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Towards a Sustainable Land Use Option in the Bamenda Highlands, Cameroon: Implication for Climate Change Mitigation, Income Generation and Sustainable Food Supply

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Abstract: A land use option that can contribute to climate change mitigation and welfare improvement of poor smallholder farmers who cannot integrate traditional markets, but need alternatives for income generation, remains a challenge for researchers and policy makers in the Bamenda highlands. In a degrading agricultural landscape as such, where traditional cultivations and pasture have released quantities of greenhouse gases that are today significant in terms of their current impact and potential for long-term contribution to global warming, carbon sequestration projects, like agro forestry, can be an alternative. To verify this hypothesis, cost benefit analysis was employed. To estimate opportunity cost of land use change, the net present value of agroforestry was compared with those of pasture and traditional cultivations. Some indicators of profitability and cash flow viability (net present value, pay back, etc.), were used. Sensitivity analysis was used to simulate some salient conditions like interest rates, establishment costs and carbon prices. To complement these results, a rapid ecological services assessment was undertaken. This was to determine the relative contributions of the different options to environmental "viability". All the options were found to be economically viable. However, agro forestry (NPV = \$1361 ha^{-1}, IRR = 30%, payback 4.5 years), though not as profitable as the pasture (NPV = \$6829 ha^{-1}, IRR = 63%, payback 2 years), appears to be the only option that can meet up with the current challenges. Opportunity cost is least ($|\$2.09\ ha^{-1}|$) for a change from traditional cultivations to agroforestry than from pasture to agroforestry (\$12.16 ha^{-1}). However, land suitability analysis, education and precise silvicultural practices would be an asset.

Key words: Cost benefit analysis, opportunity cost, environmental viability

INTRODUCTION

Mitigating climate change and optimizing food production to ensure food security are some of the greatest challenges now facing humanity today and may likely remain so for generations to come. Scientists have estimated that at current emission rates the accumulation of greenhouse gases in the upper atmosphere is expected to lift average global surface temperature by approximately 0.3-2.5°C in the next 50 years and 1.4-5.8°C in the next century (Houghton 1996; Houghton *et al*., 1992; Watson *et al*., 1998). Carbon dioxide is the most important of the greenhouse gases due to both its abundant concentration and superior ability to trap heat. Each year, humans discharge roughly eight billion metric tonnes of carbon into the atmosphere, 6.5 billion tonnes come from the burning of the coal, oil and natural gas that drive the industrial world's economy and 1.5 billion tonnes come from deforestation, burning of forests and clearing of land for agriculture and settlement (Houghton, 1996).

In the Bamenda highlands of Cameroon, the living consequences include, global warming, deterioration of ecological goods (Costanza *et al*., 1998) services and low agricultural output. The insecurity of the environment further insecure the people, especially the poor smallholder farmers, who cannot integrate traditional markets, but need alternatives for income generation. This makes their survival more difficult, uncertain and may likely remain so for generations to come. Natural capital refers to ecological goods and services (Costanza *et al*., 1998). Ecological services are defined as the processes and conditions of natural ecosystems that support human activity and sustain human life, e.g., soil fertility, natural pest control, climate regulation. Ecological goods are those derived from ecosystem services, e.g., food, timber and fresh water.

To meet up with the current challenges of life, farmers have increased hectares seeded to specialty crops, diversified into livestock and cultivation of physically marginal lands. The higher prices for specialty crops and the peak of the market cycle for livestock had allowed

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for increased profitability for producers that were early entrants into these markets. As many of the producers have diversified and intensified the focus of their operations, the supply of specialty crops and beef increased. The result is that the market cycles for beef and specialty crops now appear to be on the downturn as the overall profitability levels are falling. Producers now seem to be in a management system, which maximizes the short-run returns from the land. Such a situation may fail to factor out in the long-run sustainability of the farm operation and thus creates uncertainty regarding its future. The question now is, "which land use option can optimize agricultural production to satisfy the ever growing and hungry human race while at the same time mitigate climate change and generate more income?"

Given human society's strong reliance on activities that emit carbon dioxide, there is an increasing need to design strategies that will both curtail emissions and remove excess CO_2 . One way to ease CO_2 accumulation in the atmosphere is by removing it from the air and storing it on land in the form of biomass and soil-carbon reservoirs. This, however, needs regulations and motivations that will ensure easy implementation.

The United Nations Framework Convention on Climate Change (UNFCC) was created in 1992 to address the problem of global warming. The Kyoto Protocol provides for three flexible market mechanisms to reduce greenhouse gases. These are emissions trading, joint implementation and the clean development mechanism (CDM) (WRI 1998). The CDM is outlined in Article 12 of the Kyoto Protocol. The Clean Development Mechanism of the Kyoto protocol adopted the concept of Certified Emissions Reduction (CERs) credits as a form of motivation to help investment in the forest sector which are seen as the main sources of sinks for GHG. It also provides a framework within which it is possible for a developed country to continue its normal emissions rate while simultaneously reducing emissions in another part of the world in order to reach its emissions goals.

The role of forest as potential sources of sinks has been highly elaborated in many literature. For example, in an early study involving an average cost approach, Dudek and LeBlanc (1990) estimated the costs of carbon storage under the U.S. Conservation Reserve Program (CRP) at $38 per ton. Plantinga, Stavins (1999) used econometric methods to forecast carbon storage potential in the United States by estimating forest supply functions and then converting projected forest biomass into carbon levels. Stavins based his estimates on average annual revenue and production data from 36 southern U.S. counties, concluding that annual marginal costs of carbon storage through expansion of U.S. pine plantations could be as high $1,000 per acre and $665 per ton.

While, forests play a key role in removing carbon from the atmosphere through photosynthesis, the contribution that agroforestry systems, such as multipurpose trees on farmland (agrisilviculture), make to this end cannot be ignored. Agro forestry has been demonstrated to be a promising mechanism of carbon sequestration in India (Singh and Lal, 2000), Mexico (De Jong *et al*., 1997), sub-Saharan Africa and elsewhere. Dixon (1995) reports that the carbon storage potential of agro forestry systems ranges from 12-228 t C ha^{-1}, with agro forestry in the humid tropics displaying the greatest carbon storage ability. Moreover, Kursten and Burschel (1993) report that the amount of carbon sequestered directly by the aboveground tree component of agro forestry systems ranges between 3 and 25 t C ha^{-1}. This practice have the potential to act as carbon sinks and carbon storage pools while contributing to increase farm productivity, environmental conservation and poverty alleviation (Pandey, 2002).

However, landholders often base their decision mainly on the actual profitability and cash flow consequences of an innovation. Abadi Ghadim and Pannell (1999), Trapnell (2001) and Jgap and Ong (1997), warned against widely advocating so called 'best-bet' technologies to farmers without first carrying out an analysis of the conditions and scenarios under which agro forestry would be economically viable. Hence, if agro forestry is important as enumerated, to be adopted as an alternative for farmers in the Bamenda highlands, there it becomes pertinent for there to be an economic evaluation of the option against current land use options.

