Estimating the Break-Even Price for Forest Protection in Central Kalimantan

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Abstract

This paper estimates the break-even price in Central Kalimantan province, Indonesia and evaluates the effectiveness of a REDD+ mechanism in this area. On the basis of data collected through a field survey, we found that the break-even price is $17.14 per ton of carbon or $4.68 per ton of carbon dioxide. The figure can be even lower when we take the peat thickness of the area into account. Our analysis shows that the current level of carbon price can provide adequate compensation for Indonesian farmers.

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1 Introduction

The Reducing Emissions from Deforestation and Degradation plus (REDD+) mechanism is central to an international discussion of carbon emissions control. Tropical deforestation and forest degradation contribute to 1.6 Gt, or 20% of worldwide carbon emissions into the atmosphere every year (IPCC 2007). Forest protection, therefore, should be considered a critical part of the solution to climate change.

Indonesia can supply as much as 11.8% of the world's carbon credit through REDD+ (Deveny et al. 2009). Forests in Indonesia have rapidly been disappearing and have emitted huge amounts of carbon over the last two decades: forestland has decreased substantially from 121 million hectares in 1990 to 100 million hectares in 2005 (Hansen et al. 2009). A key characteristic of forestland in Indonesia is in its peat thickness. At least 55 Gt of carbon are stored in Indonesian peatlands (Jaenicke et al. 2008). Indonesia accounted for 82% of the carbon emissions from decomposition of drained peatlands in Southeast Asia in 2006 (Hooijer et al. 2010). For these reasons Indonesia is an important place for a REDD+ mechanism.

REDD+ provides rewards for forest protection. Still, while it would make a significant contribution to mitigating climate change, it can cause the loss of a chance for regional economic development: local farmers, for example would lose the opportunity to profit from additional agricultural activity. To design a workable REDD+ mechanism, revenues from forest protections must be higher than the revenues sacrificed by refraining from deforestation. The right compensation for protecting a given forest depends on the carbon fixation achieved in the area and would not be higher than the carbon price in a global market like the EU Emissions Trading Scheme (EU ETS). We define the break-even price of carbon (BEP) as a carbon price satisfying the minimum needed to compensate for a forgone chance of development. This paper estimates the BEP in Central Kalimantan province, Indonesia, and evaluates the effectiveness of a REDD+ mechanism in this area. Our analysis shows that the current level of carbon price can provide the necessary compensation to Indonesian farmers.

There have been many attempts to estimate the BEP needed to protect forestland in various countries. One of the earliest studies, by Osborne & Kiker (2005), estimated the BEP in Guyana to be \$0.71 per ton of carbon. They considered that logging was the only factor for deforestation in that area. Bellassen and Gitz (2008), estimated the BEP in Cameroon, focused on the role of shifting cultivation in deforestation and estimated the BEP to be \$10.44 per ton of carbon. Studying Indonesia, Butler et al. (2009) estimated the BEP in regard to oil palm plantation to be \$3,835-\$9,630 per hectare. Although oil palm plantation has been a significant factor in deforestation, this threat most likely has decreased as a result of a moratorium agreement between the Indonesian and Norwegian governments signed on 20 May 2011. The BEP for Indonesia in regard to small-scale agriculture is summarized in Grieg-Gran (2008), but the figure given in this study is based on the relatively old data given in Tomich (1998).

The contribution of our study is twofold. First, we focus on the Indonesian forestlands, which have a potentially large impact on carbon emissions; successful implementation of REDD+ in this area would be important in a global climate policy. Second, we estimate the BEP in regard to small-scale agricultural activity based on original field research: information on the net revenue from rice and rubber cultivation collected by a field survey in three villages in Pulang Pisau Regency in Central Kalimantan Province, helps to calculate an up-to-date and adequate compensation for protecting the forestland in this area.

2 Compensated Reduction and the Break-Even Price

Compensated Reduction is one of the REDD+ mechanisms currently discussed in the UNFCCC negotiations (Bellassen and Gitz 2008). Under this mechanisms, developing countries that voluntarily reduce their national carbon emissions from deforestation would be authorized to sell carbon credit using their historical rate of deforestation as a baseline. It assigns monetary value to carbon stored in standing trees and soil, thereby providing a financial incentive for forest protection to stakeholders. Funds for Compensated Reduction would be supplied from the global carbon market or from developed countries.

