Ecological Economics xxx (2009) xxx–xxx

Contents lists available at ScienceDirect

Ecological Economics

journal homepage: www.elsevier.com/locate/ecolecon

Analysis

The cost of carbon abatement through community forest management in Nepal Himalaya

Bhaskar Singh Karky [a,*], Margaret Skutsch [b,c,1]

[a] Economic Analysis Division, International Centre for Integrated Mountain Development, GPO Box 3226, Kathmandu, Nepal
[b] Centro de Investigaciones en Geographía Ambiental, Universidad Nacional Autonoma de Mexico, Morelia, Mexico
[c] University of Twente, PO Box 217 7500 AE Enschede, The Netherlands

ARTICLE INFO

Article history:
Received 30 March 2009
Received in revised form 9 October 2009
Accepted 9 October 2009
Available online xxxx

Keywords:
Abatement cost
Community forest
Carbon sequestration

ABSTRACT

This paper estimates the economic returns to carbon abatement through biological sequestration in community managed forest under future REDD policy, and compares these for three possible management scenarios. For the estimation, the research relies on forest inventory data together with other socio-economic and resources use data collected from forest users in three sites of Nepal Himalaya. The paper estimates the incremental carbon from forest enhancement on a yearly basis over a five-year period using the value of $ 1 and $ 5 per tCO_2 for conservative analysis. The results based on the three sites indicate that community forest management may be one of the least cost ways to abate carbon with a break-even price under Scenario 2 which ranges from $ 0.55 to $ 3.70 per tCO_2. However, bringing community forests into the carbon market may entail high opportunity costs as forests provide numerous non-monetary benefits to the local population, who regard these as the main incentive for conservation and management. An important finding of the research is that if forest resources use by local communities is not permitted, then carbon trading will not be attractive to them as revenue from carbon will not cover the cost foregone by not harvesting forest resources.

1. Introduction

New policy entitled 'Reduced Emissions from Deforestation in Developing Countries' (REDD) is under consideration by the United Nations Framework Convention on Climate Change (UNFCCC). If this policy is adopted, carbon abated by reducing deforestation and degradation and by forest enhancement may be eligible for carbon crediting. This opens the possibilities for communities that are engaged in forest management to participate in the global carbon market. Whether they will do so depends in part on the costs and benefits that they face in participating in this market.

The paper estimates the cost of carbon abatement by community forest management (CFM). Sequestration rates were measured in the field in three community managed forests in the Himalaya region of Nepal. The paper starts by reviewing literature on the cost of reducing carbon from forestry in general. It then explains the type of baseline or reference scenario that would be needed to estimate carbon credit under community forestry. Participation in the carbon market will involve costs as well as benefits. Different scenarios were created for a gross margin analysis, and the breakeven price of carbon offsets for each site and the net benefits are estimated under each of the scenarios. It is clear that to provide an incentive to communities to participate voluntarily in carbon trading, there must be a net gain.

The objective of this paper is to assess how the benefit of forest management and carbon measurement compares with the probable income from sale of carbon credits, thus establishing whether carbon trading could be profitable for local communities under a variety of management conditions. The underlying consideration is to assess whether this trade would deliver more benefit to communities than they currently derived from CFM. If this is the case, then there may be scope for community forest user groups (CFUGs) in Nepal to participate in the global carbon market under the UNFCCC REDD policy in the post Kyoto treaty.

The methodology adopted in this study included biomass survey for assessing carbon stock, following the IPCC (2003) Good Practice Guidelines. Gross margin data were collected through a socio-economic survey and through Focus Group Discussions in three sites (Ilam, Lamatar and Manang). To obtain the necessary economic data a reference scenario was created. Carbon credits were estimated on the basis of annual net increment of stock, over a five year period from 2004.

* Corresponding author. Tel.: +977 1 5003222, +977 9851072991(mobile); fax: +977 1 5003277.
E-mail addresses: bkarky@icimod.org (B.S. Karky), m.skutsch@utwente.nl (M. Skutsch).
[1] Tel.: +31 53 4893545; fax: +31 53 4893087.