Economic analysis of land use options, especially agro forestry systems is not a new concept, neither is the quantification of carbon sequestrated in some agro forestry systems a new concept. For example, Sonwa *et al.* (2001) reported that cocoa agro forestry in South Cameroon conserves 62% of the carbon found in a natural forest and contains a plant biomass of 304 tons h^{-1} (compared to 85 tons per hectare in crop fields). Various authors, including Brown (1997), Dixon (1995), Budowski (1999) and Segura (1997) have alluded to the importance and need for further research to be conducted that attempts to quantify the amount of carbon sequestered and stored in forest-based systems, including agro forestry systems, as a means of establishing the economic value of the environmental services they provide.

However, what farmers and decision makers do not know yet is the economic value of the environmental services this provides. In addition, in an era of the CDM, there is need for farmers in fast-degrading landscapes to know the additional monetary value such services can contribute. Furthermore, until date, especially in sub-Saharan Africa, we are not yet aware of an economic analysis that incorporates carbon sequestration in the most common practised agrisilvicultural system. To this end, the research presented in this paper attempts to compare the main land use systems in the area (shifting/traditional agriculture and cattle rearing) with agro forestry as an alternative option. We outline a method for valuing the carbon storage potential of an agricultural area. We empirically estimate the value of agricultural land and the opportunity cost of changing to agroforestry from existing land uses. We compute the stream of payments that would be necessary to compensate farmers for engaging in agroforestry for the purpose of carbon sequestration and, based on these payments, we calculate carbon prices per ton of carbon dioxide emitted. The result is a set of empirically derived cash flow estimates for the area. From a methodological perspective, our approach constitutes a departure from the average cost approach that characterizes many previous studies. We also derive costs based on a stream of payments to smallholders.

Statement of purpose: The purpose of this research was to use cost benefit analysis as major decision tool, supplemented by a rapid ecological service survey, to determine the most economically and ecologically viable land use option in the Bamenda highlands.

Among the research questions guiding this research are: what is the opportunity cost of changing from the conventional system to agroforestry. How significant are certified emission credits? How much better off would a farmer be by replacing his conventional agricultural practice with carbon sequestration project such as agroforestry?

The models and tools used in this research should enable the analysis of land-use change scenarios, identifying the land-use options and land management practices that would simultaneously maximize food and biomass production, soil carbon sequestration and biodiversity conservation and minimize land degradation in our study area.

In these specific contexts, the objective is to implement a "win-win" scenario that would involve viable alternatives to slash and burn agriculture, increased food security through increased yields, increased carbon sequestration in the soil, increased soil fertility through soil organic matter management and increased biodiversity.

We do not consider here deeper issues of value, such as the intrinsic value of nature and ethical issues associated with conservation. These values, while impossible to quantify in economic terms, are clearly fundamental to conservation of the natural world.

MATERIALS AND METHODS

Study area: The Bamenda highlands are located in the North West province of Cameroon. It is one of the most populated regions of Cameroon.

According to Mbah (2002), annual average temperature ranges between 14 and 28°C, while annual average rainfall averages 2500 mm. The topography is mountainous and the altitude ranges from 800 to over 3000 m with an average of 1200 m above sea level. The soils are not uniform; moderately deep, varied, generally acidic, with pH range of 4.5-5.0, sandy-clay ferruginous soil (laterite). Some areas have soils formed from alluvial material.

The economy of the Province like that of Cameroon depends largely on agriculture with cattle grazing; slash and burn-shifting cultivation (traditional agriculture) is being the commonest agricultural practices. Agroforestry is still in its juvenile stage and needs education and incentives for its adoption.

Field survey: The field survey was carried out in 3 of the seven divisions that make up the North West Province of Cameroon, namely Mezam, Boyo and Ngoketunjia. The divisions are composed of small landholders that use diversified farming systems, located not too far from the provincial capital (Mezam) and supported by the current Forestry and agroforestry support project (PAFRA), a project sponsored by the African Development Bank. The survey was oriented to document the main inputs and outputs (including carbon sequestration) resulting from Traditional Agriculture (TA), Cattle grazing (P) and Agro Forestry (AF). A rapid ecological services assessment of the land use options was also captured. Only 47 farmers could be identified and visited since agroforestry is still in its juvenile in the province.

Data collection

Estimating costs: Costs for land preparation, planting and establishment, maintenance and harvesting for the different land use options were collected. Farmers, market men and women and staff of the rural forestry and agroforestry support project (PAFRA) were consulted to provide estimates of costs of establishing and maintaining trees, timing of harvests and yields and prices of pulpable wood.

For traditional agriculture and cattle grazing, farmers were to recall the past five year records (establishments cost, yields etc) since this was still fresh in their memories. The results were used to make projections of future harvest, assuming everything remain same. All recordings were in local units of measurement. Market survey was carried out in order to calibrate and quantify local units of measure and common units of trade. Average retail prices for major products were calculated assuming a median value between the highest and lowest seasonal price. Family labor was not assumed.

Estimating benefits

Timber harvest: To estimate the economic value from sustainable timber harvests, we used Mean Annual Increment (MAI) and Current Annual Increment (CAI) data. (Growth culminates where MAI = CAI). This is the value to the landowner of a standing tree and does not include the value added through harvesting and sales to a mill. Timber revenue per hectare was calculated as: Timber revenue ($ha^{-1}yr^{-1}$) = [MAI (m^3 ha^{-1})* Price/ton]*5 years, assuming a 1:1 conversion of m^3 to tons.

Benefits from the traditional system were calculated as the difference between the net revenue should all the crops be sold at a particular year and the total input costs.

For cattle grazing, the net benefit was arrived at by subtracting establishment cost from the revenue obtained should all the cattle be sold at a given year.

Existence value/carbon storage: In theory, standing forests are economically valuable if they are at risk of conversion, because preventing conversion also prevents potentially substantial rises in CO_2 emissions. We considered the economic value of forests for the avoided emissions of carbon that is currently stored in aboveground biomass.

The Rural Forestry and Agroforestry support project (PAFRA has permanent experimental plots of *Eucalyptus globolus*. For the past 6 years, they have documented measurements of Current Annual Increments (CAI) and Mean Annual Increments (MAI) for clonal *E.globolus* for pulpable wood. With this information available, we simply conducted field studies to estimate the ratio of pulpable wood to the total above ground biomass. Total tree biomass was then multiplied by 0.5 (the fraction of carbon in biomass) to obtain estimates of carbon stored in the tree.

Below ground biomass was estimated by applying the default conversion factor of 0.26 of aboveground biomass (IPCC, 2003).

Valuing carbon sequestration: Price is a very important factor that determines demand and supply of a commodity. Suppliers will produce and supply more if the prices are favorable. On the other hand, demanders will buy if the supplied price is favorable. Hence, our evaluation/valuation of carbon sequestration takes into consideration the needs of demanders (Annex 1 countries) and suppliers (Non-annex 1 countries).

The opportunity cost of land use change was defined as the value of any land use in its best alternative or its value in use (as measured by willingness to pay).