The actual amount of reduced deforestation in a developing country should be measured by comparing the realized deforestation rate with a baseline deforestation rate. Once a developing country receives carbon credits and sells them on the global market, it must commit not to increase its deforestation rate. Consequently, emission reduction must be measured and verified continuously during the commitment period. Although Compensated Reduction assigns a value to a tropical forest with carbon dioxide fixation, it does not take into account the total value of a tropical forest in the ecosystem, which includes maintaining biodiversity, supporting the local climate, and providing elements of local livelihood such as agricultural and pharmaceutical products.

At what carbon price would conservation compete with agricultural development? To answer this question, it is necessary to calculate the BEP as the price of carbon at which conserving forests become financially attractive for farmers. In case of Central Kalimantan, we consider rice and rubber production as a driving force of deforestation. Once compensation according to BEP paid, forest protection would provide revenue to farmers at least as much as profitable from rice and rubber production. We define the BEP as a minimum price that farmer receive in order to make carbon fixation more attractive than rice and rubber production.

3 Field survey

To collect information on the net revenue from rice and rubber cultivation, we conducted a field survey in three villages in Pulang Pisau Regency, Central Kalimantan, in June 2010. We visited 189 randomly chosen households living in Bawan Village, Garantung Village and Maliku Village. The response rate was 71%, thus we have 134 samples for analysis.

Bawan Village is located the in northern part of Pulang Pisau Regency, where the Dayak tribe has traditionally lived. Maliku Village and Garantung village are located in the southern part of the regency. Many people living in Garantung Village came from Java during the Mega Rice Project in the 1990s that was planned to turn one million hectares of unproductive peat swamp forest into rice paddies but finally failed. Table 1 summarizes the number of samples of our field survey. “Target” households means the number of households in the area targeted for random sampling in the village. Since the population of Maliku village is widely spread out over a large area, the number of households targeted in the village was set lower than in the other two villages.

We asked households how much rubber and rice they harvested in the previous year. On average, the amount of rice harvest per hectare was 1071.5kg and the rubber harvest per hectare was 2,336.1kg (see Table 2). There is considerable variation in the average rubber harvest among the three villages: 780kg for Garantung, 1,170kg for Maliku, and 2,344.9kg for Bawan. The difference would be due to the fact that rubber trees in Garantung and Maliku are still young and not yet ready for tapping. Many farmers in these two villages started to plant rubber trees only in recent year. As the trees continue to grow, the income of farmers will increase. We also asked the number of labor force and labor hours for planting and harvesting the rice and for harvesting the rubber. From this information, we estimated the net revenue from rice and rubber cultivation per hectare.

Table 1: Details of field survey

	Population	Households	Target	Visited	Responded
Bawan	829	211	148	79	54
Garantung	2,916	790	458	63	44
Maliku	3,424	918	79	47	36
Total	7,169	1,919	685	189	134

Table 2: Average harvest per hectare

	Average rice harvest (kg)	Average rubber harvest (kg)
Bawan	660	2344.9
Garantung	1085.3	780
Maliku	1060.2	1170
Total	1071.5	2336.1

4 Empirical analysis

In Central Kalimantan, rice and rubber cultivation have been two of the main causes of deforestation. According to Grieg-Gran (2008), these activities have accounted for 49% of deforestation, with oil palm plantation and cassava cultivation accounting for the rest (32% and 19%, respectively). This paper assumes that rice and rubber cultivation are sole factors of deforestation in this area. Although oil palm plantation can be another major factor of deforestation, we omit this possibility because of the moratorium agreement between the Indonesian and Norwegian governments. We calculate the economic revenue from deforestation as the Net Present Value (NPV) of agriculture over a commitment period discounted at the rate of 10%. To obtain the BEP, The total NPV is divided by the total carbon density of a hectare of forestland.

