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Carbon Finance Schemes - Incentives for Forest and Agroforestry Systems

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Deforestation contributes a quarter of all anthropogenic greenhouse gas emissions. On the island of Sulawesi in the vicinity of the Lore Lindu National Park, smallholders contribute to deforestation processes with their agricultural practices, specifically with cocoa plantations.

This study assesses the impact of carbon sequestration payments for forest management systems on the prevailing land use systems. Additionally, the level of incentives which induces farmers to adopt sustainable agroforestry practices is determined.

We show that low carbon credit prices have a small impact on household income. However, with rising prices, the poorest households can realise an increase of 18 percent. The majority of the households have an incentive to adopt the more sustainable shade intensive agroforestry system and stop deforestation activities with prices observed on markets. The cost-efficiency of avoided deforestation, compared to biofuels, is demonstrated. The study shows that forestry activities provide an important opportunity as climate mitigation strategies.

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1. Introduction

Forest cover is decreasing globally and developing countries, especially those in tropical areas, experience even higher rates of deforestation due to a variety of contributing factors including agricultural expansion. Deforestation causes about a quarter of human induced carbon dioxide emissions. Solutions and strategies to actively sequester and conserve the remaining stocks of carbon such as Payments for Environmental Service (PES) schemes are used as market-based incentives to enforce or support sustainable forest management and conservation activities [1].

On the island of Sulawesi in Indonesia, the forest of Lore Lindu National Park (LLNP) covers 220,000 hectares and has been facing encroachment and consequently deforestation. The area dedicated to agricultural activities has increased by 20 percent during the last two decades, the perennial crop plantations area has tripled and there has been expansion into former forest areas, as well as selective and clear-cut logging. A village survey in 2001 revealed that 70 percent of the villages bordering the LLNP have agricultural land inside the Park [2]. The region's mean annual deforestation rate of 0.3 percent between 1983 and 2002 [3] does not include plantations under shade trees or the intensification process among the cocoa agroforestry systems (AFS), whereby farmers gradually reduce the shade tree cover. The focus of the present research is twofold: to assess the impact of payments for carbon sequestration activities on the land use systems of smallholders in the regions bordering the LLNP in Indonesia, and to determine if payments provide an incentive for the adoption of more sustainable land use practices thus contributing to the conservation of the rainforest margin.

2. Framework

The research seeks to understand which level of incentives is needed for farmers in the research area to cease further deforestation and land use intensification activities.

It reflects the growing international awareness for payment mechanisms and incentives for the provision and preservation of environmental services where local actors are given payments in return for switching to more sustainable land-use practices and ecosystem protection, which usually implies payments by the beneficiaries of the environmental services. These payments for environmental services (PES) policies have been defined by Wunder [4], as voluntary, conditional agreements between at least one “seller” and one “buyer” over a well-defined environmental service – or a land use presumed to produce that service.

In the region around the LLNP four cocoa AFS can be distinguished according to the degree of shading and shade tree species, as well as the management intensity: AFS I exhibits a high degree of shading with natural forest trees and a low management intensity, while AFS IV involves intensive management and fully sun grown cocoa. The gross margins of cocoa consistently increase along the cocoa AFS gradient from I towards IV [5]. The trade-off situation appears to be between the high economic returns of cocoa cultivation in shade-free plantations and the lower returns for shade-grown cocoa. However, although shade-free cocoa has higher mean yields and substantially higher net returns in comparison with shade grown cocoa, the anticipated agronomic risks (declining soil nutrient levels), socio-economic dangers (single crop dependency) and negative impact on local food security [6] render it unsustainable. Furthermore, AFS I provides high biodiversity values and habitat for the native fauna, whereas AFS IV plantations reduce the landscape level diversity by eliminating secondary forests on fallow land and may adversely affect the soil fertility [7]. Thus, to prevent a transformation of the AFS to monocultures in the region, economic incentives are required. Price premiums, as used for fair trade and organic coffee, or alternatively carbon certificates, could offer an incentive for the more shade grown, biodiversity rich and sustainable cocoa AFS and slow down the intensification process.

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Another contributing factor is related to land sales. In the 1990s many Bugis people settled into the research area and have since started to buy land from the local Kaili and Kulawi households. In many cases this land is obtained by clearing primary forest on the border of the National Park [8, 9]. The local groups consider themselves the owners of the village territory and therefore do not need to buy land, but realise the opportunity to sell land. The additional income generated is usually used for ceremonial purposes, which require substantial amounts of cash [10].

