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Payments for carbon sequestration services - a solution to stop deforestation of the Lore Lindu National Park in Indonesia?

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1. Introduction

On a global scale the net decrease in forest resources has been slowing down during the last years in comparison to the 1990s by 18 percent due to plantations and restoration of degraded land, especially in Europe, North America and East Asia. However, primary forests are lost or modified at a rate of six million hectares per year due to human intervention, selective logging or deforestation and there is no indication that the rate of change is slowing down. Indonesia is the second country with the largest annual net loss in forest. During the last five years two percent of its remaining forest area was lost every year (FAO, 2006). Deforestation in turn plays an important role in the global warming process, as it accounts for up to 25 percent of the global greenhouse gas emissions. Frequently land-use change and forestry activities associated to smallholders' practices are partly responsible for deforestation and can affect the local emissions of carbon and influence the carbon stocks and associated fluxes. Therefore, when emission reductions are targeted, small farmers can provide an important contribution through the adoption of more sustainable practices or change of their land use. Internationally the awareness for the need to develop and support payment mechanisms and instruments for the provision of environmental services such as biodiversity conservation, watershed management and carbon sequestration is growing. Initiatives and projects are promoted where local actors are given payments in return for switching to more sustainable land-use practices and ecosystem protection, as well as innovative deals involving payments by the beneficiaries of the environmental services. With respect to forests these incentive payments to owners can make an important contribution to the conservation and the enlargement of forest sinks. Already Meade (1952) recommended to generalise the Pigouvian welfare theory to find a market solution for a positive externality situation where private production results in additional social benefits, using a subsidy. It is argued that the discrepancy between the private marginal costs for the provision of sustainable forest management systems and the social marginal cost of such measures can be reduced through the introduction of payments for external benefits of management measures. Thus, the present research focuses on the impact of payments for carbon sequestration activities on the land use systems of smallholders in the surroundings of the Lore Lindu National Park in Indonesia and whether they can provide an incentive for the adoption of more sustainable land use practices and contribute to the conservation of the rainforest margin.

2. Methodology

The field research was carried out on the island of Sulawesi in Indonesia in the surroundings of the Lore Lindu National Park. In this region the encroachment on the forest margin of the national park through agricultural activities and especially cocoa production is increasing at an alarming rate. In 1979 there were no cocoa plantations to be found in the region, whereas in 2001 cocoa agroforestry systems had expanded to 17.984 hectares. In a village level survey conducted in 2001 nearly half of the 80 villages reported that they have agricultural land inside the Park and on average the households acquired 30 percent of their land by clearing forest (STORMA, 2003). A satellite image analysis detected a mean annual deforestation rate of 0.3 percent in the research region between 1983 and 2002 (Erasmi and Priess, 2007). However, cocoa plantations under shade trees cannot be detected by optical satellite instruments, thus the encroachment process at the forest margin is not reflected by this figure. Additionally a great spatial heterogeneity in the surroundings of the Park can be observed. In general in the northern and western part of the park the human activities are much more concentrated in comparison to the southern borders. For example in Palolo, one of the four main valleys embracing the national park in the north-east, the closed forest decreased by 35 percent between 2001 and 2004 due to logging, whereas the area covered by cocoa plantations increased by 11 percent (Rohwer, 2006).

A household survey was conducted in six villages in the surroundings of the National Park to collect the data on the existing agricultural production systems. The households were categorised according to their dominant agroforestry system (AFS). In this region the AFS are characterised by the degree of shading and shade tree species, as well as the management intensity. They can be subsequently divided into four types: D (natural forest trees as shade trees and extensively managed), E (shaded by a diverse spectrum of planted trees and trees naturally grown after clear-cutting), F (shaded by planted trees), and type G (no shade trees and high management intensity). These AFS constitute the basis to characterise the four household classes which are the focal point for the analysis: HH_D, HH_E, HH_F, HH_G. The household categories are based on the dominant or largest AFS to be found among the cocoa plots of their farm. A random sample of 46 households was drawn from the total sample of 325 households in 13 villages from the STORMA A4-project. These were randomly selected based on a stratified sampling method (Zeller *et al.*, 2002) for a household survey in 2001 and 2004. The survey at hand focused on general aspects of the household and farm characteristics, land resources and their use, agricultural production activities, forest use, as well as the households' perception of the National Park, the forest, and its functions.