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doi:10.1016/j.ecolecon.2009.10.004

2. Review of studies on the costs of reducing carbon emissions from forests

There is a growing amount of research investigating the cost of reducing forest carbon emissions. Emission reduction from reduced deforestation could be one of the least cost solutions in reducing atmospheric carbon. The Stern Review (Stern, 2007) analyzed data from eight countries in the tropics and estimated that the cost of stemming deforestation would be under $ 2 per $t\mathrm{CO}_2$ for 65% of the world's forest, which is similar to the value estimated by Eliasch (2008).These values are very low and highly competitive with carbon savings resulting from energy interventions, and well below the expected costs of damage per ton of CO_2. In other studies however higher costs have been estimated.

Nabuurs et al. (2007:543) for example estimated that reductions could be achieved for $20 or less per $t\mathrm{CO}_2$ with large variation between regions. In all estimates of carbon reduction costs, the main element is the opportunity cost of use of land. This varies considerably from place to place, depending on what the alternative use of the land would be. Van Kooten et al., (2004: 248), estimate that when opportunity cost is taken into account, the price of $t\mathrm{CO}_2$ will be from $ 12.27 to more than $ 354.55. Interestingly Van Kooten et al., (2004: 246) also show carbon reductions from planting of forest (afforestation and reforestation) will be 257–297% more expensive than forest conservation (i.e. avoiding deforestation) and agroforestry 261% more expensive than conservation. These findings are derived from case studies spanning tropical to non-tropical areas and covering 55 different case studies.

Most studies on the opportunity costs of avoiding deforestation are based on marginal cost analysis, and on discounting of the future production benefits foregone over e.g. a 30 year period. There is considerable doubt as to whether this method is appropriate, given that a one-off payment at time T1, representing these future benefits, may not in reality be sufficient to deter later clearance of the forest. Moreover, if deforestation were to be stopped over large areas there would clearly be knock-on effects as prices of the forest products would rise. For a more accurate picture, a general equilibrium model would have to be constructed. Sathaye et al. (2006) have made global estimates using a partial equilibrium model, but these take into account a much broader range of costs and their results are not directly comparable with the local opportunity costs which are presented here.

All the studies available in the literature on costs and opportunity costs of avoiding loss of carbon stocks from forest refer, usually implicitly, only to deforestation and not to degradation. Deforestation implies a complete change of land use from forest usually to agriculture, pasture, or urban development. Degradation in the context of climate change mitigation implies that the forest remains forest, but with a lower density of biomass. Although in some humid tropical forests degradation is associated with selective logging for high value timbers, over the vast majority of tropical forests including dry and savannah forests, and indeed in the Himalayan forests of Nepal, degradation is related to over-exploitation of forest products by local communities for subsistence purposes and sometimes for trade. By and large, community forest management can be said to counteract these kinds of degradation. The opportunity costs of this have not been considered up to now.

3. Community forest management in Nepal

The concept of CFM emerged in response to the deteriorating condition of the state-controlled forests in the late 1970's. Nepal's forestry sector has under gone a paradigm shift that reflects devolution of forest resources from state control to community control (Gilmour and Fisher, 1991; Hobley, 1996).

Under state management, forests were prone to 'the tragedy of the open access' (Ostrom, 1990); anyone and everyone had unlimited access any time because the state owned the resource. This was turned around by implementing CFM and handing over forests to local communities in the 90's. Usufruct rights were spelled out for the commons (Gilmour and Fisher, 1991; Hobley, 1996) and deforestation rates were considerably reduced, particularly in the hills (Acharya & Sharma 2004; Banskota, 2000). At present over 1.1 million ha, or about one quarter of the country's forest (Kanel, 2004), is being managed by communities with 93% of this is in the hills and 7% in the Terai (plain areas) (Springate-Baginski et al., 2007: 47).

Handing over forests to communities for management has gradually improved the forest condition (Malla, 1997) with positive impacts on biodiversity conservation (Jackson and Ingles, 1994) and increased production of firewood, timber, fodder, forest litter and grass and other non-timber forest products (NTFP) which support subsistence livelihoods (Kanel, 2004; Acharya and Sharma, 2004). The same has also been observed by Banskota (2000) who states that numerous degrading ecosystems have improved due to decentralized and participatory forest policies. The impact of this policy in the forestry sector has undoubtedly been positive in reducing deforestation and forest degradation in Nepal Himalaya. From a climatic perspective, community forest has contributed to enhancing the capacity of natural sinks.