A potential farmer in Non-annex 1 country would like shift from conventional practice, A, to carbon sequestration project if:

$$\underbrace{NPV_A \leq PV_B(P_{CER}CER) + NPV_B}_{\text{Revenues from selling Certified Emission Reductions (CER)}}$$

Where,

NPV_A	:	Denotes the net present value for conventional practice.
NPV_B	:	Denotes the net present value for carbon sequestration project.
PV_B	:	Denotes the present value for certified.
$(P_{CER}.CER)$	:	Emissions reductions.
P_{CER}	:	Denotes the price (or payments) for certified emissions reductions.

It follows from the above inequality that:

$$P_{CER} \leq \frac{NPV_A - NPV_B}{PVB(CER)}$$

$$PV_B(CER) \neq 0$$

Hence, the minimum price a non-annex 1 country would accept will be:

$$P_{CER} \min = \frac{NPV_A - NPV_B}{PV_B(CER)}$$

Taking Agroforestry (AF), Traditional Agriculture (TA), Pasture (P) and forestry investments into consideration, we can distinguish between 2 of 4 cases:

$$P_{CER} \min = \frac{NPV_P - NPV_{AF}}{PV_{AF}(CER)}$$

For a change from P to AF

$$P_{CER} \min = \frac{NPV_{TA} - NPV_{AF}}{PV_{AF}(CER)}$$

For a change from TA to AF

As P_{CERmin} depends on PV (tCER), it follows that:
As $i_{annex1} \rightarrow +\infty$, PV(tCER) $\rightarrow 0$ and PtCER $\rightarrow +\infty$,
As $i_{annex1} \rightarrow 0$, PV (tCER) $\rightarrow$+8 and PtCER $\rightarrow 0$;

Where, i_{annex1} denotes the interest rate in annex1 country.

Hence, landowners in non-annex 1 countries may not be willing to adopt carbon sequestration project if P_{tCER} min (or i_{annex}1) is too high as this translates a loss in welfare value.

Alternatively, demander (annx1 countries) is free to choose either a permanent credit ($PCER_0$) or to take a temporal credit (tCER) today and replace it with $PCER_0$ in future. However, the maximum payments will remain same by the end of the accounting or project period. That is,

$$P_{tCER} + P_{CERT} / (1+i)^T = P_{CER\,0} \leftrightarrow$$
$$P_{tCER}\max = P_{CERO} - P_{CERT} / (1+i)^T$$

If P_{CER0} remains constant, then:

As $i \rightarrow +\infty$, $P_{CER}\max \rightarrow P_{CER0}$ and as $i(\neq -1) \rightarrow -\infty$, $P_{CER}\max \rightarrow -\infty$

From our analysis, it is evident that, a potential market between annex I and non-annex I countries can exist if i_{annexI} is reasonably low.

A number of assumptions based on the policy context of carbon emissions are needed for these economic values to be viable. On the policy context front, we made three significant assumptions. First, we assumed that avoided deforestation, which is not currently part of the Clean Development Mechanism (CDM) of the Kyoto Protocol, is a valid means of reducing CO_2 emissions. Second, we assumed as a baseline that all forests face imminent deforestation without an intervention project that invests in the carbon content of these forests. This assumption is necessary to satisfy the "additionality" criterion (Greiner, 2003) of the Kyoto Protocol. Third, we assumed the existence of a willing buyer who would invest in the area's forests for their carbon value. We did not consider transaction costs that can reduce the viability of small CDM projects (Michaelowa, 2003). Lastly, we took a "social damage" accounting standpoint that reflects the damage avoided by society from increased CO_2 emissions. We therefore assumed a one-time initial payment for avoided emissions that result in permanent forest protection.

Cost benefit analysis: Most of the studies found in the literature that carry out analysis on the land use change and forestry options are developed using the Cost Benefit Analysis (CBA). CBA is a framework (partial budgeting method) for evaluating the social costs and benefits of an investment project. This involves identifying, measuring and comparing the private costs and negative externalities of a scheme with its private benefits and positive externalities, using money as a measure of value.

In the comparative analysis, key assumptions were held constant while alternative land uses were compared. The constants are items such as project life (6 years), discount rate, farm yield and soil type. Furthermore, all calculations were based on one hectare of used land. The applied rate of discount was 10%. This discount rate was considered because it reflects the market discount rate. No financial costs due to loans are included. This is because according to farmers, conditions for loans are too difficult to meet and the majority of them do not work under this system. No inflation is considered. Financial analyses are made from the social planner perspective.

All the data was assembled and analyzed in Microsoft Excel 2003. The partial budgeting technique asks the question, 'how much better off would a farmer be replacing his conventional agricultural practice with an agro forestry project?'

The following indicators of cash flow and profitability were used in the investment analysis:

Net Present Value (NPV): The present study follows the Present Value model used by ANTLE *et al.* (2000) adjusted to account only the carbon present in tree biomass. The Net Present Value (NPV) of implementing a land use system *i* for T periods is given by:

$$NPV(A) = \sum_{n=1}^{N} Dn \begin{bmatrix} NR(pn, wn, zn) \\ +gn(A) - CMn(A) \end{bmatrix} - CE(A)$$

Where,

Dn = 1/(1+i)^ n, (i , is the annual interest rate) is the discounting factor.

NR (pn, wn, zn) = net returns for system A in period n, with given product price pn, input prices wn and capital services zn ($/ha/yr);

gn (A) = Payments for carbon sequestration service in the system A ($/ha); gn (A) = 0 in the case of non carbon projects.
CMn (A) = Annual maintenance costs ($/ha/yr).
CE (A) = Establishment costs ($/ha).

Decision rule: If NPV > 0, benefits exceed costs,Cthen the project is profitable if private, or that the project increase welfare of society (if it is a public the project); GIf NPV = 0, then profits are zero (private perspective), or welfare remains unchanged (public perspective), GIf the NPV < 0, the project is not viable (private perspective) or welfare loss (public perspective).

For several land use alternatives, their profitabilities can be compared by ranking their NPVs. The magnitude of NPV reflects the total financial value created by the project; hence, the project with the highest NPV would be the most economically beneficial.

Equal annual income (EAI): EAI can be thought of as an annuity spreading the net present value evenly across the project life.
Mathematically (Bullardand Straka, 1998),

$$EAI = NPV\frac{i(1+i)^\wedge n}{(-1+i)^\wedge n}$$

Where, n is the number of years in the rotation.

It is useful in comparing projects with differing cycles. An investment with the highest EAI would be the most economically viable.

Benefit cost ratio (BCR): It is the algebraic sum of the ratios of discounted benefits to discounted costs over a given time. A BCR higher than one indicates that a project is advantageous (Olschewski, 2001).

Internal rate of return (IRR): The IRR is the discount rate at which NPV is zero. A project is feasible if IRR is greater than the alternative rate of return (Olschewski, 2001; Godsey, 2000). The IRR, on the other hand, reflects the interest rate that you earn from investing in your project.

Peak debt, payback and break-even: According to Trapnell (2001), Peak debt is the highest cumulative discounted cash deficit that occurs during the life of the investment project; Payback period is the time required for cumulative discounted cash flow of the agro forestry project to become surpluses while Break-even period is the time required before the cumulative cash flow of the agro forestry project equals that of the agricultural land use.