The average agricultural revenue per hectare (R) is obtained by using the following formula (Bellasen and Gitz 2008):

$$R = V_1 + \theta \sum_{t=0}^{T} \left(\frac{1}{1+\gamma} \right)^t \times V_s + (1-\theta) \sum_{t=k}^{T} \left(\frac{1}{1+\gamma} \right)^t \times V_g, \tag{1}$$

where T is the commitment period of forest protection, V_1 is the one-time net revenue from logging per hectare, V_s is the net revenue from rice cultivation per hectare, V_g is the net revenue from rubber cultivation per hectare, $\theta \in [0,1]$ is the ratio of rice cultivation per hectare of expanding agricultural land, and γ is the discount rate. We assume $k = 11$: the revenue from rubber production is generated after 11 years.

The net revenue from rice cultivation per hectare (V_s) is obtained by the following formula:

$$V_s = \frac{\sum_i (Y_{si} \times P_s - L_{si})}{\sum_i M_{si}}, \tag{2}$$

where Y_{si} is the yield of rice by the farmer i, P_s is the price of rice, L_{si} is the labor costs for rice production at the land of the farmer i, and M_{si} is the total agricultural land for rice production used by the farmer i.

The net revenue from rubber cultivation per hectare (V_g) is obtained by the following formula:

$$V_g = \frac{\sum_j (Y_{gj} \times P_g - L_{gj})}{\sum_j M_{gj}}, \tag{3}$$

where Y_{gj} is the yield of rubber by the farmer j, P_g is the price of rubber, L_{gj} is the labor costs for rubber production at the land of the farmer j, and M_{gj} is the total agricultural land for rubber production used by the farmer j.

The net revenue from agricultural land is the difference between the value of output ($Y \times P$) and the cost of labor force (L). The labor costs for rice production, the amount that a farmer could earn from an alternative job, is obtained by the following formula:

$$L_{si} = W \times (N_{si} \times H_{si} + N_{hsi} \times H_{hsi}), \tag{4}$$

where W is the minimum wage in Central Kalimantan province, N_{si} and H_{si} are the number of labor force and the labor hours for planting rice, N_{hsi} and H_{hsi} are the number of labor force and the labor hours for harvesting rice.

The labor costs for rubber production can be represented by the following formula:

$$L_{gj} = W \times (N_{hgj} \times H_{hgj}), \tag{5}$$

where W is the minimum wage in Central Kalimantan, N_{hgj} is the number of labor force and H_{hgj} is the labor hours for harvesting rubber.

The revenue from forest protection per hectare (R^f) is obtained by the following formula:

$$R^f = C \times P_c, \tag{6}$$

where C is the carbon density of land per hectare and P_c is the carbon price. To protect a hectare of forestland, net revenue from forest protection should be at least as large as forgone net revenue from agricultural development.

$$R = R^f \Leftrightarrow R = C \times P_c \Leftrightarrow {P_c}^* = \frac{R}{C} = BEP \tag{7}$$

Table 3: Parameters used in analysis

Parameter		Estimate used in models
γ	Discount rate	10%
θ	Share of rice production per hectare	1/3
T	Commitment period of forest protection	30 years
P_s	Price of rice	\$0.32/kg
P_g	Price of rubber	\$0.87/kg
W	Minimum wage	\$0.68/$hour$
C	Carbon density	225t/ha

We used the producer price of rice and rubber in Indonesia in 2008 as reported by FAO (2010), and estimated what it would be in 2010 by applying the inflation rate.

5 Result

The parameters used to estimate the BEP is provided in Table 3. We assume that, on average, one-third of one hectare of additional agricultural expansion is devoted to rice cultivation and two-thirds to rubber tree cultivation. The period committed to forest preservation is 30 years. The estimated average revenue from rice and rubber production over 30 years is $3,856 per hectare. We used 225 tons per hectare as carbon density in Indonesia. This figure is calculated by $350 * 0.47 * 1.37 = 225$, where 350 is a ton of above-ground biomass for tropical moist forests in insular Asia, 0.47 is the carbon fraction of above-ground biomass (tropical and subtropical), and 1.37 is the conversion rate from above-ground to total biomass in a tropical rainforest (IPCC 2006).