4. Case study sites

The three case study sites were selected in the Himalaya region namely Ilam, Lamatar and Manang. The characteristics of these sites are depicted in Table 1. Community forest in Nepal started in the Himalaya region in the 1980's and has expanded successfully in the Himalaya terrain which covers 89% of the forest land and 86% shrub lands in the country. About one third of this forest is now under community control and this has in most places reversed degradation. Most of the community forest in the Himalaya region involves guarding against encroachment and fires, and agreed quotas for off-take of products such as fodder and firewood which are used by the local population. The management is done at grass roots level by locally based Community Forest User Groups ('CFUGs'). This type of CFM forms an integral part of the rural subsistence economy in many parts of Nepal. The three sites were selected to represent different ecological conditions and tree growth conditions, and they also differ in size (see Table 1), but there are no significant social differences or differentials in the wage rates between them. They are in fact rather typical of the majority of community managed forests in Nepal Himalaya.

5. Setting the baseline for carbon measurement

Community managed forests such as those found in Nepal Himalaya would not be considered additional in Clean Development Mechanism (CDM) terms. They represent natural forests that had been managed by communities as described above for some years before the research started. In any case, the gains due to forest enhancement could not be claimed under CDM, which allows only for afforestation and reforestation (planting of trees in non-forest areas). However, under REDD, not only will forest enhancement and sustainable forest management be permitted, but also the additionality restriction is removed at the local level since it is dealt with at the national level by measuring improvements over the national reference scenario.

When forests are brought under such management, there are two carbon components which need to be measured; 1) the avoided emission due to stemming deforestation and forest degradation and 2) the increased carbon stock resulting from forest enhancement. Conceptually these are two different things, since the first involves

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Table 1
Profile of research sites.

Location	Ilam	Lalitpur (Lamatar)	Manang
Name of CFUG	Namuna CF	Kafle CF	Manang CF
Management practice	Community managed	Community managed	Community managed
Area (ha)	383	96	240
Year established	1998	1994	1995
No. of member household in CFUG	450	60	164
Rainfall	200 cm	160 cm	40 cm
Temperature	Min 6 °C–30 °C Max	Min 3 °C–30 °C Max	Min −5 °C–20 °C Max
Altitude	400–800 masl	1830–1930 masl	3500–4200 masl
Vegetation/forest type	Subtropical broad-leaved	Lower temperate broad–leaved	Temperate conifer
Dominant species	Various species of bamboos, *Lannea grandis* and *Schima wallichii*	*Castanopsis tribuloides* and *Schima wallichii*	*Pinus wallichiana*

reduction of emissions, i.e. a source, while the second involves increasing a sink. Fig. 1 shows the two different components.

The first component is the avoided emission from stemming deforestation and degradation. Here the line *xy* indicates business as usual in an unmanaged forest that is steadily degrading, i.e. with steadily declining biomass levels. The assumption is that without management interventions the forest would continue to lose biomass. If management is introduced at time T_1, then biomass starts to increase, shown by line *ab*, and reversing the declining trend of line *ay*. The avoided emission due to management which stems deforestation and forest degradation is represented by triangle *yac*.

With regard to the second component, line *ab* shows the trend as regards increment in biomass between 2004 and 2006. Any point above line *ac* represents enhanced carbon stock over the period when measurements were made, as shown by triangle *cab*.

In the research carried out in the three community forest management sites, only the second of these two trends was measured: the reasons for this are

1. Firstly, there were no data to determine the local historic deforestation trends (line *xa*) in each site that could be used to predict the situation without CFM intervention (i.e. extending the line *xa* to *ay*). And, since all the forests in the area of the three case studies are under management already, there is no control site available were measurements of deforestation/degradation rates could be made. These areas have been under management for at least a decade, and data on loss rates before that is simply not available.

