1. Introduction

1.1. Background

The fact that anthropogenic and natural factors are contributing negative impacts on climate is already known. In the Bamenda highlands of Cameroon, the living consequences include global warming, deterioration and/or insecurity of ecological goods and services[1], and low agricultural outputs. 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.

Mitigating climate change and optimizing food production to ensure food security is therefore a great challenge to scientists in general.

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 *et al*., 2000), Mexico (De Jong *et al*, 1997), sub-Saharan Africa (Unruh *et al*., 1993) .

However, landholders often base their decision mainly on the actual profitability and cash flow consequences of an innovation and not necessary on the so called 'best-bet' technologies. Hence, if agroforestry is important as stated, 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.

1.2. 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: 1) what is the opportunity cost of changing from the conventional system to agroforestry. 2). How significant are certified emission credits? 3).How much better off would a farmer be by replacing his conventional agricultural

[1]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, fresh water

practice with carbon sequestration project such as agroforestry?"

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.

2. Materials and Methods

2.1. Study area

The Bamenda highlands, located in North West Cameroon are one of the most populated regions of the country. Annual average temperatures range between 14 and 28°C, while annual average rainfall averages 2500mm (Mbah James Mbah, 2002). The soils are not uniform, moderately deep, varied, and generally acidic, with pH range of 4.5-5.0, sandy-clay ferruginous soil (laterite). The economy of the Province depends largely on agriculture with cattle grazing; slash and burn-shifting cultivation (traditional agriculture) being the commonest agricultural practices. Agroforestry is still in its juvenile stage and needs education and incentives for its adoption.

2.2. Data collection

Costing (establishment and maintenance and marketing) involved in all, expert knowledge, farmers, market men and women, were consulted.

To estimate benefits, the difference between the net revenue should all the products under cultivation be sold at a particular year, and the total input costs was calculated.

For timber harvest, the Mean annual increment (MAI) and current annual increment (CAI) data were used to estimate the economic value from sustainable timber harvests Timber revenue per hectare was calculated as:

Timber revenue ($ha^{-1}yr^{-1}$) = [MAI (m^3 /ha)* Price/tonne]*5 years, assuming a 1:1 conversion of m^3 to tons.

For Carbon Storage, data for CAI and MAI for the past six years, from clonal *E.globolus* plantation were used. Total tree biomass was then multiplied by 0.5 (the fraction of carbon in biomass (Houghton RA, 1995)) 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).

2.3. Valuing Carbon sequestration

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:

$$\boxed{NPV_A = \underbrace{PV_B(P_{CER}.CER)}_{\substack{\text{Revenues from selling} \\ \text{Certified Emission Reductions (CER)}}} + NPV_B} \qquad \text{……………………………… (1)}$$

Where,

NPV_A denotes the net present value for conventional practice, A, NPVB denotes the net present value for carbon sequestration project, B, $PV_B(P_{CER}.CER)$ denotes the present value for certified emissions reductions for project B, and P_{CER} denotes the price (or payments) for certified emissions reductions. It follows from (1) that,

$$P_{CER} \leq \frac{NPV_A - NPV_B}{PV_B(CER)}; PV_B(CER) \neq 0 \Leftrightarrow P_{CER}\min = \frac{NPV_A - NPV_B}{PV_B(CER)} \text{..........................(2)}$$

Where P_{CER} min denotes the minimum price a non-annex 1 country could accept.

Taking agroforestry, (AF), Traditional agriculture (TA), Pasture (P), and forestry investments into consideration, we have:

$P_{CER}\min = \dfrac{NPV_P - NPV_{AF}}{PV_{AF}(CER)}$, for a change from P to AF, and $P_{CER}\min = \dfrac{NPV_{TA} - NPV_{AF}}{PV_{AF}(CER)}$,

for a change from TA to AF, and so on.

