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Economic Analysis of REDD+: Empirical Studies in Central Kalimantan, Indonesia

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Chapter 1

Introduction

With increasing carbon emissions from forest sectors in developing countries in recent decades, REDD+ (Reducing Emissions from Deforestation and Degradation, plus foster conservation, sustainable management of forests, and enhancement of forest carbon stocks) has been gaining momentum in international discussion on mitigating climate change. REDD+ is expected to help reduce the conflict between developed and developing countries in order to achieve an international agreement on climate change. REDD+ offers an opportunity for forest protection in developing countries and provides carbon credits for developed counties. However, REDD+ is still under international negotiation because its economic viability has not yet been thoroughly evaluated. This paper aims to elucidate the benefits of REDD+ and evaluate the economic viability of REDD+ in Indonesia based on field survey data and econometric analysis.

Indonesia is a candidate site for the implementation of REDD+ because of its large amount of carbon stock and increasing deforestation. Forests in Indonesia have been disappearing: forestland in Indonesia has decreased substantially, from 121 million hectares in 1990 to 100 million hectares in 2005 (Hansen et al., 2009), and the burning of forests has emitted huge amounts of carbon over the last two decades. A key characteristic of forestland in Indonesia is the thickness of peat. At least 55 Gt of carbon are stored in Indonesian peatlands (Jaenickeet al., 2008). Indonesia accounted for 82% of Southeast Asia's carbon emissions from the decomposition of drained peatlands in 2006 (Hooijer et al., 2010). Deveny et al. (2009) assess the capacity for implementing REDD+ in each country using the Forest Carbon Index (FCI). They give Indonesia a high evaluation along with Brazil, Russia, Peru, Bolivia, and Colombia.

To design a workable REDD+ mechanism, the revenues from forest protection must be higher than the revenues sacrificed by refraining from deforestation. For example, conserving a forest might mean depriving local farmers of the chance to earn money from agricultural development. This paper examines this issue by estimating the break-even price of carbon (BEP) that satisfies the minimum compensation for a forgone chance of development. The result of the BEP estimation shows that REDD+ can provide adequate compensation for Indonesian farmers based on the carbon price in the European Union Emission Trading Scheme (EU ETS).

Peatland fire is another key issue for implementing REDD+ in Indonesia. Forestland in Central Kalimantan, Indonesia suffers from a high risk of peatland fire. During a large-scale peatland fire in 1997, the total carbon dioxide emission from Indonesia was estimated to be between 0.81 and 2.57 giga tons, which is equal to 13-40 percent of the mean annual global carbon emissions from fossil fuels (Page et al., 2002). In 2008, the governments of Indonesia and Australia jointly announced the KFCP (Kalimantan Forest Carbon Partnership), one of the world's first REDD+ pilot projects, to reduce the risk of peatland fire. In chapter 4 of this thesis, we consider how REDD+ has been applied to peatland fire according to changes in farmer's decision making.

The main focus of this thesis is as follows. Firstly, we investigate the economic potential of REDD+ based on field survey data. Forest conservation requires compensation for the loss of other land use opportunities, such as agricultural expansion. We estimate the BEP as the minimum carbon price to achieve forest protection in Indonesia. Secondly, we investigate the factors that promote peatland fire prevention. While peatland fire is an important aspect of forest and climate policy, it has not been seriously addressed in economic literatures. Thirdly, we evaluate the impact of the KFCP as a pilot project of REDD+. Fourthly, we provide policy implications for REDD+ in Indonesia that may be applicable to other tropical regions.

The rest of this thesis is structured as follows. Chapter 2 discusses the concept and role of REDD+ as a policy for mitigating climate change. Chapter 3 presents the results of our BEP estimation analysis. Chapter 4 discusses the results of fire prevention analysis. Chapter 5 presents our conclusions, posits goals for future research, and provides brief concluding remarks.

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Chapter 2

Role of REDD+ as a Policy of Mitigating Climate Change

2.1 Introduction

This chapter investigates the possibility of REDD+ with reviewing the key features and challenges of REDD+ that have been discussed in international negotiation. In the later part of this chapter, we focus on the key topics for implementing in REDD+ in Central Kalimantan Province of Indonesia, where the large area of peatland captures considerable amount of carbon.

Forests work as important carbon sink through the process of photosynthesis. Deforestation and degradation of forest thus lead to release of carbon dioxide into the atmosphere. According to IPCC (2007), 1.6 giga tons of carbon is emitted every year due to deforestation. This amounts to 20% of global emissions of GHG (Greenhouse Gases) and is beyond the percentage of emissions from transport sector. When we account the emissions from forests, countries such as Indonesia, Brazil, and Malaysia, would be comparable to Russia, Japan, and Germany in terms of total amount of GHG emissions (Myers Madeira 2008).

REDD+ is an attempt to reduce the emission of carbon dioxide due to deforestation and forest degradation in developing countries. While attempts for mitigating climate change has mainly focused on industrial emission, enough attention has not been paid to emissions from forest sector. However, the role of forests play in carbon fixation and the speed of deforestation throughout the world warrant the necessity to advance the effort in forest areas, especially in developing countries.

REDD+ can be regarded as one of the LULUCF (Land Use, Land-Use Change and Forestry) activities in developing countries. Article 3.3 and 3.4 of the Kyoto Protocol allows developed countries to account afforestation activities in LULUCF since 1990 for compliance of the target in the protocol. After the COP7 (Conference of Parties of United Nations Conventions), afforestation and reforestation in developing countries are validated as Clean Development Mechanism project under the protocol. REDD+ differs from these activities in its focus on prevention of degradation and deforestation in developing countries.