In addition, the financial analysis included two payments schemes often cited in the literature: "Business as usual scenario", where no carbon payments are available and the farmer earns NPV(i) and Tonne-year carbon payment contract, where the farmer receives payment according to amount of carbon sequestered per year.

Uncertainties and sensitivity analysis: Peirson *et al.* (2002) stated that knowledge of the sensitivity of the results of financial analysis to changes or errors in the key economic drivers place the investor in a better position to decide if the project is too risky to accept. For the sake of consistency and brevity, the sensitivity analyses in this paper focus on a few variables likely to be of economic importance.

Environmental service assessment: The economic value of any land use option would be incomplete if its contribution to restoring ecological integrity and/or its ability to mitigate climate change is not investigated. In addition, an area's importance can be characterized by its total biodiversity, its degree of endemism, the uniqueness of an ecosystem and the degree of risk of extinction (Parker *et al.*, 1993). Hence, for each land use system, a rapid ecological services assessment and their impacts on flora and fauna in the region conducted. Each ecological service indicator was classified as either low, medium or high and relative weights calculated in order to get the value or relative contributions by weight of the different land use options to environmental security. If an indicator contributes well to mitigate an impact, it is scored 3 else, 2 or 1.

We assumed that the provision of ecosystem services was independent within a land use option, for example, the sustainable harvest of timber does not affect values associated with carbon storage. The degree to which interactions affect ecosystem service provisioning and value is an empirical question that we did not have the data to address. Finally, we were unable to model spatial interdependencies of ecosystem services among the different land use options. Addressing these deficiencies in empirical works is an important avenue for future research.

RESULTS

Carbon Biomass estimation: The biomass expansion factor ranged from 40.32-52.73% of the pulpable wood.

The estimates for above and below ground biomass (Table 1) show that total biomass varied from 6.35 tC ha^{-1} in the first year, to 63.14 tC ha^{-1} in the 5th year.

Certified emission reduction accounting (tCO_2): Carbon prices are not fixed. Estimates from: IETA, 2003, forecasted CER prices that range from \$9.9 to \$13.7; PointCarbon 2004 estimates this to \$10/tCO_2. Based on these two estimations, our study assumed a price of \$10/tCO_2 from which we have,

$$P_{tCER}\max = 10 - 10/(1+0.03)^\wedge 6$$
$$= \$1.63t/CO_2e$$

This is the maximum amount a demander can pay per ton of carbon dioxide sequestered under the defined conditions.

Table 1: Estimates of aboveground and below ground biomass growth rates for Eucalyptus clone (5-year rotation cycle)

No.	Parameters	Year 1	Year 2	Year 3	Year 4	Year 5
A	Current annual increment of pulpable wood (m^3)[1]	12	18	48	24	24
B	Wood density	0.55	0.55	0.55	0.55	0.55
C	Annual increment of pulpable wood (t ha^{-1})[2]	6.6	9.9	26.4	13.2	13.2
D	Biomass expansion factor (%)[3]	52.73	47.54	44.40	40.32	40.08
E	Wet weight of aboveground biomass (t)	10.08	14.61	38.12	18.52	18.88
F	Annual Increment of Above ground biomass (dry wt t ha^{-1})[4] = E*0.5 (50%)	5.04	7.30	19.06	9.26	9.44
G	Total standing biomass(AGB; dry wt t ha^{-1})[5]	5.04	12.34	31.40	40.67	50.11
H	Below ground biomass conversion factor (%)[6]	26	26	26	26	26
I	Below ground biomass (dry wt t ha^{-1}) = G*0.26	1.31	3.21	8.16	10.60	13.03
J	Total biomass (tC ha^{-1}) (AGB+BGB) = G+I	6.35	15.55	39.56	51.27	63.14
K	Total tCO_2e ha^{-1}/yr (tCER) = J*44/12 (3.667)	23.28	57.02	145.05	188	232
L	Total tCO_2e ha^{-1}/yr(lCER)	23.28	33.74	88.03	42.95	44

(1).Pulpable wood is under bark excluding branches, twigs, leaves and bark; (2). Calculated as CAI x wood density;(3). Ratio of branches, twigs, leaves, barks to the pulpable wood,(4). Moisture content is 50%; (5). Cummulation of AGB; (6). Ratio of BGB to AGB harvest method, NB $C + O_2 \rightarrow CO_2 \rightarrow$ 12C``` $\rightarrow$ 44 CO_2; hence the conversion factor, 3.667 or 44/12

Table 2: CER accounting for both tCER and lCER

Year	lCER	I = 10% (SS)	Minimum cumulative Payments ($)/ha/yr)
1	23.28	0.91	33.86
2	57.02	0.83	75.40
3	145.05	0.75	174.37
4	188.00	0.68	205.45
5	232.00	0.62	230.49
Total	645.35		719.56
PV(tCER)	449.73		

lCER: long term certified emission reduction; tCER: temporal certified emission reduction; PV (tCER) is the cumulative amount of carbon sequestered. Counting started at year 1 since no carbon in sequestered during year 0 (1$ = 500FCFA)

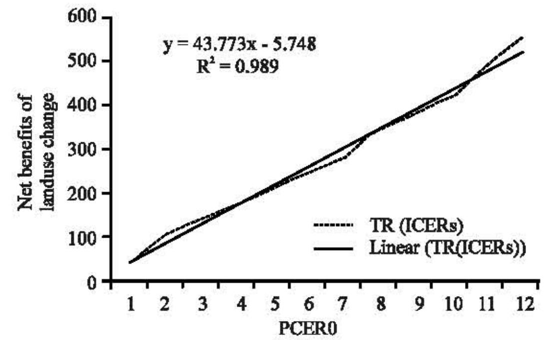

Fig. 1: Relationship between net benefits and price of certified emissions reduction

It was based on this value that we calculated the cumulative amounts and discounted cumulative values of carbon dioxide per annum (Table 2).

Relationship between net benefits and price of certified emissions reduction: Carbon benefits were found to increase in the same sense as $PCER_0$ (Fig. 1).

Cash flow and Profitability analyses: This study describes results of a comparative financial analysis of the different land use options. All results (Table 2) are for the complete farming systems.

The cattle grazing system generated an EAI of \$1801 ha^{-1} per annum, which is \$16times ha^{-1}more profitable per annum than the TA system, \$7 times ha^{-1} more than AF without CERs and \$5 ha^{-1} times more than the AF system with CERs.

The internal rate of return for the TA system is 0 <10% (the base interest rate), compared to 63% for cattle grazing, 30% for AF with CERs and 26% for AF without CERs.

In terms of BCR, our results show that, returns on investment after breaking even of are, respectively US\$6 (= 7-1), US\$13(= 14-1), US\$10(= 11-1) and US\$11(= 12-1) for the TA, P, AF and AF+CERs.

Peak debt, Payback and Break -even period: Reporting these key cash flow indicators is necessary because, a landowner or investor may reject new investment projects such as agroforestry, with higher profitability than conventional agricultural practices, based on unsustainably high peak debt or long break-even periods. Often there are projects whose payback period is longer than a farmer (investor) can bear. Farmers, like most investors, prefer land management practices that are profitable and have short payback periods.