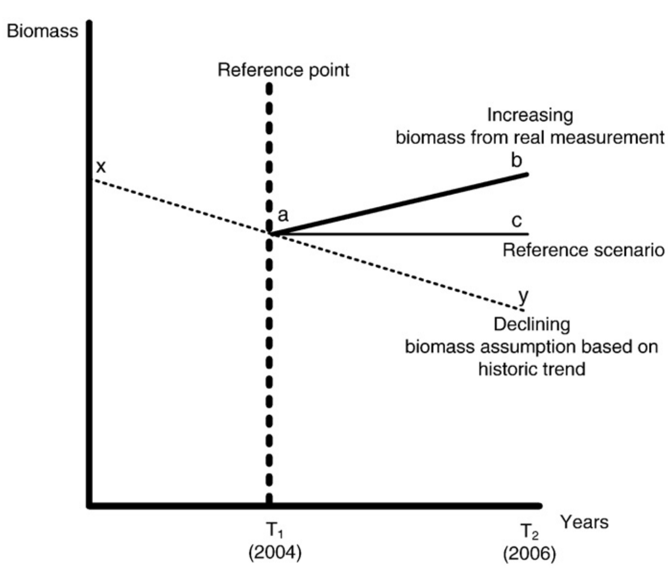

Fig. 1. Drawing baseline for community managed forests.

2. Secondly, there is uncertainty and difficulty in establishing the reference point. CFM management started at different times in the different sites. The reference point T_1 is 2004 because that was the year when measurements started. Increasing biomass trends could have started earlier, as the communities had already been engaged in management for some time.

The baseline used in this research therefore presents a conservative estimate of carbon savings since only the increment is accounted. In reality, the carbon gains are considerably more than what was measured. Each community forest has its own sequestration rate dependent on the rate of biomass growth and rate of forest resources extracted. Forests nearing their maximum carbon capacity will have a smaller marginal increment rate of biomass growth than juvenile forests. The overall size of carbon pool will of course be greater in forests reaching their maximum biomass level, but the baseline does not take into account the size of the pool because it is only accounting for the change.

6. Creating different scenarios to find marginal benefits for carbon management

In order to understand what the benefits of carbon management would be, there is a need to compare forest management as it is being currently undertaken with what would be necessary if the forest was to be managed with a view to claiming carbon credits. To estimate the cost of carbon sequestration in forested land, three different scenarios were established so that the marginal benefits could be analysed for different scenarios. These three scenarios try to capture the different ways in which these forests could be utilized for carbon offset projects.

The three scenarios are listed in Box 1. Scenario 1 is a 'no change' scenario in which communities continue to manage their forest with the objective of meeting their subsistence needs without receiving any payment for carbon. The off-take permitted is less than the mean annual increment of the forest, meaning that the management is sustainable and forest stock tends to increase. The benefits derived from this management are fuelwood, fodder, timber and non-timber forest products (NTFPs) while the costs include labour, day-to-day-management and operation costs, and forest protection work. This is the base-case, and one that in fact applies in large areas of Nepal.

Scenario 2 represents the case in which carbon management is added to Scenario 1. Communities continue to meet their sustenance needs from the forest by harvesting forest resources and at the same time sell credits for any increases in carbon stock that occur. To claim credits, is it presumed that they would have to carry out forest inventory regularly to establish stock changes. The carbon sequestration rate is thus net, after timber and fuelwood extraction as agreed in the management plan. In this scenario, additional benefits include carbon revenue derived from forest, for which we have applied rates of $ 1 and $ 5 per tonne CO_2 for the sake of the calculations. Additional costs in this scenario include carbon stock measurement (forest

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inventory), preparation of project proposal/documentation, marketing of credits, adoption of a more formal management system, and employment of more forest guards, as these are items which would typically be associated with a REDD carbon project and which incur important local transaction costs.

Scenario 3 reflects the case of forest managed solely for carbon sequestration, in which extraction of forest resources is no longer permitted. Under this scenario, the annual fuelwood consumption rate estimated from the socio-economic survey is converted to carbon credits, as fuelwood extraction is not permitted. Thus the total number of credits that could be claimed will be higher than in scenario 2. However, under scenario 3, the benefits enjoyed under scenario 1 and 2 from using fuelwood, fodder, timber and NTFPs are lost, while the transaction costs of carbon marketing still have to be covered. The costs and benefits associated with these three scenarios are presented in Box 1.