Recent negotiation on climate mitigation has emphasized the potential of REDD+. At COP11 held in Montreal in 2005, Papua New Guinea and Costa Rica, on behalf of the Coalition for Rainforest Nations (CfRN), proposed a mechanism to issue carbon credits for avoiding deforestation in developing countries. In response to this proposal, REDD+ has been addressed in SBSTA (Subsidiary Body for Scientific and Technological Advice) of the UNFCCC (UN Framework Convention on Climate Change).

The Bali Action Plan adopted at COP13 in 2007, called for enhanced national and international action including: "Policy approaches and positive incentives on issues relating to reducing emissions from deforestation and forest degradation in developing countries; and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries". After the Bali Action Plan, the concept of REDD has been expanded to REDD+, taking into account the role of forest conservation, sustainable management, and forest carbon sink. In addition, COP13 required the relevant organizations and Parties to implement verification activities for institution-building in the future. One example is Forest Carbon Partnership Facility by the World Bank. In addition, discussion for financial support was advanced as Norwegian government promised 1.8 billion euros over five-year period. On the basis of the Bali Action Plan, the Ad Hoc Working Group on Long-term Cooperative Action (AWG-LCA) was established in which the policy relating to REDD+ will be discussed. Currently, the discussions on REDD+ is mainly addressed at AWG-LCA and SBSTA.

COP15 in 2009 confirmed the effectiveness of forest conservation for climate change mitigation and the necessity of REDD+. The Copenhagen accord that the Parties took note includes the following statement: "We recognize the crucial role of reducing emission from deforestation and forest degradation and the need to enhance removals of GHG emission by forests and agree on the need to provide positive incentives to such actions through the immediate establishment of a mechanism including REDD+, to enable the mobilization of financial resources from developed countries". Although this does not differ too much from the Bali Agreement, establishment of the financial support from developed countries has advanced in COP15. In order to promote mitigation and adaptation, technology transfer, capacity building in developing countries, financial assistance with the goal of $30 billion from 2010 to 2013 and $100 billion per year until 2020 was included in the Copenhagen accord. In addition, Australia, France, Japan, Norway, the United Kingdom, and the United States, announced jointly to offer $3.5 billion in support of REDD+.

Through these international negotiations, REDD+ is becoming increasingly important in global attempt to mitigate climate change. Many NGOs and international organizations are working on pilot projects for REDD+. However, there has not been agreement on what framework of REDD+ is implemented, and what kind of incentive is offered under the framework. One reason is that it is not easy to establish a system for careful measurement, reporting, and verification (MRV) in developing countries. Another is that it is not easy to reach a consensus on institutional arrangement that is agreeable for every country.

This chapter investigates the possibility of REDD+ with reviewing the cost analysis of REDD+ and analyze practical hurdles in its implementation from the economic points of view.

2.2 Estimating Cost of REDD+

2.2.1 Definition of REDD+

Forest conservation can be the least expensive measures for climate change mitigation (Nabuurs et al. 2007). Several studies so far has analyzed the extent to which reduction of carbon emissions can be realized under various carbon price (Osafo 2005; Osborne and Kiker 2005; Sathaye et al 2005; Silva-Chavez 2005; Vera Diaz and Schwartzman 2005; Bellassen and Gitz 2008; Grieg-Gran 2006, 2008; Kindermann et al 2006;. Sohngen and Beach 2006; Kindermann et al. 2008;. Strassburg et al 2009). In this section, we overview some results of these studies.

The basic functions of REDD+ is to offer developing countries an opportunity for financial support from developed countries in response to the avoided amount of carbon emission through forest conservation. In exchange, developed countries can acquire carbon credits which can be used for the compliance of target of carbon emission. In this context, REDD+ might play a role for reducing the conflict between north and south.

The financial institution that are currently under consideration can be broadly divided into the fund mechanism and the market-based system (Parker et al 2009; Isenberg and Potvin 2010). Under the market-based system, credit is issued for emissions reductions by REDD+ and the developed countries trade them in the carbon market. Under the fund-based scheme, money is provided directly to developing countries.

Payments to developing countries is based on the difference between baseline that define the amount of forest estimated from the trend of deforestation in the past and the actual amount of forest. Setting of baseline can change the amount of payment to the country so that it is not easy to reach a consensus on the principle of baseline that every country can agree with. In order to obtain more funding, there is an incentive to exaggerate the seriousness of current deforestation. If there is a possibility that deforestation is suppressed by decreasing future timber price, the use of current deforestation rate leads to overestimation of the effect of REDD+. In this regard, baseline settings in REDD+ has similar issue with additionality in CDM (Asuka and Takeuchi 2004).

In order for the mechanism of REDD+ to work, funds obtained by forest conservation must be greater than the benefit that might be obtained by development for commercial logging and agriculture. Thus, the size of the opportunity cost is very important for the evaluation of REDD+. The opportunity cost can be estimated in two ways: bottom-up analysis and global model analysis. In next subsection, we review the results from bottom-up analysis that calculate the profits obtained from various land use change.

2.2.2 Bottom-up analysis

In bottom-up analysis, the opportunity cost is evaluated by estimating benefits that local residents can earn from transformation of forest into agriculture, commercial logging, and cattle raising. The advantage of bottom-up analysis is that it offers insight for appropriate institutional design by investigating motivation of local people for forest development. The drawback of the analysis is that it lacks comprehensiveness and does not consider the price change of agricultural products and forest products by land use change.

