abated over time. In the case of the logging the forecasts are for 2012 to 2025 and in the case of palm oil for 2012 to 2037.

The modelling of the expected business as usual trajectories of these industries enables the estimation of opportunity costs in terms of present value of income foregone, as follows:

- net profits and incomes of stakeholders (landowners, smallholders, governments, logging and palm oil companies)
- export income
- national income.

This approach recognises that opportunity costs are borne by stakeholders other than companies; that is, government, landowners and smallholders and is in stark contrast to recent Indonesian studies of opportunity costs of REDD in palm oil that have ignored the profits earned by smallholders or government revenues, or both. Taking a national approach – an approach which it is argued is likely to be taken by tropical developing countries interested in receiving REDD compensation – could push compensation claims considerably higher than suggested by profits foregone by stakeholders

In the case of oil palm in PNG, stakeholder and national opportunity costs are sufficiently high to rule out REDD as an economical option. That is unless there is a marked rise in international prices paid for CO_2 emissions abated. While the cost of REDD in the case of logging will likely be higher than hitherto suggested, its price is still reasonable and delivers a large quantity of abatement.

An enormous challenge for PNG is the design of management arrangements that effectively deliver REDD compensation, particularly in the case of payments to the customary owners of the forest resource. The likely relocation offshore of PNG and logging and palm oil companies raises the important issue of leakage and brings into focus the need for regional or even global approaches to managing abatement of emissions by REDD.

The political and financial risks in REDD and its compensation for both developing country governments and donors are high, which may prompt developed countries to revise their commitments to abating their own emissions.

Appendix1: Emissions from land-use change and forestry

There is a great deal of uncertainty in the estimation of GHG emissions from land-use change and forestry (LUCF) in tropical countries, in a particular year. The likely errors stem from the estimation of biomass lost per hectare through land conversion as well as from errors in estimation of forest hectares converted (Houghton 2005). The volatility and variation in country estimates is highlighted in Appendix Table 1.

Appendix Table A1. Reported emissions Land Use Change and Forestry, PNG and Indonesia 2009 and 2010

Country	Source	2009 MT	2010 MT
PNG	WRI (2009; 2010)*	146	44
	Busch et al. (2009)	n.a.	104
Indonesia	WRI (2009; 2010)*	2563	1462

WRI (2009) Version 6; WRI (2010) Version 7.

Appendix 2: Abatement alternatives in PNG forestry

While this paper focuses on a cessation of logging, the feasibility of the enhancement of carbon stock recovery in logged areas through post-harvest reforestation and through reduced impact logging needs to be discussed, as both activities qualify under REDD-plus.

The collateral damage of logging causes large gaps in the forest canopy which encourages the growth of low-value pioneer tree species and shrubs. These gaps can be filled with transplants of desirable species, an activity termed enrichment planting or 'reforestation naturally'. Rehabilitation of logged-over areas should enhance the value of regenerating forest, making a second cut by loggers more economical and more likely. However, enrichment planting is hard to justify economically and has not been successful in PNG even though levies have been collected for that purpose. Moreover, such rehabilitation may not increase the sequestration rate of carbon by the forest given that pioneer species are faster growing than desirable species. And if rehabilitation enables a second cut then the carbon loss and environmental losses incurred are increased.

Collateral damage from selective harvesting presently generates large quantities of decomposing biomass, including tree crowns, non-merchantable forest and adjacent trees killed, and was found to release 45 TC/ha (Fox et al. 2009). It is generally recognised that the most effective way to improve the growth rates of the remaining trees is to carefully plan and control the harvesting process. Such low impact logging would also reduce the level of emissions associated with biomass decomposition. However, logging companies see no benefit in reducing collateral damage and minimise their costs of operations; the evidence is that adherence to the *Logging Code of Practice* (PNGFA 1995) is very patchy (Hunt 2002). While the retention of carbon provides an incentive for the adoption of low impact logging, its costs and benefits are uncertain and cannot be quantified with any confidence.

Appendix 3: Sensitivity analysis

Table A2: Quantity of CO_2 emissions abated and opportunity cost per tonne of CO_2 by cessation of export logging 2012-2025, A:Low, B:Medium and C:High projection of BAU

A: Low projection

Mitigation CO_2 TM		Opportunity Cost (NPV) US$/TCO_2	
Total	356.8	Loggers	0.88
Average per year	22.3	Landowner	1.09
		Government	1.08
		Total stakeholder income	3.05
		Export income	5.10
		National income	5.10

B: Medium projection

Mitigation CO_2 TM		Opportunity Cost (NPV) US$/TCO_2	
Total	426.0	Loggers	1.11
Average per year	26.6	Landowner	1.34
		Government	1.41
		Total stakeholder income	3.85
		Export income	6.65
		National income	8.20