Box 1
Types of benefits and costs included in the 3 scenarios.

	Scenario 1	Scenario 2	Scenario 3
Benefits	Fuelwood Fodder Timber NTFP	Fuelwood Fodder Timber NTFP Carbon revenue	Carbon revenue
Costs	Labour Management Forest protection	Labour Management Forest protection Carbon measurement Prepare project proposal Marketing carbon credits Formal management Forest guards	Labour Management Forest protection Carbon measurement Prepare project proposal Marketing carbon credits Formal management Forest guards Fuelwood (foregone) Fodder (foregone) Timber (foregone) NTFP (foregone)

7. Valuing benefits and costs to local communities

Calculations of benefits and costs were carried out for a 5-year period. Each CFUG has a 5-year Operational Plan which is approved by the District Forest Office and which is adhered to and followed by the communities managing the forest. In the Operational Plan, detailed activities relating to management, protection, harvesting and distribution are spelt out in an operational calendar. During the collection of financial data in the 3rd year, financial and resource extraction records were available for the preceding 3 years, while change in the biomass stock for the three previous years was available from our field survey. Projections of financial flows, resources extraction and biomass stock *i* for the following two years were made in consultation with CFUG members based on the Operational Plan.

Leakage as defined in CDM was not accounted for in this study, for two reasons. Firstly, all forests within the vicinity of villages throughout Nepal Himalaya have been handed over to community for management, which controls leakage as communities are confined to their own forest. Secondly, the proposed REDD policy will work at national level and be accounted for at the national level, where any leakage will cancel out gains against the national reference scenarios.

The benefits and costs are calculated from direct use values of forest resources consumed by the local people. Where the use values are traded in money, monetary values are given (e.g. for timber); where the values are not traded in monetary terms directly, non-monetary values are given (e.g. for voluntary labour) and then converted to their economic values. Economic values for non-monetary transactions were estimated in consultation with the local CFUG members and where possible, national average wage rates were used to reflect the real market value. Hence, costs and gains include and value both types of transactions: monetary and non-monetary. These values have not been discounted, since the period of consideration is only 5 years, three of which are already in the past, and the flow of future benefits is rather uniform.

8. Gross margin analysis of benefits to local communities

Based on real time data from the financial records of CFUGs and biomass assessment derived from the forest survey which was conducted over three years, gross margin analysis was carried out and projected over a five-year period, representing one commitment or accounting period. Estimation for the fourth and fifth year was done in consultation with the CFUG members based on the expectation of the output of their sustainable management practices in line with their Operational Plan.

9. Result from the three sites under different scenarios

We now compare the net benefit for each site under different scenarios at CFUG level and at household level. As Table 2 shows, under Scenario 1 with current management conditions or ‘no change’, CFUG in Ilam gain the most at CFUG level ($ 57,656) and also at household level ($ 128). The CFUG in Manang ($ 13,919) gain more than Lamatar CFUG ($ 4290) from managing and conserving their forest, and the trend is the same at household level, in Manang households derive $ 85 per annum whereas in Lamatar they derive about $ 72. These figures estimate the value derived from managing and conserving mountain forests by the communities for fulfilling their sustenance needs; from these values we can say a typical household derives products and services whose values ranging from $ 85 to $ 128, as a result of managing the forests. The variations in values are largely dependent on the variations in size of the forest. The importance of these statistics is that they provide a benchmark. For communities to participate profitably in carbon trading, the returns must be above these Scenario 1 levels.

Table 3 shows the gains at CFUG and household levels for each site under Scenario 2. Under this scenario, the forest inventory and carbon assessment costs are included, which were estimated to be $ 3 ha^{-1} for the first year and then $ 2 ha^{-1} per annum from the second year

Table 2
Value of net benefit derived under scenario 1 at community and household levels for each site.

	Scenario 1				
	Business as usual				
US$	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
Ilam: net gain	57,511	57,656	57,656	57,656	57,656
Ilam: net gain per HH	128	128	128	128	128
Lamatar: net gain	4145	4290	4290	4290	4290
Lamatar: net gain per HH	69	72	72	72	72
Manang: net gain	13,775	13,919	13,919	13,919	13,919
Manang: net gain per HH	84	85	85	85	85

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Table 3
Value of net benefit derived under scenario 2 at community and household levels for each site.