Table 2.1 summarizes the result of bottom up analysis. Estimated opportunity costs ranges from \$0.15 to \$30 per ton of carbon. Many of the estimates are lower than the carbon price observed in the market. It suggest that forest conservation is one of the cheapest measures for mitigating climate change. Vera Diaz and Schwartzman (2005) focus on deforestation in Brazil. Emission of GHG from Brazil account for 2.5% of the world's total emissions and 75% of emission from Brazil is due to deforestation. Cattle raising, soybean cultivation, and logging are major causes of deforestation. Assuming that the cattle raising after harvesting timber, minimum amount of compensation for avoiding deforestation, i.e. break-even price for carbon, is estimated. The break-even price per hectare is estimated as \$1,699 that is composed of \$1,435 for one-time logging and \$264 for cattle raising after the logging. Assuming 155 tons of carbon for carbon stock per hectare, \$1,699 per hectare is equivalent to \$11 per ton of carbon. If one uses \$150 for logging revenue, break-even price becomes \$449 per hectare, \$3 per ton of carbon.

Table 2.1: Summary of bottom-up analysis

Country	Cost (dollar/ha)	Cost (dollar/tC)	Changes in Land Use	Sources
Brazil	449-1,699	3-11	logging, cattle raising	Vera Diaz & Schwartzman 2005
	2,215-3,465	14-22	logging, cattle raising	Vera Diaz & Schwartzman 2005
	713	-	logging, cattle raising, soybean	Grieg-Gran 2008
Ghana	1,776	30	maize, cassava	Osafo 2005
	1090	-	maize, cassava	Grieg-Gran 2008
Bolivia	886	4.43	soybean	Silva-Ch'avez 2005
	1,522	-	cattle raising, soybean	Grieg-Gran 2008
Guyana	6.36-24.56	0.18-0.71	logging (aboveground carbon only)	Osborne & Kiker 2005
	6.36-24.56	0.15-0.58	logging (including underground carbon)	Osborne & Kiker 2005
Cameroon	2,221	30.08	plantain, cassava	Bellassen & Gitz 2008
	1,811	-	grain, cocoa	Grieg-Gran 2008
Congo	1,811	-	grain, cocoa	Grieg-Gran 2008
Indonesia	2,008	-	oil palm, rubber, rice	Grieg-Gran 2008
PNG	2,744	-	oil palm, subsistence crop	Grieg-Gran 2008
Malaysia	1,991	-	oil palm, rubber, rice	Grieg-Gran 2008

Note) Nominal value. The number of Bellassen and Gitz (2008) is converted from per ton of carbon dioxide to per ton of carbon. The result of Grieg-Gran (2008) is considering the logging revenue.

Osafo (2005) examines the effect of REDD+ in Ghana. Assuming that logging and agricultural conversion are main cause of deforestation, the break-even price is estimated by dividing the sum of logging revenue and agricultural revenue by carbon emissions. The revenue from logging is estimated as $498 per hectare, and the present value of agricultural revenue for cassava and maize is estimated as $1,278 per hectare at 10% discount rate. When one assumes 60 tons of carbon per hectare, the break-even price is estimated approximately $1,776 per hectare, equivalent to $30 per ton of carbon. Using similar time scale and discount rate, Silva-Chavez (2005) estimates the break-even price in Bolivia at $886, equivalent to $4.43 per ton of carbon.

Osborne and Kiker (2005) estimates the break-even price in the Republic of Guyana. The revenue from large-scale timber production is considered to be the opportunity cost of forest conservation. By avoiding the logging, one can prevent emissions of 34.76 tons of carbon per hectare. When one includes underground carbon, the estimate becomes 42.37 tons of carbon. Minimum compensation for logging revenue thus becomes $0.18 per ton of carbon at 15% discount rate and $0.71 per ton of carbon at 3% discount rate when we consider only the above ground carbon. When underground carbon is included, $0.15 per ton of carbon at 15% discount rate and $0.58 per ton of carbon at 3% discount rate. These amounts are calculated by dividing the discounted net present value of timber production revenue for 50 years by the carbon emissions associated with the production.

As the discount rate assumed be higher, the present value of compensation for avoiding deforestation be lower. It should be noted that the discount rate here refers to the rate that is employed in the calculation by, say timber production company. Including the underground carbon in estimation lower the amount of compensation. This may seem odd, but one should note that preventing more carbon emission at same hectare of land makes REDD+ cheaper.

Grieg-Gran (2008) is an update of Grieg-Gran (2006) that was carried out for the Stern review (Stern 2007). Countries included for analysis are Bolivia, Brazil, Cameroon, Democratic Republic of the Congo, Ghana, Indonesia, Malaysia, and Papua New Guinea. The target is to halve the current deforestation rate on the earth (13 million hectares per year). Opportunity costs for alternative land use in the eight countries are adopted from existing research. The total cost becomes \$4 billion or \$8 billion, depending on the inclusion of revenue from selective logging before slash-and-burn. When the revenue from logging is excluded, 39% of the total cost is due to oil palm plantation and 71% of the total cost is occurred in Brazil and Indonesia.

2.2.3 Global model analysis

In global model analysis, the impacts of REDD+ on the whole world are evaluated with using simulation models. When considering the impact of REDD+ on a global scale, it is necessary to take into account its impacts on the agricultural market and timber markets.[1] A number of studies using the global model simulate the impacts of forest preservation over a period of 50 to 100 years. The amount of forest preservation depends mainly on the carbon price. Forest preservation occurs in areas with lower opportunity cost against other land use such as agriculture and logging.