The consequences of establishing each of the land use options on cash flow for the landowners are as follows:

Peak debt: The cattle grazing system (P), has a cumulative cash deficit of US\$3000 ha^{-1} for the landowner in the first year after establishment. For agro forestry with or without certified emissions reductions, the peak debt stood at US\$1700 ha^{-1}, while for the traditional system, it is only US\$900 ha^{-1}

Payback period: Though with the highest peak-debt, the P system requires a year for cumulative discounted cash flow to become a surplus (Fig. 2). It took the same period for the TA (which started generating income from the first year onwards.) system and four years for AF system, with or without CERs.

Table 3: Summary of the economic analysis of the land use systems (scenarios)

Farming system	Enterprise and product(s)	NPV ($ ha^{-1})	EAI ($ ha^{-1})	IRR (%)	BCR	Peak debt ($ ha^{-1})	Payback period.(Years)	Break-even period(Years)
TA	Maize and beans	422	111	0	7	(900)	3	p = 2 AF = 4.5
P	Cows	6829	1801	63	13	(3000)	2	TA = 2 AF = 1.5
AF	*E. globulus*, beans and maize	1050	277	26	11	(1700)	5	p = 1.5 TA = 4.5
AF+CERs	AF+CERs	1361	359	30	12	(1700)	5	p = 1.5 TA = 4.5

NB: In row 2 , column 9 for example, P = 2, AF = 4.5 means that, with respect to TA system, the break even period for P system is 2 years and 4.5 years with respect to the AF system. Rule applies to other rows and columns.(1$ = 500FCFA)

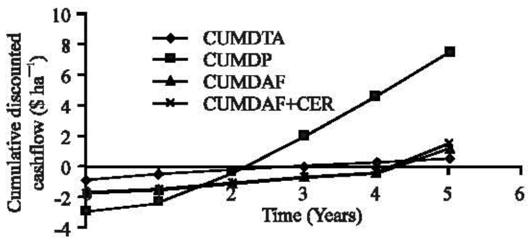

Fig. 2: Cumulative discounted cash flow analysis of the land use scenarios CUMD(TA/P/AF/AF+CERs): Cumulative discounted TA, P, AF and AF+CERs systems

Break-even period: The cattle crazing system breaks-even with the AF system in the second year and with the TA system in year two. Furthermore, the cashflow of the cattle system increases rapidly from year one onward. AF remains constant until the 4th year.

Sensitivity analysis: This study describes the sensitivity of results to key assumptions of the different land use options (Table 3). For the sake of consistency and brevity, the sensitivity analyses in this report focus on a few variables likely to be of economic importance. The sensitivity analyses use pessimistic, optimistic and expected expert-estimates for each key variable, limited to: interest rates, establishment costs, timber prices, biomass yield, transaction cost, prices of beef and crop yield. All variables were varied by ±50% of the base case.

Varying the interest rate by ±50% has a large effect on the overall economics of the farmers. For example, if interest rates are reduced by 50%, the NPV for the TA system will increase from US$422 ha^{-1} to US$42840 ha^{-1}, which is more than a hundred times higher. However, an equivalent percentage increase in the interest rate will result in a loss of $183 ha^{-1}. The sense of variation is same for the AF and P systems. There is no significant change in the IRR and BCR due to the variations. Of course, the EAI should vary in the same sense like the NPV since they are annualized versions of NPVs.

For the AF system, if interest rate is raised to 50%, welfare will be lost NPV<0 in both cases (With/without). The fact that IRR>10% in both cases show that with high interest rates, investors will not be able to pay back any sums of money borrowed.

However, if interest rates are reduced by 50%, both systems will become profitable:

- Without CERs, the NPVs increases to $184,740 from $1050.
- With CERs, to $220, 068 from $1361, a difference of $35328.

Equal annual earnings also increase in the same sense. More interestingly, the hurdle rates are more favorable for the situation with CERs (30%) than without (26%) CERs.

Furthermore, the BCR shows that the returns on capital invested will be $1 higher in a situation with CERs than without CERs.

If timber prices and /or yield or price drops by 50%, profitability will decrease and vice versa.

The inclusion of transaction cost in the AF+CERs system leads to a sharp decrease in its profitability. For example, a transaction cost of about $1000 reduces profitability to $452 (57% decrease), with equal annual earnings dropped to $119 (67% decrease).

Biomass yield seems not to significantly influence the profitability of the system. For example, a ±50% change in biomass will lead to just about ±11% change in profitability. The price per tCO_2e would be a more influencing factor than biomass production.

Changing establishment costs significantly affects profitability of both systems. For example, decease in establishment cost by 50% will lead to an increase in profitability by 34% ($461) in the case with CERs and vice versa. EAI behave in the same senses.

Like in the AF system, the TA system is very sensitive to changes in interest rates, establishment cost and any factors that might affect crop yield (Table 4).

For example, increasing the interest rate by 50% leads to a loss of $105 per annum and a peak debt of $183 ha^{-1}. On the other hand, if interest rates are reduced by 50%, a gain of $691 per annum and a peak profit of $42,840 profit will be made.

Table 4: Sensitivity of profitability and cash flows of the land use options to variations in some key assumptions

Land use scenarios	Variable	Change in assumption	NPV ($ ha^{-1})	IRR (%)	BCR	EAI ($ ha^{-1})
	Intrest rate	-50%	$184.740	26	11	$2980
AF		+50	($502)	26	11	($289)
without	Timber price	-50	$485	19	10	$ 128
CER		50	1614	32	13	$ 426
	Intrest rate	-50%	$220.068	30	12	$3549
		+50%	($454)	30	12	($261)
	Timber prices	-50	$485	19	10	$ 128
		+50	$1614	32	13	$ 426
	Transaction cost added	1000	$452	15	12	$119
	Biomass yield	-50%	$1206	28	12	$318
		+50	$1517	31	13	$400
AF +	Establishment	-50%	$1822	55	11	$481
CERs		+50%	$277	13	11	$73
	Intrest rate	-50%	42.840	0	7	691
		+50	(183)	0	7	(105)
	Yield	-50%	(1473)	n/a	4	(389)
		+50	(2318)	1	11	611
TA	Establishment	-50%	832	1	7	219
	cost	+50%	13	0	7	4
	Intrest rate	-50%	$188.880	63	13	$7885
		+50%	$567	63	13	$327
	Sale of cattle/beaf	-50%	($1.007)	-1	7	($266)
			+50%	$14.664	113	20 $3868
P	Establishment	-50%	$8.192	112	13	$2161
	cost	+50%	$5.465	42	13	$1442

NB: 1$ = 500FCFA,

If the yield of the system decreases by 50% leads to and annual lost of $389 as opposed to $611 per annum in the case the yields are increased by 50% (Prices remaining constant).

A reduction in the establishment cost by 50% increases the NPV by $832 (= 97% increase), which is equivalent to $219 per annum.

For the cattle grazing system, if the interest rates are fixed at 50% compared to the 10% assumed in the original analysis then cattle grazing would still be worth establishing. Under this condition, this system still generates $567 ha^{-1} per annum (Table 5) compared to a loss of $105 ha^{-1} per annum and $261 in the TA and AF systems, respectively.