	Scenario 2					Scenario 2				
	US$ 1 per tonne CO_2					US$ 5 per tonne CO_2				
US$	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
Ilam: net gain	58,369	59,767	59,620	59,620	59,620	75,557	78,117	77,381	77,381	77,381
Ilam: net gain per HH	130	133	132	132	132	168	174	172	172	172
Lamatar: net gain	2073	2908	2903	2902	2902	4097	4989	4960	4956	4956
Lamatar: net gain per HH	35	48	48	48	48	68	83	83	83	83
Manang: net gain	11,708	12,673	12,673	12,673	12,673	15,913	16,734	16,734	16,734	16,734
Manang: net gain per HH	71	77	77	77	77	97	102	102	102	102

onwards; while marketing costs are estimated at 1.5% of carbon revenue.

When the selling price for tCO_2 is $ 1, net gain in Ilam increases compared to Scenario 1, but for Lamatar and Manang, net gain reduces (from $ 4290 to $ 2903 and from $ 13,919 to $ 12,673 respectively) compared to Scenario 1 for each site. This indicates that at $ 1, the cost of managing carbon is more than the monetary gain. This effect is more noticeable in Lamatar, since it has a smaller forest, and its cash flow is small. Manang is better off under 'no change scenario' than when participating in carbon trading. Because the break-even price for tCO_2 under this scenario for Ilam is $ 0.55, Lamatar is $ 3.7 and Manang is $ 2.3, only Ilam can operate profitably at $ 1 tCO_2 rate; which reiterates the impact of the size of the forest. The larger the forest area, the less the unit cost, due to economies of scale.

Table 4 shows the gains at CFUG and household levels for each site under Scenario 3, i.e. when forest resources are not harvested for consumption but converted to CO_2 credits. In this scenario, the loss from not being able to use forest resources is so high in non-monetary terms that any additional carbon revenue even at $ 5 rate is not sufficient to make the net gains profitable. Larger forested areas like Ilam lose more from foregoing greater volume of fuelwood use for subsistence needs. Consequently, Ilam has a net gain of − $ 34,869, Lamatar − $ 11,664 and Manang − $ 14,042. At the household level, Ilam looses − $ 77, Lamatar − $ 194 and Manang − $ 86. Hence, the larger the forest area, the bigger the loss from foregone use of fuelwood. Therefore, under such scenario, it is highly unlikely for carbon trading will occur as the break-even price for tCO_2 is very high; for Ilam it is $ 8.95, for Lamatar $ 17.44, and for Manang $ 12.78.

10. Discussion on net benefits from gross margin analysis

Before drawing conclusions on the net benefits under different scenarios, it is important to note the variation between the sites. As illustrated below in Table 5, factors such as forest area, biomass growth rate, population pressure and fuelwood consumption rates differ between the three sites and it is due to these differences that there are differences in net benefits, as shown in Tables 2–4. The break-even price of CO_2 is also crucial.

Taking the example of Ilam (from Table 5), we find that the largest forest (383 ha) yields more benefit ($ 128 per hh) even though it has the highest population pressure (0.85 hh/ha forest) and consumes more fuelwood than the other cases (3.2 t/hh/yr). Ilam also has the lowest break-even price for tCO_2 ($ 0.55) compared to other sites. From this Table we find that area of forest is a major factor that determines: 1) the level of net benefit in managing the forest and 2) break-even price of tCO_2.

In addition, when dealing with CFM and carbon trading, it is important to keep in mind that benefit and cost levels vary because of the many differences between the sites, and not least the altitude and the management which may affect these levels of benefit and cost.