To analyse the households' behaviour and their resource allocation a static comparative linear programming model was chosen. If applied to farm planning, it can assist farmers in efficiently adapting to a changing economic and technological environment, but it can also be used as a tool for policy analysis. Generally it is a flexible tool for modeling farm decisions and with changing profitability of the activities it models the adjustments in the resource allocation. As an input for the model, the gross margins for the main cropping activities paddy rice, upland rice, maize and cocoa were calculated. Additionally forest conversion activities were included to portray the behaviour of the smallholders as realistically as possible. The objective of the linear programming model was to achieve a maximum total gross margin by optimising the area shares of several crops and taking into account the resource constraints of labour and land availability, land suitability, food security and the credit limit. The cocoa gross margins which were obtained indicated an increase in the profitability when moving along the cocoa agroforestry intensification gradient from D towards G, a result which was observed in other studies as well (Steffan-Dewenter *et al.*, 2007).

In the policy analysis where payments for carbon sequestration are offered, two forest management options are considered. These embrace the existing AFS, as well as the case of deforestation avoidance in the forest margin area. Hence, the carbon sequestration rates of the cocoa agroforestry systems had to be calculated in order to identify the potential payments.

3. Results

For carbon accounting the amount of carbon sequestration which is to be claimed as "carbon credit"[1] is limited to the net amount of change in the total forest carbon pool from one period to the next. In order to obtain the site specific total above- and below ground biomass for cocoa trees, a logarithmic growth regression model was adopted. The biomass can then be converted to carbon using a conversion factor of 0.5g of carbon respectively for 1g of biomass (Brown, 1997). Results are that on average, a cocoa tree stores 8.05 kg carbon in a time span of 25 years, where the more intensively managed and densely planted G system accumulates more carbon (46 kg/ha) than the more extensive D-F systems (39 kg/ha). Additionally, 0.5 t ha^{-1} yr^{-1} of soil organic carbon was added, a figure from the literature (Hamburg, 2000), as no site-specific data exists. Due to lack of data, the calculation for carbon accumulation in soils is assumed to occur linearly in time.[2] All carbon measurements for above-, below-ground and soil carbon were added up to obtain an estimation of the total carbon per hectare of the cocoa trees. Finally, this amount was converted to carbon dioxide equivalents (CO_2e), which is the basis to calculate the amount of certificates to be obtained for the different agroforestry systems.

According to the Kyoto protocol, only the trees which are planted at the beginning of the crediting period, can be assigned temporary certificates of emission reductions (tCER). A tCER is defined as a CER issued for an afforestation project activity under the Clean Development Mechanism (CDM), which expires at the end of the commitment period following the one when it is issued (UNFCCC, 2003). However, it can be argued that additionally the annual net rate of carbon accumulation of the shading trees, which are present in the first three land-use systems should be accounted for. Otherwise there is a great incentive for purely managed cocoa plantations and cutting down of the shading trees could take place. An accounting scheme of tCER was applied, envisaging a 25 year time horizon. The net carbon accumulation is the highest for the most shade intensive agroforestry system D and for the shade free G cocoa plantation (67 tCO_2e ha^{-1}), whereas the two other agroforestry systems E and F accumulate 64 and 62 tCO_2e ha^{-1} in a 25 year project. The prices for tCERs represent only a fraction of the prices for regular CERs from other project categories. This is due to the fact that in forestry projects the certificates expire after a certain time period, so that they are only allocated non-permanent certificates. These must be replaced by permanent ones at some point in the future, therefore the non-permanent credits need to be converted to permanent CER. Finally, the annual remuneration to the farmer was obtained for each land-use system through the calculation of the net present value and its equivalent annuity. This serves as an input for the linear programming model to indicate the annual payments which the farmer could receive from a 25 year sequestration project. The prices for permanent CER vary considerably on carbon markets, hence different prices have been considered (Table 1) to indicate the range.