An increase in either yield or price of 50% increased the NPV of farmer pasture system to $14,664, which is equivalent to $3868 per annum. However, a 50% decrease in the selling price will lead to a loss of $1,007 ha^{-1} which is equivalent to ($266) ha^{-1} per annum.

Again, varying establishment cost by ±50% leads to only ±20% change in the NPV and equivalent earnings per annum.

A reduction or increase in profitability, every being constant as earlier assumed, should translate to the same effect on payback, peak debt and break-even payments.

In all 3 cases, the BCR and IRR do not have any significant change.

The results of the sensitivity analysis show there are some significant economic values in interaction effects.

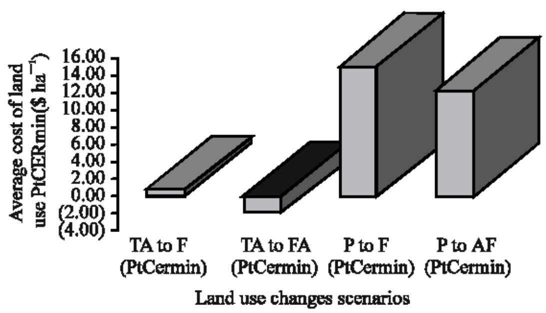

Fig. 3: Opportunity cost of land use change

Opportunity cost of land use change: The opportunity cost of adopting carbon sequestration project was measured in terms of minimum price of carbon sequestration is the benefit that producers would have to give up in order to provide sequestration. Figure 3 shows that, $NPV_{TA} < NPV_{AF}$; $NPV_P > NPV_{AF}$.

The figure shows that the opportunity cost of land use change is highest for a change from the P to the F system (US$15.14 ha^{-1}) as compared to US$12.16 ha^{-1}, US$0.89 ha^{-1} and US$(2.08) ha^{-1} for a change from P to AF, TA to F and TA to AF, respectively. In other words, landowners will be more willing to forgo traditional agricultural practice than the pasture system under the assumptions of this thesis.

Ecological services valuation: Economic analysis and the convention of CBA in particular, which is based upon a common national accounting framework, have

Table 5: Ranking of parameter sensitivity assuming ranges of sensitivities tested are equally likely to occur for each parameter tested

			Change in EAI ($ ha^{-1})			
Rank	Variable	Range*	TA	P	AF	AF+CERs
	Interest rate	80% of base	796	7558	3269	3810
	Sale Price of beef	80% of base	n/a	(4134)	n/a	n/a
	Establishment cost	80% of base	215	719	408	408
	Timber Price	80% of base	n/a	n/a	(298)	(298)
	Crop yield	80% of base	(1000)	n/a	(1000)	(1000)
	Biomass yield/Price	80% of base	n/a	n/a	(82)	(82)

*Range is expressed as a percentage of the base value

Table 6: Relative contributions to ecological degradation by land use options

Criteria/Indicator	AF	TA	P	ΣAW
Ecological	*AW	AW	AW	
Potential to sequester CO_2	3	2	1	6
Invasive species	3	1	1	5
Sustained productivity	3	2	2	7
Resilience of ecosystem	3	1	1	5
Sedimentation	2	1	1	4
Deforestation	3	1	1	5
Soil physical properties (Favorability)	2	2	1	5
Biodiversity (i.e., mean richness in birds, plants, animals, fungi)	3	1	1	5
Soil erosion	3	1	1	5
Conservation of soil moisture	3	2	1	6
Microbial biomass within soil	3	2	1	6
Organic matter in soils/ add soil nutrients	3	2	1	6
Earthworm density in soil	3	2	1	6
Soil pH	3	1	2	6
?AW	40	21	16	77
Maximum score	42	42	42	126
Weighted average contributions of the different land use systems (2dps)	65.45	34.36	26.18	1.00

Average Weight (AW) is an indicator of the ability or capability of a land use to effect a positive change. The higher the value for any land use option, the more ability it has in contributing to that effect. For example, in table 17, the P and TA systems have low ability to sequester carbon and so have been assigned AW = 1, compared to "3" for the AF system

Table 7:Impacts of land use on flora and fauna in the region

No.	Species	Location	Threats	Remarks
1.	*Dovyalis spp nova*	Kilum Ijim Forest	Bush fires (Resulting partly from traditionalagricultural practices)	Only two individuals are so far surviving. Endemic plant of the Bamenda Highlands
2.	*Kniphofia reflexa*	Afua swamp Kinkolong swamp	Over grazing	Endemic plant of the Bamenda Highlands
3.	*Hyparrhenia spp*	High altitudes of the North West Province	-Over grazing -Bush fires -*Farming	Although available in most areas, this grass which is used for roofing of bans and traditional houses is rare and can no longer satisfy human demands
4	*Ericaulon spp*	Laikom ridge	Over grazing	Endemic and rare species.
5.	*Chassalia laikomensis*	Laikom Valley	-Deforestation -bush fires	Mid 6. altitude species
6.	*Prunus africana*	All over the Province	-Illegal exploitation, -Unsustainable harvesting, -Deforestation	Mature plants are very rare in the wild. North West people have resorted to domestication
7.	*Podocarpus latifolius*	Ijim ridge, Kilum forest	Wood carvers	Appears in small thickets above 2000 masl
8.	*Polyscias fulva*	Widespread in the Province	Wood carvers	Mature trees have disappeared from the wild
9.	*Alchemila fisheri*	Summit of mount Kilum	Grazing	Endemiic to mount Kilum and occur at about 3000 masl
10.	*Ledermanniella keayi*	Mboh in Boyo Division	Farming	Endemic and occurs on cliffs.
11.	*Garcinia smeatheani*	Afua and Oku	Farming	Use to occur abundantly at mid altitudes and have been eliminated by deforestation

The term farming used here refers to traditional agricultural practices of all kinds

several fundamental problems with respect to its role in assessing natural capital. One of these problems is that it does not adequately reflect the depletion and degradation of natural resources and the environment. Essential waste-assimilating and life-support roles of the ecosystems are easily ignored and generally excluded from balance sheets. Many of these goods and services are not traded in the market and as such, it is extremely difficult to estimate the true value of natural capital simply in monetary values (Leefers and Castillo, 1998). Hence, a rapid ecological service carried out in order to was carried in order to assess the relative contributions (Table 6) of each of the land use options to ecosystem health restoration and/or climate change mitigation.

These results were complemented with those obtained by NGOs (Table 7) and government officials on the impacts of land use options on natural flora and fauna in the same areas.

We infer from Table 6 and 7 that the AF system contributes most (65.45%) to ecosystem integrity than the other farming options. In the context of the global carbon cycle, agro forestry has the highest potential to sequester CO_2 and thereby contributing to climate change mitigation. It also acts as habitat for a variety of biodiversity unlike the TA and P systems.

DISCUSSION

The purpose of this research was to use cost benefit analysis as major decision tool, supplemented by a rapid ecological service survey, to determine the most economically and ecologically viable land use option in the Bamenda highlands.

Economically, the cattle grazing system had the highest returns on investment $13 that is, after breaking even/or after covering all costs the system can generate $11 for every US$ invested by the farmer. The system has high investment cost and very few people are engaged in the activity.