The debate with respect to reducing emission from deforestation and forest degradation (REDD) has gained momentum after the United Nations Framework Convention on Climate Change (UNFCCC) Conference in 2007. Before this, few avoided deforestation projects existed and there was much scepticism over their implementation and success. Laurance [11] saw the potential for a viable mechanism for using tradable carbon offsets to protect rainforests. Reducing deforestation can significantly cut greenhouse gas emissions and developing countries, especially forest-rich nations, could potentially gain large revenues from carbon credits. Ebeling and Yasue [12] calculate revenues of between €1.5-9.1 billion annually if the deforestation rate is reduced 10 percent and carbon prices range from €5-30 $tCO2e^{-1}$.

3. Data and Methods

Given its reliability for studying the impact of policy activities [13], we chose a comparative static linear programming model to simulate the farmers' reactions to interventions and the effect of technology changes on economic decisions about natural resource use management. As an input for the model, the gross margins for the main cropping activities paddy rice, upland rice, maize and cocoa were calculated. Forest conversion activities based on various economic-political-environmental parameters from the research region were included to realistically portray smallholders' behaviour.

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The solution procedure maximises the farm's total gross margin (TGM) by finding the optimal set of activities for the household type with the respective restrictions of farm size, suitability of the land for various crops, food security, credit limit (formal and informal), family workforce, and peak seasonal labour requirements (Table 1).

The data on existing agricultural production systems was collected in 2006 through a random sample of 46 households in six villages bordering the LLNP. Households were categorized according to their dominant AFS resulting in four household types (HH_I - HH_{IV}). Household type I, who consists mainly of the local groups, has the lowest credit limit and the least cultivated land, which is mainly dedicated to cocoa AFS I. Household types II and III have an increasing credit limit and most land available for cultivation, dedicated largely to AFS II and AFS III, respectively. Within these household classes the share of migrants becomes more dominant. Household type IV, which is mainly non-local, predominantly grows AFS IV. However, its credit limit is the second highest and its land availability is the same as that of household type I which could influence their adoption of the more intensive production system. Using a poverty assessment tool based on principle component analysis [14], we note that there is a poverty gradient to be found from HH_I towards HH_{IV}. Within type I, 67 percent belong to the poorest households, whereas 63 percent of the type IV households can be categorised as better off. The households of the two other categories fall into all three welfare groups.

According to the Kyoto protocol, all credits from sink projects have a temporary status and expire after a certain time. Afforestation projects are awarded a temporary certificate of emission reductions (tCER) activity under the CDM, which are limited to five years, after which they can be re-issued. Once the tCER are not re-certified, a permanent solution is needed to fulfil the reduction requirements. As we envisaged a total project horizon of 25 years, we assume the tCER will be issued five times,

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assuming that the credits are synchronous with the commitment periods [15, 16]. To counter the incentives for sun-grown cocoa plantations we advocate accounting for the annual net rate of carbon accumulation of the shading trees in the AFS I, II and III as estimated by Brown et al. [17] and included in the carbon budget for the AFS I, II and III. The tCER for the first five year crediting period are related to the cumulative carbon storage of the AFS system. The first credits are generated after five years. These tCER expire after five years, but are reissued in year 10 together with additional tCER. The same procedure is applied for the following 5-year periods until the last issuance of tCER in year 25, and reflects the total net storage of CO2 since the project started.

The low prices for forestry tCERs reflect their need to be replaced by permanent ones at some point in the future. Therefore, the value of the temporary credits can be seen as the difference between the current permanent credit price and the discounted value of the future permanent credit price:

$$P_{tCER_0} = P_{CER_0} - \frac{P_{CER_T}}{(1 + d^*)^T} \qquad (1)$$

where CER0 is the price of the CERs today and CERT the price of permanent CERs discounted at rate d* found in Annex I-countries and T is the expiring time of tCER [18].

For the conversion the CER prices are assumed to be constant over time ($p\ CER_0 = p\ CER_T$), and a three percent discount rate (d*) is taken, which reflects the current low interest rates in Annex I countries [19]. As a tCER has a duration of five years, its value according to the equivalence relation in (1) is only about 14 percent of that of a permanent credit.