Sathaye et al. (2005) estimate what the amount of preserved forest land might be from 2000 to 2100 under various carbon price scenarios using GCOMP (Generalized Comprehensive Mitigation Assessment Process Mode). They reveal that REDD+ can reduce carbon emissions from the forest sector by 50.9 to 113.2 giga tons. With low opportunity costs and high deforestation rates in Africa and South America, application of REDD+ can contribute to decreases of carbon emission.

Sohngen and Beach (2006) evaluate the impact of REDD+ on forest conservation in the world with using GTM (Global Timber Model) developed by Sohngen et al. (1999). GTM is a model that incorporates land use and timber supply and demand, and maximizes the value of consumer surplus against the cost of forest maintenance. The results of their simulation indicate that the amount of reduced carbon is 1.6 giga tons per year at a price of \$100 per ton of carbon, and 0.1 giga tons per year at a price \$5 per carbon (Evaluated in 2000 U.S. dollars). Although significant amounts of carbon emission can be reduced at a price of \$100 per carbon, its total cost might be \$2,500 billion.

[1] For example, strict forest preservation in a certain area might increase the world wood price assuming the demand is constant.

Kindermann et al. (2006) used a simulation based on the land use model to evaluate how subsidies and carbon tax affect forest preservation on a global scale. Under the baseline scenario, 5% of the current forest area will be lost and 17.5 giga tons of carbon will be released from 2006 to 2025. 500 million hectares of forest area, which is one-eighth of the current forest area, will be lost and 45 giga tons of carbon will be released in 100 years. With a subsidy of $6 per ton of carbon every five years, deforestation decreases by half. However,the cost will be $34 billion every year. A tax of $12 on swidden or timber production can reduce deforestation by half also. Tax revenue would be $6000 million per year in 2005, but decrease to $700 million in 2100 by that time the deforestation rate will be low. The authors argued that a combination of subsidy and tax scheme is appropriate.

Kindermann et al. (2008) compare the costs of forest conservation by using GCOMP, GTM and DIMA (Dynamic Integrated Model of Forestry and Alternative Land Use). The results show that REDD+ can reduce deforestation rate by 10% from 2005 to 2030 at cost of $400 million to $1700 million. The price of carbon per ton, to reduce deforestation rate by half, is estimated to be $62.59 in GCOMP, $34.33 in GTM and $76.19 in DIMA. This can reduce carbon emissions of 0.41-0.73 giga tons a year. However, $17.2 billion $28 billion is required every year.

Strassburg et al. (2009) estimate the effects of REDD+ in developing countries in top 20 in forest area by a combined incentives method. Combined incentives is to combine the expected emissions and the historical emissions based on the baseline. Required carbon price is estimated to be $29.63 to reduce more than 90% deforestation. This can reduce 0.86-1.73 giga tons of carbon emissions, however it total cost will be $30 billion per a year. The result might be examined without the impact of forest conservation on timber market, thus reported result shows a relatively low cost of forest conservation.

Figure 2.1 summarizes the results of global model simulations (Sathaye et al., 2005; Sohngen and Beach 2006; Kindermann et al.. 2006; Kindermann et al., 2008; Strassburg et al., 2009). It takes carbon emission reductions of the year (giga tons of carbon) in the horizontal axis and annual cost ($1 billion) in the vertical axis.[2] Figure 1 indicates that reducing 1 giga tons of carbon emissions can be achieved with the cost at tens of billions of US

[2]The carbon prices are evaluated in 2005 US dollars

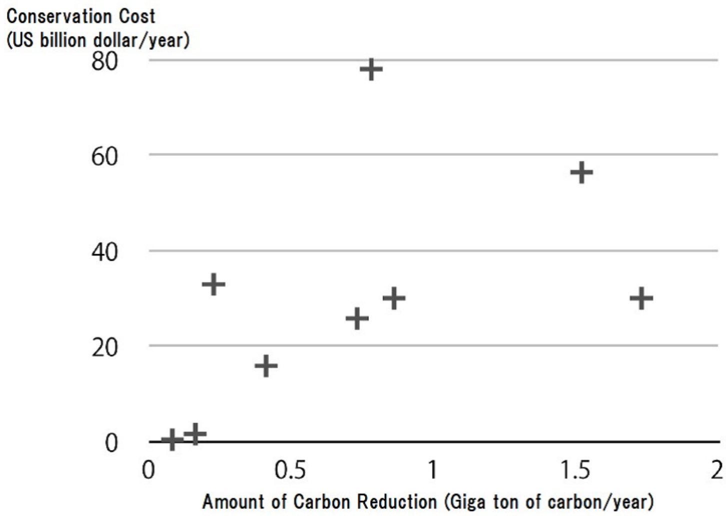

Figure 2.1: Results of global model simulation

dollars a year. According to IPCC (2007), the amount of carbon emissions from deforestation is estimated to be 1.6 giga tons per year on global.

2.3 Key challenges for implementing REDD+

2.3.1 Monitoring

Evaluating the amount of carbon stock in the forest is an important issue for implementing in REDD+. Because, the net effect of REDD+ is evaluated based on monitoring how REDD+ changes in carbon stock of forests. The carbon emissions resulting from changes in land use are measured by three stages of estimations. Firstly, creating forest inventory to record the state of the forests existing. Secondly, recording of changes in the forest area based on the field survey and remote sensing analysis. Thirdly, evaluating changes in carbon amount contributed to change in land use (Houghton, 2003; Achard et al., 2004; FAO, 2006; Mollicone et al., 2007).