Hence, landowners in non-annex 1 countries may not be willing to adopt carbon sequestration project if $P_{(CER)}$ min (or i_{annex1}) 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, $P_{CER_0} \leq P_{CER} + \frac{P_{CER}}{(1+i)^T} \Leftrightarrow P_{CER}\max = P_{CER_0} - \frac{P_{CER}}{(1+i)^T}$ …………...(3)

If P_{CER_0} remains constant, then,

as $i \to +\infty, P_{CER}\max \to P_{CER_0}$,and as $i(\neq -1) \to -\infty, P_{CER}\max \to -\infty$.

From our analysis, it is evident that, a potential market between annex I and non-annex I countries can exist if i_{annex1} is reasonably low. A number of assumptions based on the policy context of carbon emissions are needed for these economic values to be viable.

2.4. Cost Benefit Analysis

In the comparative analysis, key assumptions were held constant while alternative land uses were compared. 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.

Indicators of cash flow and profitability used in the investment analysis include, Net Present Value model **(**ANTLE *et al.*, 2000) adjusted to account only the carbon present in tree biomass; Equal annual Income (Bullard, S.H., and T.J. Straka. 1998), Benefit Cost Ratio, Internal rate of Return **(**Olschewski 2001; Godsey 2000).We also included Peak debt, Payback and Break-even **(** Trapnell 2001). Sensitivity analysis was carried out to understand changes or errors in the key economic drivers. For the sake of consistency and brevity, the sensitivity analyses in this paper focus on a few variables likely to be of economic importance.

2.5. Environmental Service Assessment

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

3. Results and Discussions

3.1.Results

3.1.1. 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; PointCarbon2004 estimates this to $10/$tCO_2$. Based on these two estimations, our study assumed a price of $10/$tCO_2$ from which we have,

$$P_{tCER}max = 10 - 10/(1+0.03)^6 = \$1.63t/CO_2e \qquad \ldots\ldots(4)$$

This is the maximum amount a demander can pay per ton of carbon dioxide sequestered under the defined conditions. It is based on the value that we calculated the cumulative amounts and discounted cumulative values of carbon dioxide per annum.

3.1.2. Cash flow and Profitability analyses

This section describes results of a comparative financial analysis of the different land use options. All results (table 1) are for the complete farming systems.

Table 1.Summary of the economic analysis of the land use systems (scenarios)

Farming system	Enterprise & product(s)	NPV ($/ha)	EAI ($/ha)	IRR (%)	BCR	Peak debt ($/ha)	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)

3.1.3. Peak debt, Payback and Break -even period

Peak debt. The cattle grazing system (P), has a cumulative cash deficit of US$3000/ha 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, while for the traditional system, it is only US$900/ha

Payback period. Though with the highest peak-debt, the P system requires a year for cumulative discounted cash flow to become a surplus (figure 1). 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.

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 fourth year.