Estimation results are shown in Table 4. The BEP is estimated to be as large as $17.14 per ton of carbon or $4.68 per ton of carbon dioxide. As of 13 December 2010, the price of carbon dioxide allowances in the EU ETS is $90.9 per ton of carbon or $24.8 per ton of carbon dioxide. With the high carbon price in the EU ETS, carbon revenue clearly outweighs agricultural revenue in Central Kalimantan.

Table 4: Estimation result of BEP

Parameter	Result
Rice net revenue (V_s)	\$ 75.1
NPV of rice production	\$ 783.5
Rubber net revenue (V_g)	\$1,643.2
NPV of rubber production	\$5393.7
Average agricultural revenue per hectare (R)	\$3,856.9
Carbon density (C)	225
BEP of carbon ($P_c{}^*$)	\$17.14
BEP of CO_2	\$4.68

We extend the analysis and estimate total compensation across Central Kalimantan Province. The amount of compensation payment is determined by realized deforestation rate (with REDD+ policy) in comparison with expected deforestation rate (without REDD+ policy). According to the Indonesian Ministry of Forestry, the forest area in Central Kalimantan Province had been reduced from 9.48 million hectares in 2002 to 8.9 million hectares in 2003. We therefore assume that the deforestation rate is approximately 6 percent a year. At this rate, the size of the forest area would be 5.75 million hectares in 2010 and 0.88 million hectares in 2040. If Central Kalimantan Province successfully prevents the deforestation after 2010, the forest area maintained would be 5.75 million hectares in 2040. Thus, the size of protected forest would be 4.87 million hectares (5.75 hectares minus 0.88 hectares). Multiplying the estimated BEP per hectare by this figure, the compensation payment to Central Kalimantan Province amounts to $18.9 billion.

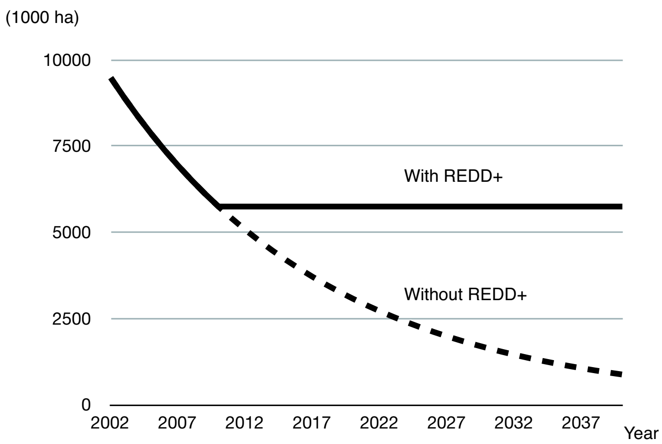

Figure 1: Prediction of deforestation with and without REDD+ policy in Central Kalimantan

6 Sensitivity analysis

The analysis in the above section does not take into account several uncertainties in the parameters. Since there can be considerable variation in these parameters, it is important to examine how the amount of compensation should change if we assume different parameters. In this section, we conduct a sensitivity analysis for key parameters in estimating compensation payments. We find that several parameters have a significant effect on the BEP (Table 5). In particular, a slight variation in the discount rate or the rubber price would seriously affect the BEP.

The amount of compensation is determined by comparing the realized deforestation rate with the baseline scenario. In the previous section, the deforestation rate of Central Kalimantan is assumed to be 6% a year. Depending on the expected deforestation rate, the amount of compensation would be greater or smaller.

Furthermore, identifyinging carbon contents in crops would also lead to an increase in the NPV of crops. Palm (1999) reported that natural rubber contains 89.2 ton of carbon. If we take carbon in natural rubber into account, the NPV of rubber become that BEP times 89.2 ton of carbon. Thus the compensation received by a farmer cultivating rubber becomes $5,397 ($3,596 + $1,801). Although taking into account the carbon in crops is important for realizing carbon fixation, it may foster monoculture plantation and make conservation of natural forest areas more difficult.