According to Bellassen et al. (2008), data of forest area in each countries that has been reported in the 1980's by FAO is based on the prediction from old studies or expert assessment. It is necessary to measure the up-to-date of carbon sequestration accuracy with additional field survey and satellite analysis. Changes in forest area is measured by remote sensing and carbon density is measured by the ground survey. However, conducting follow-up research in the time series and large scale field investigation require high cost (Matsumoto, 2010). It is important for monitoring the state of forest at low cost to develop the technology, such as forest degradation evaluated with satellite images in the future.

2.3.2 Baseline

Baseline can be defined by a prediction in the state of forest with no policy interventions. The net effect of REDD+ would be evaluated by the deference between the baseline and the actual state of forest. This is similar to the baseline set in the CDM. Baseline can be set at a variety of scales; project level, national level, and global level. Since the range is narrow, baseline set at the project level is likely to lead to leakage. Baseline set at national level is defined as the historical trend of deforestation in the country. Most of having the largest scale is a baseline set at a global level. These baselines are set with protracting the trend of deforestation rate from the past and predicting deforestation rate in the future that is often evaluated by a model with explanatory variables (such as population).

For developing countries, the definition of baseline is an important issue that must be related to the direct revenue. According to FAO (2010) that is survey and analysis announced every 5 or 10 years (Global Forest Resources Assessment), forest area in Indonesia has become 94.43 billion hectares. It means that predicted forest area in 2050 will become approximately 2.172 million hectares under the assumption of 9% deforestation rate a year or will become approximately 1.396 million hectares under the assumption of 10% deforestation rate a year. A percent change in assumption of deforestation rate leads to the difference in prediction as much as 776,000 hectares forest existence. If the carbon price per hectare of $2,000 is assumed, deference of the revenue of $1.5 billion for Indonesia would be generated by the assumption of the different baseline of 1%.

For countries that have already adopted the deforestation with some policy, the credit obtained by REDD+ would be small with setting baseline at historical trend. In order to gain more credit, there is an incentive to declares more exaggerated deforestation rate in the future or present condition. On the other hand, there is a concern in the provision side of credit. The distributed credit is increased if the baseline set with rapid deforestation, the provision of credit is reduced if the baseline set with slow deforestation. Furthermore, the impact of REDD+ on carbon market become large if REDD+ provide large amount of credit. If funding scheme is assumed as market-based, it is important to take into account the impact of setting the baseline on the emissions trading market.

Mollicone et al. (2007) suggest that the countries that outweigh a baseline on the deforestation rate of the global level can obtain credit based on the baseline set at national trend, and countries that below a baseline on the global level can obtain credit based on the difference between the baseline on global level. As a result, it is possible for developing countries that deforestation rate is in top 20 to give incentives to not only the countries with high deforestation rate but also countries with low deforestation rate.

Strassburg et al. (2009) examined the effect of REDD+ by using the combined incentive scheme. The characteristics of combined incentive scheme is to combine the historical trend of emissions with expected global emissions in estimating the baseline. The payments based on historical trend of emissions I_1 can be described as follows:

$$I_1 = (HE \quad E_t) * P, \tag{2.3.1}$$

where HE is the trend of carbon emissions a year, E_t is the carbon emissions at year t, and P is the carbon price per ton. The payments based on expected global emissions I_2 can be described as follows:

$$I_2 = (EE \quad Et) * P, \tag{2.3.2}$$

where EE is the expected carbon emission on global a year. Then, payment with combined incentives scheme can be described as follows:

$$\begin{aligned} CI &= \alpha * I_1 + (1 \quad \alpha) * I_2 \\ &= [\alpha(HE) + (1 \quad \alpha)(EE) \quad E_t] * P, \end{aligned} \tag{2.3.3}$$

where α is the weight which emphasize I_1 or I_2 (α $\mathcal{L}$ $[0, 1]$). If the α takes 1 or 0, incentive obtained from REDD+ is eliminated for some countries and the incentives to participate in REDD+ framework would be decreased, leading to the possibility of leakage for some countries. The suggestion from Mollicone et al. (2007) can be described that apply $\alpha = 0$ for countries with $HE > EE$ and apply $\alpha = 1$ for countries with $HE < EE$.

There is the uncertainty in baseline setting because baseline is intended to predict the state of deforestation without REDD+ in the future. In this regard, Schlamadinger et al. (2005) suggest that the baseline should have a width in forest carbon stocks. For example, credit can be obtained between upper or lower limit with a weight of constant reductions.

2.3.3 Leakage

Leakage is a challenge not only in a forest sector but also in a variety of sectors on climate change mitigation. For example, when a cap become tight in developed countries, iron and steel sector transfer to developing countries where a cap is not so tight. The effect of emission reduction would be offset throughout the world. A same concern can be happened in the forest sector. REDD+ activities became popular in certain developing country, that had been supplying timber to Japan, and forest conservation is advanced, however, deforestation might be occur in another developing countries. Because timber demand from Japan would not be decreased and move into the another developing countries. Then, the effect of emission reduction is canceled from as total perspective. As long as the all forest would be under the same REDD+ scheme, the problem of leakage can occur.

By increasing the number of countries participating in REDD+, the possibility of leakage entire world can be reduced. This is why it is important to agree with institutional decisions of REDD+ by all countries. According to Strassburg et al. (2009), using the combined incentive scheme can encourage most countries to participate in REDD+ scheme.

2.3.4 Impermanence

Whether the emission reduction from REDD+ can be defined as permanently or not is called the problem of the non-persistent (Ellis 2001). There is a possibility that a certain forest, that is preserved in a certain period, would be harvested in the next period. In addition, the forest is suffer from some natural factors, such as a fire or disaster that destroy the forest, as well as artifact. The Reserve Accounting, The Ton-Year Accounting and The Expiring Credits are suggested to be coping with the problem of the non-persistent.