Given the high demand for beef all over the country, the forces of demand and supply therefore play to its favor. Because of this, the system requires a very high discount rate of 63% > 10% (minimum acceptable discount rate) to annul its net present value. The initial very high peak debt can be attributed to the establishment and maintenance costs accumulating in the absence of any revenue. This shows that, everything being equal, the system can generate more income into the future.

However, the system is very sensitive to changes in selling prices. Other factors such as changes in the prices of veterinary drugs, eventual cow diseases, drought etc., which determine the yield and hence, the selling price were not taken into consideration.

On the whole, the conclusion from this sensitivity analysis is that the Pasture system would be the most favorable investment even if more unfavorable bio-economic conditions than those originally assumed were to prevail during the life of the project.

For the agroforestry option, the initial revenue came from the traditional crops. Payback and break-even payment took a longer period because the revenue generated from the traditional crops was not sufficient to meet up with the peak debt incurred during its establishment. By the end of the project period, when revenues from other sources start to flow in, the system experienced greater profitability (Fig. 1).

The slope of the curve for both AF with or without CERs becomes steeper than that of the TA system (which is at all times steady). This gives us another reason to suggest that, in terms of long-term profitability, the AF system, with or without CERs could stay longer into the future and generate more income than the TA system.

Based on the sensitivity analysis the most important area requiring research and development is the price of biomass. This analysis used a price of $10 per tonne carbon dioxide but if that price could be improved by improving the quality of the biomass, e.g. a high value extractive then woody phase crops are more likely to be attractive to farmers. Again, the research used Eucalyptus species that is generally accepted in scientific circles as a water drainer and thus out competes other plants. Hence, an investigation using more environmental friendly and multi-used plants species like *Prunus Africana* and other agro forestry crops (especially fruit crops and/ or economic crops) may give more insight into the value of this land use option. Land suitability analysis and silvicultural studies will be essential to ensure substantial yield. Which agroforestry plant species can yield more biomass without upsetting the local ecosystem processes?

Ecologically, based on the variables used in this study, the cattle grazing system appears to contribute the least (26%) to ecological services and hence, ecosystem functions. Unlike in the agroforestry system, grazing areas were found to have high disturbance on the soil, increase sedimentation in adjacent streams and destroy habitats for biodiversity (i.e., mean richness in birds, plants, animals, fungi).

In terms of global carbon sequestration and based on our assumptions, the results showed that, the AF system has the potential of sequestering a substantial amount of carbon. Our results fall in the same range with those reported by Dixon (1995), who stated that the carbon storage potential of agro forestry systems ranges from 12-228 t C ha^{-1}, with agro forestry in the humid tropics displaying the greatest carbon storage ability.

For example, in an earlier study involving an average cost approach, Dudek and LeBlanc (1990) estimated the costs of carbon storage under the U.S. Conservation Reserve Program (CRP) at $38 per ton. Stavins based his estimates on average annual revenue and production data

Fig. 4a: Agrisilviculturalist at Mendakwe: Trees (*Pygeum, Eucalyptus*, Raffia palms) and crops (beans, corn, cocoyam etc) mixed together- a multipurpose forestland

Fig. 4b: Bush fire a serious threat to biodiversity and vegetation in the NWP

from 36 southern U.S. counties, concluding that annual marginal costs of carbon storage through expansion of U.S. pine plantations could be as high $1,000 per acre and $665 per ton.

In all AF systems it was found that apart from being a source of carbon sink, the system also played the role of reducing sedimentation into adjacent streams, biodiversity (i.e., mean richness in birds, plants, animals, fungi), richest in organic matter, earth worms etc. The reason for the highest biodiversity richness can be attributed to its ability to maintain ecosystem processes as opposed to the other two options. More over, the system has the ability to sustained productivity, reduce sedimentation and possible drying off streams, as is the current situation in the Bamenda Highlands and provide habitats for biodiversity (i.e., mean richness in birds, plants, animals and fungi). The World Bank in 2002 identified similar findings for agro forestry plantings in Indonesia where the system was found to harbor 50% of the plants, 60% of the birds and 100% of the large animals that normally would be found in a natural forest. In the same line, Pandey (2002), found that agroforestry systems were important in India as they reduce deforestation and the trees employed in the system act as carbon sinks until they are cut or die. These findings, among many others, argue for increasing education of the population on the importance of agro forestry in the Bamenda highland area.

Fig. 4c: Typical traditional crop cultivation in the Bamenda highlands (Mixed cropping: Maize, beans cassava combined in Mankon village)

Fig. 4d: Cattle grazing

Finally, our results also indicate that agro forestry can act as a buffer between protected forests and surrounding agricultural land and minimize edge effects in natural forests.

According to Table 7, the traditional agricultural system and the cattle grazing are generally seen in the province by both government and NGO officials as threats to natural flora and fauna. The slash and burn cultivation, clearing of the forest with wild fire (Fig. 4) in the dry season for traditional crop cultivation and to have fresh grass for cattle rearing are just some few examples. When compared to agroforestry in terms of their importance to ecological integrity, these two systems were found to be less friendly with the ecological system. It is like all what is right with the agroforestry system is wrong with its alternatives in terms of sustainability and provision ecological services and vice versa.

Finally, in terms of opportunity cost of land use change, our results show that it will cost a potential investor more if he/she would decide to change from P to AF. The high opportunity cost can results from the low present value of CERs. This result shows the need for carbon prices to be significantly high enough. It also shows that, pricing carbon at low prices may not significantly contribute to farmer's income and, may lead to an unbalanced situation where the environmental and/ or ecological integrity will be secured at the expense of food security or both.

CONCLUSION

Hence, keeping aside the environmental impacts of the system, particularly its role in climate change mitigation and or environmental services the land use options may offer, then, under the assumptions driving this analysis the TA system may not be recommended as an economically viable land use system in the Bamenda highlands.

Keeping aside the environmental impacts of the land use systems, particularly its role in climate change mitigation and or environmental services, then, under the assumptions driving this analysis the P system could be seen as the most economically viable land use system in the Bamenda highlands, while the TA system, the least viable.

Taking into consideration the relative contributions of the different land use options to ecological services or climate change mitigation and sustainable food production, agro forestry, particularly, is seen as the most viable option, while the TA system, the least viable.

Hence, based on the objective of this study and the assumptions set forward, the agroforestry option, especially agrisilvilculture, could be looked upon as the land use option that can contribute to climate change mitigation and welfare improvement of poor smallholder farmers who cannot integrate traditional markets, but need alternatives for income generation, in the Bamenda highlands. However, carbon prices and/ or biomass production seem to be constraints to the system.

The following information will be important for the success of the system:

- Thorough sivilcultural studies to determine the tree crops which best sequester carbon dioxide.
- Land suitability analysis will also be needed for precision agro forestry.
- Finally, the analysis refers to the farm households' view, therefore includes only costs and benefits to local farmers. The macroeconomic effects have not yet been analyzed. Further research is needed to study the impacts of the agro forestry system on reduction in shifting cultivation and deforestation.
- As earlier mentioned, we were unable to model spatial interdependencies of ecosystem services among the different land use options. Addressing these deficiencies in empirical works is an important avenue for future research.