The annual remuneration to the farmer was obtained for each land-use system through the calculation of the net present value, using equation (2), where d represents the discount rate in Indonesia and T the 5 year periods from year 5 until 25. The calculations refer to the net carbon accumulation.

$$\Sigma tCER \cdot (1+d)^{-T} = \frac{(\text{net } CO_2 \text{ storage})_5}{(1+d)^5} + \frac{(\text{net } CO_2 \text{ storage})_{10}}{(1+d)^{10}} + \ldots + \frac{(\text{net } CO_2 \text{ storage})_{25}}{(1+d)^{25}} \quad (2)$$

For the linear programming model the net present values are converted to annuities, in order to show the annual payments which the farmer would receive from a 25 year sequestration project.

4. Results and Discussion

4.1. Impact of carbon payments on smallholders' land use systems

Low carbon credit prices of €5 $tCO2e^{-1}$ result in annuity payments of 4 percent of the cocoa gross margin for high shade AFS (€100 ha^{-1}), and less than 1 percent of the sun-grown AFS cocoa gross margin (€1,460 ha^{-1}) whereas prices of €25 $tCO2e^{-1}$ result in payments of 18 and 2 percent respectably. As the net carbon accumulation is similar between all four systems, the variation between the four AFS is very small. However, the highest carbon sequestration payments are always obtained for the high shade AFS and decline towards the AFS III. AFS IV obtains mid-range payments because the cocoa trees are more densely planted in comparison to the other three shaded systems.

Baseline TGMs of the crop activities at the household level were calculated. Although the cocoa gross margins increase in profitability along the cocoa AFS intensification gradient from I towards IV, local farmers do not only employ necessarily

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the AFS with the highest gross margin. The factors and circumstances for this (distance of the plot to the forest, traditional land use practices and cultural preferences) are not reflected in the model. The baseline exhibits an increase of the TGM from crop activities from HHI towards HHIV which mirrors the poverty gradient. Hence, the wealth gradient from household type I towards household type IV is corroborated.

Results from the linear programming model indicate that payments for carbon sequestration has a limited impact in absolute terms on the TGM between the four household types (Table 2) - between €10 and €70 annually. The relative impact is the most pronounced for the household type I (a potential increase of 18 percent at €25 $tCO2e^{-1}$), whereas for household type IV the corresponding impact is almost negligible. However, at current carbon prices no switches between the different systems are observed.

In assessing whether carbon payments were an incentive for households to adopt the biodiversity rich, shade intensive agroforestry system, credits were targeted only towards the first two agroforestry systems in recognition of the functionality of their high-level ecosystem. The results indicate that with carbon credit prices of up to 32€ $tCO2e^{-1}$ the first three household types will adopt more of the sustainable agroforestry systems. These prices are in a range of offset credits to be observed on carbon markets currently and lower than organic cocoa price premiums. Only household type IV would need very high credit prices of 185€ $tCO2e^{-1}$ to induce him to adopt more of the less intensive cocoa production practices.

4.2. Reducing emissions from deforestation and forest degradation

The discussion on REDD usually focuses on the national level, but incentives can also be set at the local level, as agricultural activities are often a major driving force of conversion processes. Although the arrangements as to who should be paid for avoided deforestation has yet to be resolved, for this case study we appraise the feasibility of compensation payments being made to farmers with a simple projection. The current estimate for the carbon content of the LLNP forest is 435 tCO2e ha^{-1} [20]. Assuming that the current deforestation rate of 0.3 percent is reduced to 0, annual emissions of 13 tCO2e ha^{-1} could be avoided. Depending on the prices paid for avoided emissions from deforestation, payments between €65 and €326 per hectare could arise .

At €12 per ton the evolving payments are sufficiently high enough to provide an incentive for the household types I and II to stop forest conversion activities. Increasing prices to €23 $tCO2e^{-1}$ avoided would stimulate household type III to desist from further tree cutting. Household type I obtains a much lower cocoa gross margin and, hence, needs a much lower compensation payment to stop forest conversion. In comparison, household type IV receives a very high gross margin for the intensively managed cocoa and needs a credit price of €54 $tCO2e^{-1}$ avoided.

As mentioned earlier, households from the local ethnic groups often sell the land to Bugi migrants who tend to have more intensively managed cocoa agroforestry systems (see also Table 1). As the income gained through land sales is often spend on ceremonial purposes, local households will convert further forest to fulfil their subsistence needs. Compensation payments specifically targeted towards the shade intensive AFS I and II, which are mainly cultivated by the local ethnic groups, could provide a solution to this situation as the payments will enable the poorest households to escape poverty and address the need to convert additional forest to obtain more income and/or land.

To determine if focussing only on agricultural production activities is a cost-efficient solution for the abatement of greenhouse gases, we compare the abatement costs of alternative biofuels to the opportunity costs of conserving the LLNP forest.