The Reserve Accounting is employed by Voluntary Carbon Standard, Carbon-Fix and Greenhouse Friendly (Bellassen 2008). In Reserve Accounting approach, reserving a portion of the credit that was produced by deforestation reduction and deposit and compensate with the same amount of credit if the forest is destroyed due to failure the project or policy or natural factors. This approach is similar to the insurance, and the credit can be handle a permanent credit.

The Ton-Year Accounting is an approach to consider the credit as permanently reduction, if the carbon fixed in the forest over a certain period (Moura-Costa and Wilson 2000). Released carbon into the atmosphere will be absorbed by biosphere and oceans over time. Thus, the period is considered as equivalence factor. If the forest absorb carbon in the period, it is considered as permanent reductions. However, there is uncertainty in natural scientific to estimate the equivalent period, so far the estimations reported that equivalence period is range from 42 to 150 years (Marland et al. 2001).

The Expiring Credits is an approach to issue a valid credit with the deadline (Maréchaland Hecq 2006). The credit become invalid after expired, it is necessary for extended using credit to obtain a new limited credit or obtain the permanent credit. In fact, for afforestation and reforestation in the CDM, temporary Certified Emission Reduction tCER and long-term Certified Emission Reduction: lCER are established.

2.3.5 Funding mechanism

As a way to fund a REDD+, two mechanisms are considered that the market based and the foundation based (Parker et al 2009; Isenberg and Potvin 2010). In the market based mechanism, the credit are traded through the market, and price is determined by relationship between supply and demand. Credit are able to use in developed countries to achieve the reduction target of the country. This mechanism is to be considered as an effective mechanism in the implementing forest conservation, however, the invest is affected by the changing in price. Large amount of credit provision from REDD+ might decrease the investment for emission reduction on other industry sectors (Bosetti et al. 2009).

NGOs such as Greenpeace and CCAP (Center for Clean Air Policy) suggest that dual market system to create a trading market for REDD+ separately from the conventional carbon markets (Ogonowski et al. 2007). Under the dual market system, credits produced by REDD+ is not tradable in normal carbon markets. However, developed countries can use the credit in the realization of the reduction target. It is also possible to link the two markets after REDD+ mechanism has been matured.

The foundation based scheme is to establish a fund at the international level or national level to promote voluntary fund provision. A fund of $1 billion that the Norwegian government has reached an agreement with the Indonesian government in May 2010 is an example of foundation based scheme. Foundation based scheme can avoid the instability of the carbon price, however, the support would be stops if fond is exhaustive.

As a one of the other issues than the above, there is a problem of allocation of funds in the developing countries. That because of the hurdle of national sovereignty, REDD+ is not able to determine how fond would be distributed in the developing country. However, incentives from REDD+ do not work well, if funds would be reach the decision makers who determine the deforestation (Strassburg et al. 2009). CCBA (The Climate, Community, and Biodiversity Alliance) that is a third-party certifier of GHG reduction project was based upon that more than 50% of poor households receive profit from project (CCBA, 2008) In addition, there is a possibility that implementing in REDD+ excludes local people who depend their livelihood on forest from using forest. With respect to these aspects, it is necessary to pay enough attention.

As an another issue than the design of REDD+, there is problem acceptance capacity of the host countries. Forest Carbon Partnership Fund of the World Bank and the Amazon Fund in Brazil have been supporting to improve the acceptance capacity; Creating scenarios for deforestation and forest degradation and land use change, constructing the effective monitoring system, and promoting indigenous peoples to participation in projects.

2.4 Key topics in REDD+ in Indonesia

Forest area in Indonesia has been decreased from 121 million hectares in 1990 to 100 million hectares in 2005 (Hansen et al. 2009). About 75% of deforestation in Indonesia has been occurred in Kalimantan island and Sumatra island. The average rate of deforestation in Indonesia during 2000 to 2005 was 710,000 hectares per year. This is rather modest than 1.78 million hectares per year between 1990 to 2000, although still high.

Indonesia has significant potential as target areas for REDD+. Deveny et al. (2009) uses the index of FCI (Forest Carbon Index) to assess the capacity for implementation of REDD+ in each country. FCI evaluate the ability of countries to obtain carbon credit at low cost, considering the situation of economy and forest, the governance capacity and implementability. Although there is some problems with respect to its governance capacity and implementability, FCI gives a high evaluation to Indonesia, as sixth in the world after Brazil, Russia, Peru, Bolivia, and Colombia.

Estimating the cost of forest conservation in Central Kalimantan is one of the important challenge to evaluate the workability of REDD+. Because, characteristic of the forests in Central Kalimantan is that they grow on peatland that contains a lot of carbon. It means that forest conservation in this area has high importance from the viewpoint of carbon fixation. Jaenicke et al. (2008) estimate that there are at least 55 giga tons of carbon in Indonesian peatland. Carbon in peatland can be released into the atomosphere by deforestation, degradation of land, and forest fire. Peatland forest in Southeast Asia has been decreased rapidly in the last decades by these factors (Hooijer et al. 2010). In chapter 3 of this thesis, the cost of forest conservation in Central Kalimantan is estimated with BEP estimations.

Another challenge is how promote peatland fire prevention. By the large scale fire that occurred in 1997, land area of 790,000 hectares in Central Kalimantan province was damaged and additional 0.24 to 0.28 giga tons of carbon were released into atmosphere (Page et al. 2002). When we extrapolate this to entire Indonesia, 0.81 to 2.57 giga tons of carbon were released in a year. This is equivalent to 13 - 40% of the emissions from the fossil fuel sector. In chapter 4 of this thesis, the factors promoting individual fire prevention is investigated.