Table 5: Results of the sensitivity analysis

Parameter	Initial value	Change in value	Change in BEP
Discount rate (γ)	10%	+2%	-66%
Rate of rice expanding (θ)	1/3	$-1/3$	+40%
Carbon density (C)	225	+75	-25%
Value of logging (V_l)	0	+$830	+22%
Price of rice (P_s)	$0.32	+$0.68	+66%
Price of rubber (P_g)	$0.92	+$3.08	+409%

7 Discussion

Osafo (2005) estimated the BEP for Ghana and found a higher amount than our analysis ($29.59). Silva-Chávez (2005) found a smaller BEP of $4.43 for Ghana. One of the reasons different estimates of a BEP are generated is the assumption made in regard to carbon density. For example, Osafo (2005) used 60 tons of carbon density and Silva-Chávez used 200 tons of carbon density for the area, while we use 225 tons of carbon per hectare. Furthermore, if we were to take oil palm plantation into account, the NPV of land development would increase. Butler et al. (2009) estimated that the NPV of oil palm agriculture in Indonesia is between $3,835 and $9,630.

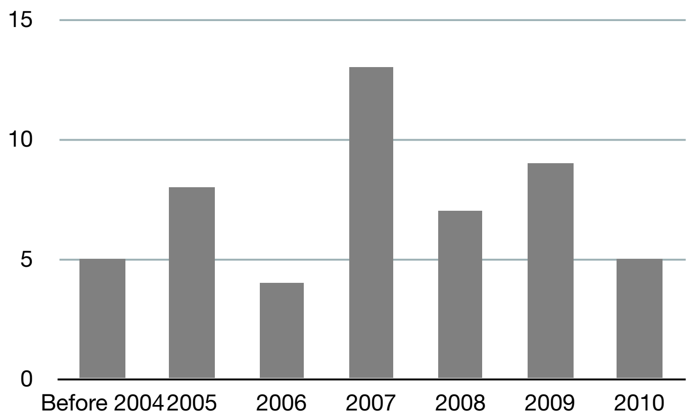

Figure 2: Number of households commencing rubber tree planting

In our field survey, we found that 46 out of 51 farmers planted rubber trees after 2005 (Figure 2). Because of this, a relatively large number of households in Garantung and Maliku have rubber trees that are still young and not yet ready for tapping (Table 6). Since the international rubber price has been increasing recently, this might affect the crop choice of farmers. An increase in rubber planting means increasing the NPV (rubber becomes more profitable) in this area. We must take the change in farmers' behavior into account when designing a workable implementation of REDD+.

The estimated BEP might be drastically cheaper if we consider the peat thickness of Central Kalimantan. The below-ground biomass used in our model is based on IPCC (2006). However, this underestimates the amount of below-ground biomass in this area. For example, Jaenicke et al. (2008)

Table 6: Number of households by condition of rubber trees

	Holding	Still young	Ready for harvest	Failed, etc
Bawan	47	18	21	8
Garantung	32	28	1	3
Maliku	18	15	2	1
Total	97	61	24	12

reported that carbon storage of Sebangau peat domes in Central Kalimantan is 2.3Gt at $734,700$ hectares. If we simply divide the former figure by the latter, we have 3,130 tons per hectare. This carbon density is more than ten times higher than the figure we assumed in our analysis.

8 Conclusion

This paper investigated the effectiveness of a REDD+ mechanism in Central Kalimantan. The BEP in Central Kalimantan is estimated to be $17.14 per ton of carbon and this is below the carbon price today in the EU ETS. So a carbon fixation activity is more profitable than rice and rubber plantation. REDD+ would provide an alternative to stakeholders and has a great potential to generate forest protection in this area. As well as reducing carbon emissions, REDD+ holds out the prospect of providing economic gain to

Central Kalimantan that exceeds the current revenue from rice and rubber plantations.

As our field survey suggests, increases in the price of rubber would lead to deforestation. To achieve the goal of reducing carbon emissions worldwide, attention should be paid to the impact of natural resource prices on farmers' behavior in developing countries. A REDD+ mechanism can offer developing countries an incentive to participate in international negotiations. Combining this mechanism with other policy tools that can help protect forests would contribute to reducing carbon emissions and to building sustainable development.

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