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[1] Carbon credits are a tradable permit scheme. They provide a way to reduce greenhouse gas emissions by giving them a monetary value. One credit is considered equivalent to one tonne of CO_2 emissions. The term "credits" and "certificates" is used interchangeable.

[2] For comparison, the total carbon pool has also been calculated excluding soil carbon. As the difference is quite small (3% decrease in annuity payment), it is assumed that it is acceptable to include soil carbon.

	Agroforestry System			
Annuity payments € ha^{-1}	**D**	**E**	**F**	**G**
d 10%, CER €5	5.54	5.18	5.00	5.09
d 10%, CER €12	13.30	12.40	12.00	12.20
d 10%, CER €25	27.70	25.90	25.00	25.50

Table 1. Annuity payments for different prices of CER

At very low certificate prices, the evolving payments per hectare for carbon sequestration are also quite low. Taking high credit prices of €25 tCO_2e^{-1}, and using a normal discount rate of 10 percent the annuity payments per hectare are around €25-27. The variation between the four different AFS is not very pronounced, however the highest annuity payments from carbon sequestration are to be obtained for the agroforestry system D.

The baseline model was developed for the four household categories, and a steep intensification gradient was observed. The total gross margin rose from household type D towards G. Thus, there seems to be a wealth gradient to be found from household type D towards household type G. Consequently, the baseline model was compared with different scenarios which included the payments for carbon sequestration of the AFSs. The impact of changing carbon credit prices is assessed with a constant discount rate of 10 percent (Table 2).

	Household class			
Total gross margin (€ yr^{-1})	**D**	**E**	**F**	**G**
Baseline	276	909	1.101	2.486
Scenario 1 CER €5	371	1.042	1.298	2.713
Scenario 2 CER €12	390	1.062	1.315	2.725
Scenario 3 CER €25	425	1.098	1.347	2.748

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

The relative impact of the payments for the whole farm is most pronounced for the household type D. The rise in total gross margin when comparing the baseline situation with the different payment scenarios is quite considerable with an increase of 35, 41 and 54 percent respectively for Scenario 1 until 3. For the household types E and F the increase is less pronounced (around 18 percent (HH_E) and 20 percent (HH_F)) and for the household type G there is only a small increase to be observed (around 10 percent). However, when looking at the absolute impact on the total gross margin of the carbon payments, it can be seen that the household type G receives the highest amount of additional payments, and the amounts gradually decline for HH_F, HH_E and HH_D, who receives the lowest additional payments.

Within the region an unsustainable intensification process of the agroforestry systems towards a shade free cocoa monoculture is observed and a preference by local farmers for low shade agroforestry systems has been observed (Glenk *et al.*, 2006). Economic incentives, like price premiums offered through carbon certificates for the shade intensive cocoa could be a solution to slow down this process. With carbon credit prices of up to €19 tCO_2e^{-1} there is an incentive provided for household types D, E and F to either grow the full shade or slightly less shaded cocoa AFS. This price is within a range of certificates to be observed on carbon markets currently. However the household type G would need extremely high credit prices to adopt more of the extensive cocoa agroforestry system.

Nowadays on the climate politics agenda avoided deforestation is increasingly discussed, as an important strategy for avoiding greenhouse gas emissions in the first place. This discussion was first initiated by a group of developing nations with rainforest who formally offered voluntary carbon emission reductions by conserving forests in exchange for access to international markets for emissions trading. Usually this discussion concentrates on reducing conversion rates at the country level, however, the incentives also need to focus on the local level, as it is the smallholders who contribute considerably to these processes, such as in the research region as well. Therefore, the present model has been used to determine the necessary prices for the households to stop deforestation activities at the forest margin. The prices show a huge range, where with annual payments of €4 household type D would stop conversion activities, whereas household type E would need annual payments of €100 and household type G of €700.

4. Conclusions

The present study shows that per hectare payments for carbon sequestration of cocoa AFS are the highest for the fully shaded land use system. With low certificate prices, the remuneration for the AFS is quite low. However, with rising carbon certificate prices, the households who already obtain the highest total gross margin from their crop activities and seem to be the better-off households benefit in absolute terms most from the payments. On the other hand the apparently poorer households with lower total gross margins can almost double their gross margin from the cropping activities with the introduction of payments.