The findings of this thesis provide policy implications with respect to forest conservation in Indonesia. Providing incentives for local households to protect forest would enhance appropriate forest management. However, the result of this thesis suggest that effective policy design should take into account not only the enforcement of economic instruments but also the role of non-economic factors such as mutual aid activity in local community. The policy supporting totally activities of villagers can contribute to reduce the risk of deforestation in Central Kalimantan.

2.5 Conclusions

In this chapter, we investigate the possibility of REDD+. In COP18 held at Doha, Qatar in December 2012, it is decided to extend Kyoto Protocol until 2020 and to create new international framework after 2020. Currently, two line of proposals are juxtaposed: to involve major emitting developing countries such as China and India to participate, or to require only developed countries to owe emission reduction target. REDD+ with fund mechanism plays a significant role, in order to reduce the conflict between developed and developing countries. While there are a lot of issues to be resolved for workable institutional design, REDD+ is expected to be potentially beneficial for mitigating global climate change as well as developing countries.

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Chapter 3

Estimating the break-even price for forest protection in Central Kalimantan

3.1 Introduction

This chapter 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 \$15.45 per ton of carbon or \$4.21 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.

The Reducing Emissions from Deforestation and Degradation plus (REDD+) mechanism has been one of the central issues to an international discussion of Post-Kyoto Agreement. Tropical deforestation and forest degradation contribute to 1.6 Gt, or 20% of worldwide carbon emissions into the atmosphere every year (IPCC 2007). Forests play a significant role in global carbon sequestration (Akao 2011). 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 thesis 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. Wang and Lu (2010) found that carbon offset project has feasibility in Yunnan Province, China with the carbon price at \$14 per ton. Studying Indonesia, Butler et al. (2009) estimated the BEP in regard to oil palm plantation to be \$3,835-\$9,630 per hectare. Large-scale oil palm plantation has been a significant factor in deforestation, contributing 20 % of deforestation in Indonesia (Grieg-Gran 2008). While large-scale oil palm plantation will continue to be one of the potential factor for future deforestation, the threat has been decreased as a result of a two-year moratorium agreement on forest and peatland concessions between the Indonesian and Norwegian governments signed on 20 May 2011. According to the agreement, Indonesia will take systematic and decisive action to reduce its forest and peat related emissions of GHG, whereas Norway will support those efforts by making available up to one billion US dollars exclusively on a payment-for-results basis (Caldecott et al. 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 et al. (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.

3.2 Compensated Reduction and the Break-Even Price

Compensated Reduction is one of 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. A viable REDD+ mechanism should also pay attention to the right of forest dwellers (Couto Pereira 2010). Since it provides financial aid for forest conservation to local community or stakeholders, REDD+ is expected to play a role of poverty reduction.

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.

3.3 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 3.1 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. The number of target household for sampling is smaller than the total number of household in the area. This is because that including all households for random sampling is inefficient and time consuming to implement face-to-face interview especially in the sparsely populated villages. Therefore, we selected a geographical area where many farmers dwell as a target area for random sampling. 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 1,071.5kg and the rubber harvest per hectare was 2,336.1kg (see Table 3.2). It should be noted that households in our analysis might have relatively lower productivity of rice production, since average productivity in Central Kalimantan in 2010 is 2,627kg/ha according to the Statistics Indonesia (http://dds.bps.go.id/). 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 3.1: 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 3.2: Average harvest per hectare

	Average rice harvest (kg)	Average rubber harvest (kg)
Bawan	660	2,344.9
Garantung	1,085.3	780
Maliku	1,060.2	1,170
Total	1,071.5	2,336.1

3.4 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 thesis 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):

$$R = V_1 + \theta \sum_{t=0}^{T} \left(\frac{1}{1+r} \right)^t * \ V_s + (1 \quad \theta) \sum_{t=k}^{T} \left(\frac{1}{1+r} \right)^t * \ V_g, \tag{3.4.1}$$

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, $\theta \ \mathcal{L} \ [0, 1]$ is the ratio of rice cultivation per hectare of expanding agricultural land, and r 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:

$$V_s = \frac{\sum_i (Y_{si} * \ P_s \quad L_{si})}{\sum_i M_{si}}, \tag{3.4.2}$$

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:

$$V_g = \frac{\sum_j (Y_{gj} * \ P_g \quad L_{gj})}{\sum_j M_{gj}}, \tag{3.4.3}$$

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 ($Y * \ P$) 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:

$$L_{si} = W * \ (N_{si} * \ H_{si} + N_{ti} * \ H_{ti} + N_{hsi} * \ H_{hsi}), \tag{3.4.4}$$

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_{ti} and H_{ti} are those for tending rice, N_{hsi} and H_{hsi} are those for harvesting rice. We use data of our field survey and Tomich et al. (1998) for the number of labor force and labor hours.

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

$$L_{gj} = W * \ (N_{hgj} * \ H_{hgj}), \tag{3.4.5}$$

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. Please note that the minimum wage can be considered as an opportunity cost of agricultural labor input. When agricultural profit is higher than this cost, the farmer will decide to develop and cultivate his own land. Therefore, our procedure to estimate the BEP is valid to the case that the decision maker is a farmer who owns his/her land as well as that it is a landowner. The opportunity cost would be zero if he/she cannot find any alternative job in the labor market.