From this analysis of the three scenarios it is found that:

- Scenario 1: CFUGs derive greater non-monetary benefits than monetary benefits from managing community forests. These benefits are the economic rationale for them to manage and conserve their forest at present.
- Scenario 2: When CFUGs are permitted to use forest resources and market additional (incremental) carbon sequestrated, at $ 1 per tCO_2, there will in insufficient incentive for some CFUG, exemplified by the cases of Lamatar and Manang. These two are worse off under Scenario 2 than Scenario 1. This is because of their relatively small area of forest. The credits that could be claimed on this are insufficient to cover the transaction and other costs of carbon management, for smaller forests of Lamatar and Manang. However at $ 5 rate per tCO_2, all CFUGs were found to make profits. Under Scenario 2, the break-even price per tCO_2 is $ 0.55 for Ilam, for Lamatar it is $ 3.7, while for Manang it is $ 2.3.
- Scenario 3: As the non-monetary benefits from use of fuelwood are very high compared to monetary income, foregoing the use of forest resources has a huge cost, so that even with a carbon price of $ 5 per ton, sale of the carbon credits cannot cover the net costs involved. The break-even prices per tCO_2 under Scenario 3 are: for Ilam $ 8.95, Lamatar $ 17.44 and Manang $ 12.78.
- For the local CFUG members, carbon trading is only attractive when (sustainable) extraction of forest resources is permitted, as in Scenario 2, where gains from carbon management are additional to gains from CFM.
- Size of the area of forest is a major variable determining net benefit level and the break-even price for tCO_2. The larger the area the less the relative cost in managing the forest and also greater the net

Table 4
Value of net benefit derived under scenario 3 at community and household levels for each site.

	Scenario 3					Scenario 3				
	US$ 1 per tonne CO_2					US$ 5 per tonne CO_2				
US$	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
Ilam: net gain	−63,517	−63,222	−63,368	−63,368	−63,368	−35,615	−34,141	−34,869	−34,869	−34,869
Ilam: net gain per HH	−141	−140	−141	−141	−141	−79	−76	−77	−77	−77
Lamatar: net gain	−15,110	−15,095	−15,103	−15,103	−15,103	−11,698	−11,626	−11,664	−11,664	−11,664
Lamatar: net gain per HH	−252	−252	−252	−252	−252	−195	−194	−194	−194	−194
Manang: net gain	−20,302	−20,302	−20,302	−20,302	−20,302	−14,042	−14,042	−14,042	−14,042	−14,042
Manang: net gain per HH	−124	−124	−124	−124	−124	−86	−86	−86	−86	−86

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Table 5
Value of net benefit derived from CFM and break even prices for CO_2 credits under Scenarios 2 and 3.

Site	Biomass growth per ha	Household per ha	Fuelwood consumption per household	Value of benefit derived from CFM Scenario 1	Breakeven price for tCO_2 under Scenario 2	Breakeven price for tCO_2 under Scenario 3
	$tha^{-1}yr^{-1}$	hh ha^{-1}	$thh^{-1}yr^{-1}$	$\$hh^{-1}yr^{-1}$	$\$/tCO_2$	$\$/tCO_2$
Ilam (383 ha)	6.42	0.85	3.3	128	0.55	8.95
Lamatar (96 ha)	2.96	1.60	3.2	72	3.7	17.44
Manang (240 ha)	2.18	1.46	2.1	85	2.3	12.78

benefit. This is more important than even the size of forest-dependent population and forest vegetation as shown on Table 5.

- As is evident from the three sites, CFUGs are already managing their forest in a sustainable manner. If the global price of REDD tCO_2 credits in the post 2012 period is low, close towards the break-even price for carbon sequestration, revenue from carbon will in practice not operate as an incentive for communities to carry out forest inventory and to maintain and monitor data on carbon stock in their forest, tasks that would be necessary to claim credits. These tasks are not carried out as part of regular forest management at present.
- If the global price for REDD tCO_2 credits in the post 2012 period is considerably higher than the break-even price, it may create an incentive to promote and strengthen sustainable forest management and carbon trading may be welcomed by communities managing forest and also by the governments in developing countries where CFM is practiced.
- Moreover, higher tCO_2 prices may act as incentive for other communities to start forest management, and for the government to promote this, assuming that part of the revenue would be taken by the state.

Most literature assessing opportunity costs in relation to REDD refers to the opportunity cost of land. In Nepal's CFM case, even though the CFM is practiced on slopes that are non-arable and have no alternative possible use, there is a high opportunity cost as the forest provides numerous inputs for subsistence mountain livelihood (e.g. fuelwood, fodder, timber, NTFP), which might be foregone under a carbon management regime. It is for these products that local people are conserving their forest now, without any carbon revenue. It is these opportunity costs that need to be taken into account therefore when considering changes that might be introduced under REDD.