Carbon certificates can also offer the possibility to provide an incentives for the majority of households to adopt more shade intensive AFS. The analysis indicates that prices which are observed on the carbon markets could already be sufficient to support farmers to switch towards the more sustainable land use systems. However, current prices would only be sufficient for the poorer households to stop them from further forest conversion, whereas the better off households need extremely high carbon prices. The inherent problem lays in the fact that the fully sun grown cocoa receives very high net-revenues, which in the long run will probably not be able sustainable due to anticipated agronomic risks such as declining soil nutrient levels.

To conclude, one can say that for the carbon payments to be efficient and promote a shift towards more sustainable land uses, site-specific payments would be needed. This could ensure that the changes are made into the desired direction. Additionally win-win situations seem to be possible, where deforestation processes and poverty can be reduced with carbon payments. Again, payments would need to be targeted towards specific land use systems, so that a change will be made.

References

Brown, S. (1997) Estimating biomass and biomass change in tropical forests: A primer. FAO Forestry Paper 134. FAO, Rome.

Erasmi, S., and J. Priess. (2007) Satellite and survey data: a multiple source approach to study regional land-cover / land-use change in Indonesia in: Geovisualisierung in der Humangeographie, F. Dickmann (eds), Kirschbaum Verlag.

FAO. (2006) Global Forest Resources Assessment 2005. FAO Forestry Paper 147. Food and Agricultural Organization, Rome.

Glenk, K., J. Barkmann, and R. Marggraf. (2006) Locally Perceived Values of Biological Diversity in Indonesia - a Choice Experiment Approach. Cambridge, UK.

Hamburg, S. (2000) Simple rules for measuring changes in ecosystem carbon in forestry-offset projects. *Mitigation and Adaptation Strategies for Global Change,* Vol.5, no. 1, pp: 25-37.

Meade, J. (1952) External Economies and Diseconomies in a Competitive Situation. *Economic Journal,* Vol.62, no. 245, pp: 54-67.

Rohwer, N.-K. (2006) Object Oriented Image Analysis of High Resolution Satellite Imagery: A Land Cover Change Analysis in the Palolo Valley, Central Sulawesi, Indonesia, Based on QuickBird and IKONOS Satellite Dat. Diplomarbeit, University of Göttingen.

Steffan-Dewenter, I., M. Kessler, J. Barkmann, M. M. Bos, D. Buchori, S. Erasmi, H. Faust, G. Gerold, K. Glenk, S. R. Gradstein, E. Guhardja, M. Harteveld, D. Herteld, P. Hohn, M. Kappas, S. Kohler, C. Leuschner, M. Maertens, R. Marggraf, S. Migge-Kleian, J. Mogea, R. Pitopang, M. Schaefer, S. Schwarze, S. G. Sporn, A. Steingrebe, S. S. Tjitrosoedirdjo, S. Tjitrosoemito, A. Twele, R. Weber, L. Woltmann, M. Zeller, and T. Tscharntke. (2007) Tradeoffs between income, biodiversity, and ecosystem functioning during tropical rainforest conversion and agroforestry intensification. *Proceedings of the National Academy of Sciences of the United States of America,* Vol.104, no. 12, pp: 4973-4978.

STORMA. (2003) Ergebnisbericht 2000/2-2003/1, Sonderforschungsbereich 552 der DFG, Georg-August-Universität Göttingen.

UNFCCC. (2003) Modalities and procedures for afforestation and reforestation project activities under the clean development mechanism in the first commitment period of the Kyoto Protocol, Decision 19/CP9 (Doc. FCCC/CP/2003/6/Add.2).

Zeller, M., S. Schwarze, and T. v. Rheenen. (2002) Statistical Sampling Frame and Methods Used for the Selection of Villages and Households in the Scope of the Research Program on Stability of Rainforest Margins in Indonesia (STORMA). STORMA Discussion Paper Series No. 1. Universities of Göttingen and Kassel, Germany and Insitut Pertanian Bogor and Universitas Tadulako, Indonesia, March 2002.