There is also a need to investigate the cost of neocolonialism on environmental degradation in sub-Sahara Africa. "Neocolonialism does promote and sustain corrupt regimes. Corrupt regimes serve their "masters" instead of the citizen leading to poverty. Poor citizens in turn degrade the environment in all dimensions in order to find a means of living".

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REFERENCES

Abadi Ghadim, A.K. and D.J. Pannell, 1999. A conceptual framework of adoption of an agricultural innovation. Agric. Econ., 21: 145-154.

Antle, J.M., S.M. Capalbo, S. Mooney, E.T. Elliott and K.H. Paustian, 2000. Economic analysis of agricultural soil carbon sequestration: An integrated assessment approach. J. Agric. Res. Eco., 26: 344-367.

Brown, S., 1997. Estimating Biomass and Biomass Change of Tropical Forests: A Primer. Rome, Italy: FAO Publications.

Bruce, J.P., H. Lee and E.F. Haites, 1996. The Social Costs of Climate Change: Greenhouse Damage and the Benet of Control. In: Climate Change, 1995: Economic and Social Dimensions of Climate Change, Contribution of Working Group III to the Second Assessment Report of the Intergovernmental Panel on Climate Change, Ed. Cambridge, U.K.: Cambridge University Press, pp: 178-224.

Budowski, B. 1999. Secuestro de carbono y gestión forestal en América Tropical. Bosques and Desarollo, pp: 17-20.

Bullard, S.H. and T.J. Straka, 1998. Basic Concepts in Forest Valuation and Investment Analysis. 2.1 Edn. Preceda Education and Training, Auburn, AL, www.preceda.com.

Costanza, R., R. d'Arge and R. de Groot *et al*., 1998. The value of the world's ecosystem services and natural capital. Ecol. Econ., 25: 3-15.

De Jong, B., G. Montoya-Gómez, K. Nelson, L. Soto-Pinto, J. Taylor and R. Tipper, 1997. A framework for monitoring and evaluating carbon mitigation by farm forestry projects: Example of a demonstration project in Chiapas, Mexico. Mitigation Adaptation Strategies Global Change, 2: 231-246.

Dixon, R.K., 1995. Sistemas Agroforestales y Gases de Invernadero. Agroforestería en las Américas, 2 (7): 22-26.

Dudek, J. and A. LeBlanc, 1990. 'Offsetting New CO_2 Emissions: A Rational First Greenhouse Policy Step. Contemporary Policy Issues, 8 (1): 29-41.

Godsey, L., 2000. Economic Budgeting for Agroforestry Practices. University of Missouri, Center for Agroforestry, pp: 19.

Greiner, S. and A. Michaelowa, 2003. Defining investment additionality for CDM projects-practical approaches. Energy Pol., 31: 1007-1015.

Houghton, J.T., B.A. Callender and S.K. Varney, 1992. Climate Change 1992. The Supplementary Report to the IPCC Scientific Assessment. Cambridge, U.K.: Cambridge University Press.

Houghton, J.T., 1996. Climate Change 1995: The Science of Climate Change. Cambridge, U.K.: Cambridge University Press.

IETA, 2003. Greenhouse Gas Market: International Emission Trading Association, Switzeland.

IPCC, 2003. IPCC good practice guidance for LULUCF sector. Intergovernmental panel on climate change, Cambridge University Press, Cambridge, UK.

Jgap, S. and C. Ong, 1997. Perspectives on Issues Needs and Opportunities for Agroforestry Models. In: Agroforestry Modelling and Research Co-ordination 1996-97 Annual Report. Lawson *et al*. (Eds.). (Institute of Terrestrial Ecology, Natural Research Council: UK), pp: 110-112.

Kursten, E. and P. Burschel, 1993. CO_2-mitigation by agro forestry. Water, Air and Soil, 70: 533-544.

Leefers, L.A. and G.B. Castillo, 1998. Bridging the gap between economics and ecology. Cons. Ecol., 2 (2): 19. http://www.consecol. org/vol2/iss2/art19

Mbah James Mbah, 2000/2001. Annual report for the provincial service of control brigade. NWP, Cameroon.

Olschewski, 2001. Economic Assessment of Forestry Projects. Georg-August-University Göttingen, Inst. Forest Ecol., pp: 38.

Pandey, D.N., 2002. Carbon sequestration in agro forestry systems. Climate Change Policy, 2: 367-377.

Parker, T.A.P. III., A.H. Gentry, R.B. Foster, L.H. Emmons and J.V. Remsen, 1993. The Lowland Dry Forests of Santa Cruz, Bolivia: A Global Conservation Priority. Rapid Assessment Program Working Papers No. 4. Conservation International, Washington D.C., USA/ Fundaci\n Amigos de la Naturaleza, La Paz, Bolivia, pp: 104.

Peirson, G., R. Brown, S. Easton and P. Howard, 2002. 'Business Finance. 8th Edn. McGraw Hill: Sydney.

Plantinga, A.J., T. Mauldin and D.J. Miller, 1999. An econometric analysis of the costs of sequestering carbon in forests. Am. J. Agric. Eco., 81 (4): 812-824.

PointCarbon, 2004. Viewpoint: The market of the German NAP. www.pointcarbon.com.

Reddy, S. and C. Price, 1999. Carbon Sequestration and Conservation of Tropical Forests under Uncertainty. J. Agric. Econ., 50 (1): 17-35.

Stavins, R., 1999. The Costs of Carbon Sequestration: A Revealed Preference Approach. Am. Eco. Rev., 89 (4): 994-1009.

Segura, M., 1997. Almacenamiento y Fijación de Carbon en un Bosque de Altura en la Cordillera de Talamanca, Costa Rica. Heredia, Costa Rica: Universidad Nacional thesis.

Singh, T.P. and M. Lal, 2000. Carbon sequestration through farm forestry: A case from India.Indian Forester, 126: 1257-1264

Sonwa, W., S. F. Weise, M. Tchatat, B. Nkongmeneck, A.A. Adesina, O. Ndoye and J. Gockowski, 2001. The Role of Cocoa Agroforests in Community and Farm Forestry in Southern Cameroon. Rural Development Forestry Network Paper 25 g. Oversease Development Institute (ODI), London. Found at http://www. odifpeg.org.uk/rdfn/mailing25/25g_english.pdf.

Trapnell, L., 2001. Economics and cash flow from tree crops for restoring hydrological balance in high rainfall areas. Economic Analysis Report. Department of Natural Resources and Environment: Benalla, Victoria.

Watson, R.T., M.C. Zinyowera and R.H. Moss, 1998. The Regional Impacts of Climate Change: An Assessment of Vulnerability. Cambridge, U.K.: Cambridge University Press.

World Resources Institute (WRI), 1998. The Clean Development Mechanism and the Role of Forests and Land Use Change in Developing Countries. www.wri.org/wri/f. / climate/cbf-cdm2.htmñ (20/07/05).

World Bank, 2002. Integrating Forests in Economic Development. In: A Revised Forest Strategy for the World Bank Group. Washington, DC: World Bank.