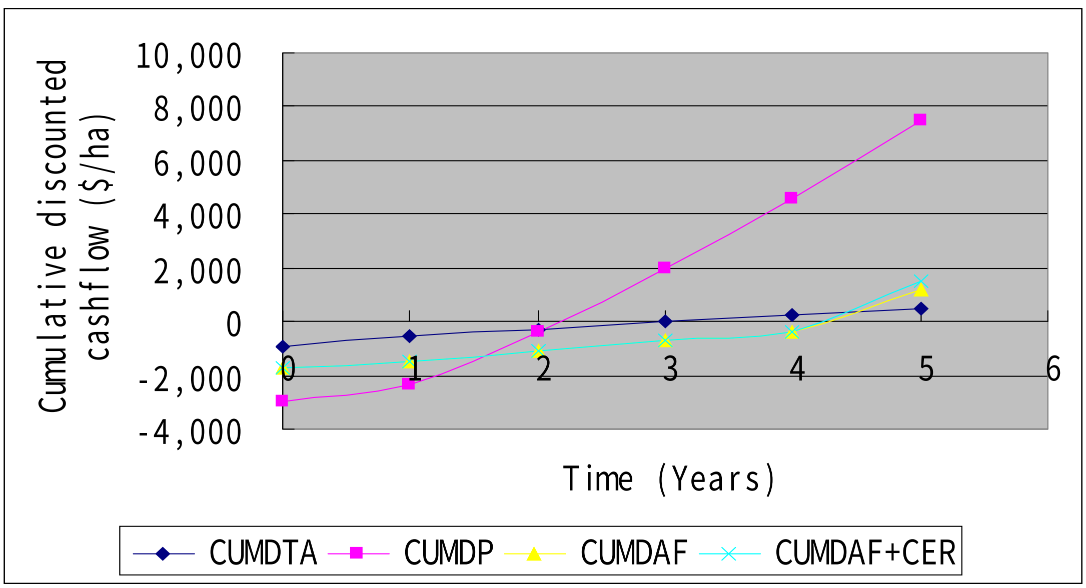

Figure 1: Cumulative discounted cash flow analysis of the land use scenarios
CUMD (TA/P/AF/AF+CERs): Cumulative discounted TA, P, AF and AF+CERs systems

3.1.4. Sensitivity analysis

All variables were varied by ±80% of the base case (table 2).

Table 2: Ranking of parameter sensitivity assuming ranges of sensitivities tested are equally likely to occur for each parameter tested

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

*Range is expressed as a percentage of the base value

Table2: Sensitivity of profitability and cash flows of the land use options to variations in some key assumptions

NB: 1$ = 500FCFA

3.1.4. Opportunity cost of land use change

Figure 2 shows that, $NPV_{TA} < NPV_{AF}$; $NPV_{P} > NPV_{AF}$

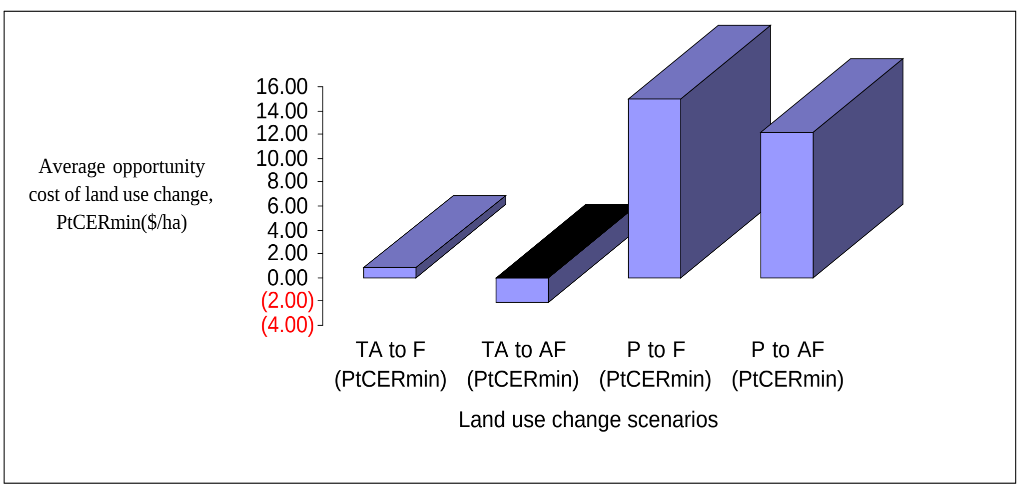

Figure: 2: Opportunity cost of land use change.

.This 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) as compared to US$12.16/ha, US$0.89/ha, and

US$(2.08)/ha 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.

3.2. Discussions

The cattle grazing system had the highest returns on investment $13 .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.

For the agroforestry option, 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 (figure1). 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.

Ecologically, based on the variables used in this paper, 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. 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.

4. Conclusion.

Keeping aside the environmental impacts of the land use systems, 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, could be seen as the most viable option, while the TA system, the least. Hence, based on the objective of this study and the assumptions set forward, the agroforestry option, especially agrisilvilculture, could be considered as the most sustainable and environmental friendly landuse option. However, thorough sivilcultural studies to determine the tree crops which best sequester carbon dioxide. Land suitability analysis will also be needed for precision agro forestry. 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. 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.

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