The findings of the research are in line with many, more large scale assessments of opportunity costs. Moura-Costa and Stuart (1998), for example, explain that carbon reduction in the tropics through biological sequestration is expected to be a low-cost carbon mitigation option due to high growth rates coupled with relatively low land and labour costs. This we can confirm for the case of Nepal Himalaya based on the data presented here.

This research provides an analysis of three different possible scenarios under REDD for CFM and their economic implications. However, there is still considerable uncertainty in terms of what the monitoring and verification requirements will be under REDD. This will have a bearing on the transaction costs for implementing REDD, but it will not affect the main finding of this study, that carbon trading will only be a favourable option for local communities if it is combined with sustainable off-take of local forest resources.

11. Conclusion

As CFM at the sites investigated is not additional in CDM terms (it was already being carried out when the study started), it will be eligible in principle under REDD. In this paper we estimated net benefit from carbon trading under different possible REDD scenarios. For this, a baseline was constructed by taking the first measurement as the reference point and valuing for all incremental carbon relative to this reference point, over an observation period. This gives a conservative value (the enhanced carbon stock) as it does not include emission avoided as a result of management intervention.

Local communities have been managing forest without carbon revenue because CFM already provides an incentive for forest management, and this has been the reason why CFM has been successful in Nepal Himalaya. Carbon trading will only be attractive when the benefit from carbon management exceeds benefit from existing management. This research shows that carbon revenues can bring about additional benefit under certain conditions as shown under Scenario 2.

A first general conclusion from this paper is that a cheap way to mitigate climate change is to make sure existing forests stay intact. The estimates for sequestrating atmospheric CO_2 in this research indicate that maintaining existing forests may be one of the least cost options for offsetting carbon, based on the breakeven price under Scenario 2 which ranges from \$ 0.55 to \$ 3.70 per tCO_2. These prices are low because of the gains from fuelwood extraction enjoyed by the local community lower the cost of forest management.

Secondly, when the local communities managing forest are paid for the carbon sequestered at rates close to their breakeven cost, this payment could provide the incentive to conduct forest inventory and carbon assessment on a yearly basis which otherwise would not be performed. The social gains from sustainable management of forest to the local communities is already high and consequently the incentive provided by a carbon trading regime would mainly cover the costs of forest inventory work and carbon assessment, with some small profit to the community. It is assumed that such local survey work would be essential if the state is to claim carbon credits at an international level under REDD, since such data cannot be obtain from other sources such as remote sensing at this scale and at this level of detail. But if the rates for credits are considerable higher than their cost, then it may be a real incentive to strengthen and promote sustainable forest management, which will be attractive to local communities as well as governments in developing countries. It goes without saying that if communities are to take advantage of opportunities under REDD, there would be need for capacity building at the local level to enable them to carry out responsible and accurate forest inventories. Though the costs of these have not been discussed in this paper, they were considered in the research and have been found to be rather low (Karky, 2008).

Thirdly, the best results are found under Scenario 2 when sustainable harvesting of forest resources by local communities is permitted and credit is only awarded for what is left after this off-take. It also clearly shows that strict forest protection measures aimed only at increasing carbon sequestration by banning all forest off take from the forest, is not a feasible option, as communities lose more than they gain. In other words, REDD policy must be built upon the existing CFM policy where communities are recognized with their forest use rights.

This paper only shows the costs associated with community forest management when community members are trained to conduct the survey. There will of course be additional costs for monitoring and verification, but this is also true for opportunity costs as calculated in most other studies on deforestation. At the same time, there are many additional benefits from this kind of forest management which have not been accounted for, for example, biodiversity conservation, water catchment protection, not to speak of aesthetic and cultural values that will be maintained. The analysis has not taken these additional costs and benefits into account, as it was largely concerned with the immediate costs and benefits to the local communities.

Acknowledgements

We would like to acknowledge the funding by Netherland Development Cooperation to the Kyoto: Think Global Act Local project, under which this research was conducted. We would also like to thank two anonymous reviewers who have given some interesting and insightful comments on the draft of this paper.

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