C: High projection

Mitigation CO_2 TM		Opportunity Cost (NPV) US$/TCO_2	
Total	497.3	Loggers	1.50
Average per year	31.1	Landowner	1.51
		Government	1.74
		Total stakeholder income	4.75
		Export income	8.25
		National income	8.25

Table A 3: Quantity of CO_2 emissions mitigated by cessation of conversion to oil palm and opportunity costs, 2012 to 2037,
A: 1ha forest converted/1ha oil palm; B: 2/3 ha forest converted/1 ha oil palm

A

Mitigation CO_2 TM		Opportunity Cost (NPV) US$/T CO_2	
Total	95.5	Smallholders	3.93
Average per year	3.4	Government	5.34
		Companies	10.57
		Total stakeholder income	19.84
		National income	36.39
		Export income	36.54

B

Mitigation CO_2 TM		Opportunity Cost (NPV) US$/T CO_2	
Total	63.67	Smallholders	5.90
Average per year	2.2	Government	8.02
		Companies	15.86
		Total stakeholder income	29.78
		National income	45.56
		Export income	54.81

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Endnotes

[1] All dollars are US$.

[2] See Houghton (2003), Houghton (2005) and Canadell et al. (2007). More recent estimates are that deforestation and degradation generates about 12 per cent of anthropogenic CO_2 emissions (Le Quéré et al. 2009; van der Werf et al. 2009).

[3] Although Stern did add that "This level of financial incentive would offset lost agricultural income to producers, *although it would not reflect the full value chain within the country*" (emphasis the author's) (Stern 2006: 610).

[4] The underpinning principles of REDD-plus are:

- REDD-plus finance mechanisms should be sufficiently robust to deal with in-country and international leakage, use credible baselines, must achieve verifiable additionality, and result in value for money.

- REDD-plus should lead to real reductions in CO_2, enhance forest ecosystem functions and the supply of critical ecosystem services, protect and respect the rights of Indigenous Peoples and local communities, and ensure equitable benefit sharing.

- In addition to reducing emissions from deforestation and forest degradation REDD-plus finance mechanisms should also create incentives for additional actions in forest conservation, sustainable forest management, and the enhancement of carbon stocks REDD-plus processes should allow the broad participation of all stakeholders, on equitable terms, at the national and international levels (The Forests Dialogue, 2010).

[5] A market approach to REDD requires that a tonne of CO_2 abated by forest conservation equates a tonne abated by all other means. Given the idiosyncrasies of forests this will be difficult to guarantee, therefore a funds-based approach is most appropriate until the problems of abatement by REDD, in terms of monitoring, verification and reporting, are solved (Hunt 2009).

[6] This level of aboveground carbon is much lower than estimates for equivalent forests in South-east Asia, where estimates are for 240 to 260 T/ha (Fox et al. 2010:6). An explanatory hypothesis is that carbon stocks in PNG are reduced by the frequency of disturbances, including ENSO related droughts and associated fires, landslides and shifting agriculture (Fox et al. 2010).

[7] Harvesting is selective in that logging companies concentrate on removing high value species with diameters greater than 50 cm.

[8] Projections for logging volumes at the 'medium' level were validated in personal communications with Bob Tate, Executive Officer of the Forest Industries Association Inc that represents the logging industry in PNG.

[9] One tonne of C=3.67 tonnes of CO_2.

[10] It is generally agreed among researchers in the field that the accessible forest resource will be exhausted by 2025 if the current rate of logging continues (Fox et al. 2010:1).

[11]Equation (1) delivers a multiplier of 1, the average found by Hemming at al. (2002: 36) for spending.

[12] Projections for the area of oil palm establishment were validated by Ian Orrell, Director of the PNG Oil Palm Research Association.

[13] Olsen and Bishop (2009:1) deliberately set out to identify financial costs "[A]ctual costs to individual investors", ignoring revenues foregone by stakeholders and costs to the economy.

[14] Grieg Gran's (2006) costings were per hectare for logging and palm oil – these have been converted to costs/T CO_2 abated by the author.

[15] The costs of administration of REDD were \$0.22/T CO_2 abated by Butler et al. (2008) and \$4.55/T by Venter et al. (2009).

[16] Discount rates employed were 10 per cent by Grieg Gran (2006) and Butler (2008), and 8.00 per cent by Venter et al; while this study employs 10 per cent.

[17] Pagiola and Bosquet (2009) make the point that if compensation and forestry activities have different economic impacts then the opportunity cost needs to be adjusted accordingly.

[18] See Pirard (2008) for a discussion of the implications of post-REDD investment strategies of companies in the Indonesian pulp sector.