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These are calculated by converting the net present values of the average cocoa agroforestry system, as well as the AFS IV to annuities, to derive the annual payments from a 100 year project horizon and divide these by the annually avoided tons of CO2e per hectare when completely reducing deforestation. Although bioethanol production from sugar cane in Brazil is the most cost-efficient solution with negative abatement costs of –27 € $tCO2e^{-1}$, the avoided deforestation of the LLNP (AD LLNP 53 €$CO2e^{-1}$) is a firm second option and far more effectual than the remaining biofuel options. These numbers do not include other environmental services provided by the forest (which raise its value even further) or the additional environmental costs caused through diverting land from previous agricultural activities or forest to biofuel production. However, the transaction costs of a REDD project have also not been included in the calculation of the abatement costs for avoiding deforestation, which would lower its benefits.

Therefore, in the search for cost-efficient solutions for the abatement of greenhouse gases among activities in the agricultural sector for Germany and other developed countries, it is reasonable to invest in the conservation of the LLNP before investing in other biofuel strategies to mitigate climate change.

5. Conclusions

This study demonstrates the importance to include smallholders when targeting the reduction of greenhouse gas emissions and searching for policy approaches as the uncontrolled agricultural expansion at forest frontiers undeniably contributes to its conversion and loss. Market-based mechanisms and incentive schemes, such as carbon credits, can offer solutions for the sustainable management and conservation of forests.

We derived that per hectare payments for carbon sequestration of cocoa agroforestry systems are the highest for fully shaded land use systems, they hardly differ between the systems. Depending on the certificate prices, a farmer could obtain between

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€6 and €28 per hectare for the carbon sequestration of the cocoa AFS. Although at €5 $tCO2e^{-1}$ the additional remuneration for the AFS in general is quite low, with carbon certificate prices at the upper end, the poorest households can realise an 18 percent increase of their gross margin from cropping activities with the introduction of payments and also realise the highest increase in absolute terms of their gross margin. Additionally, they provide the second highest (and only marginally lower than the highest) environmental benefit in terms of the annual carbon sequestration rate of their cocoa agroforestry systems. Therefore, the importance of the carbon payments is not so much the absolute impact itself, but more importantly which household type derives more benefit. Payments specifically targeted towards the high-shade AFS indirectly benefit the poorer households from the local ethnic group. In turn, this additional income could reduce their need to sell their land to the migrants.

Carbon certificates could also be used as a price premium to foster the adoption of the shade intensive AFS I and II. Although farmers of the household types I-III would need differentiated prices to stimulate the switch towards the more sustainable land use systems, current carbon market prices could doubtlessly be sufficient. Additionally, the analysis shows that compensation payments calculated at current carbon rates is sufficient incentive for three household types to cease deforestation reduction, which ultimately leads to avoided greenhouse gas emissions. The high net-revenues for fully sun grown cocoa make it very difficult to provide viable and financially attractive alternative activities for the richer farmers.

Carbon payments applied in general to all AFS will not have a great impact in terms of a contribution to environmental services. However, if other criteria, such as the provision of further environmental services are included, specific systems can be targeted in order to promote a switch towards these AFS. For carbon payments to be efficient and promote a shift towards land uses with higher environmental benefits, payments targeted towards medium to high shade intensive land use systems are needed. Carbon payments seem to benefit poorer households relatively more than the better off. A win-win situation, where both deforestation processes and poverty can be reduced with carbon payments, is possible.

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Table 1. Characteristics of household classes I – IV

	Household class			
	I	II	III	IV
Total cultivated land (ha)	2.5	2.8	2.8	2.5
Cocoa AFS I (ha)	1.49	0.24	0	0
Cocoa AFS II (ha)	0.77	1.31	1.09	0.33
Cocoa AFS III (ha)	0.25	1.16	1.73	0
Cocoa AFS IV (ha)	0.02	0	0	1.72
Family labour days per month	32.4	29.5	34.4	31.6
Credit limit (€/year)	33	720	1,015	570
Ethnicity (% non-local HHs)	0	19	22	80

Table 2. Total gross margins for the household types for different CER price scenarios

	Household class

Total gross margin (€ yr-1)	I	II	III	IV
Baseline	375	1,063	1,331	2,705
Scenario 1 CER €5	389	1,076	1,344	2,715
Scenario 2 CER €12	408	1,094	1,361	2,729
Scenario 3 CER €25	443	1,128	1,312	2,756

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