The revenue from the forest protection per hectare (R^f) is obtained by multiplying the carbon density (C) by the carbon price (P_c).

$$R^f = C * \ P_c. \tag{3.4.6}$$

To achieve forest protection, the revenue from that, R^f, should outweigh the revenue from developing the forest, R, that is defined as equation (3.41).

$$R^f \Leftrightarrow R \tag{3.4.7}$$

We define P_c^* as the minimum carbon price that satisfy the above equation.

$$P_c{}^* = \frac{R}{C} \tag{3.4.8}$$

We call P_c^* as the Break Even Price (BEP) that should be paid to attain the forest protection.

3.5 Result

The parameters used to estimate the BEP is provided in Table 3.3. We assume that, on average, two-fifth of one hectare of additional agricultural expansion is devoted to rice cultivation and three-fifth of that to rubber tree cultivation. This is adopted from Grieg-Gran (2008) that estimates the contribution of rice production and rubber production to deforestation in Indonesia as 19% and 30%. We use the ratio between two values (2/5) as the share of rice production. The period committed to forest preservation is 30 years.

The estimated average revenue from rice and rubber production over 30 years is \$3,477 per hectare. 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. We used 225 tons per hectare as carbon density in Indonesia. This figure is calculated by $350 \geq 0.47 \geq 1.37 = 225$, 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).

Table 3.3: Parameters used in analysis

Parameter		Estimate used in models
r	Discount rate	10%
θ	Share of rice production per hectare	2/5
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

Estimation results are shown in Table 3.4. The BEP is estimated to be as large as \$15.45 per ton of carbon or \$4.21 per ton of carbon dioxide. The average carbon price of EU ETS in 2009 is \$46.48 per ton of carbon or \$12.7 per ton of carbon dioxide (World Bank 2010). Therefore, carbon revenue clearly outweighs agricultural revenue in Central Kalimantan.

Table 3.4: Estimation result of BEP

Parameter	Result
Rice net revenue per hectare(V_s)	\$ 60.1
NPV of rice production per hectare	\$ 600.8
Rubber net revenue per hectare (V_g)	\$ 1,643.2
NPV of rubber production per hectare	\$ 5,393.7
Average agricultural revenue per hectare (R)	\$ 3,476.5
BEP of carbon ($P_c{}^*$)	\$ 15.45
BEP of CO_2	\$ 4.21

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 figure 3.1, the compensation payment to Central Kalimantan Province amounts to $16.9 billion.

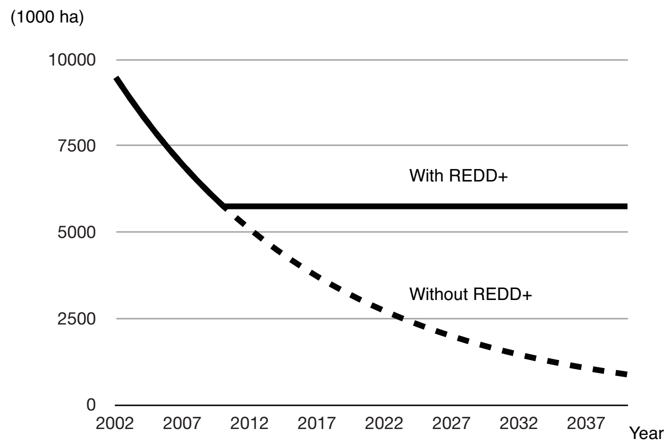

Figure 3.1: Effect of REDD+ policy in Central Kalimantan

3.6 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 3.5). For example, 2 % increase in the discount rate leads to 65 % decrease in the BEP and 100 % increase in the rubber price leads to 121 % increase in the BEP. If we assume that it is very difficult for a farmer to find an alternative job and the opportunity cost of labor is zero, the BEP increase as much as 58.9%. On the other hand, changing assumption on the costs other than labor does not change the result significantly. Farmers in this area were using simple and inexpensive equipments to produce rice and rubber, therefore we implemented a sensitivity analysis with the assumption that the cost of other inputs is as much as 10 % of the labor cost.

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, identifying 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 per hectare. To take carbon in rubber into account, the NPV of rubber should be added by the amount that the 89.2 ton of carbon times the carbon price. If we assume the carbon price is $ 15.45, the NPV of rubber would be $1,382.6 (=89.2 $*$ 15.45). Multiplying this figure with the share of rubber production (3/5) and adding to the average agricultural revenue per hectare ($3,476.5) in Table 3.4, BEP would become $ 4,306 (= $3,476.5 + $829.5) per hectare. 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.

3.7 Discussion

3.7.1 Carbon density

Osafo (2005) estimated the BEP for Ghana and found a higher amount than our analysis ($29.59 per ton of carbon). Silva-Chávez (2005) found a smaller

Table 3.5: Results of the sensitivity analysis

Parameter	Initial value	Change in value	Change in BEP
Discount rate (r)	10%	+2%	-65%
Share of rice production (θ)	2/5	2/5	+55%
Carbon density (C)	225	+75	-25%
Value of logging (V_l)	0	+$ 830	+24%
Price of rice (P_s)	$ 0.32	+100%	+38%
Price of rubber (P_g)	$ 0.92	+100%	+121%
Costs other than labor	0	+0.1* L_{si}	-3%
Opportunity cost of labor (W)	$0.68/hour$	-100%	+58.9%

BEP of $4.43 per ton of carbon for Bolivia. 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 (2005) used 200 tons of carbon density for the area, while we use 225 tons of carbon per hectare. These difference in carbon density can be attributed to vegetation and soil condition of each area. Estimation in Osafo (2005) reflects the fact that deforestation is spreading in degraded forest and this leads to the relativity lower density assumed in the analysis. Another major reason for difference in BEP is the assumed activity that drive land-use change. Silva-Chávez (2005) assumes soybean planting while Osafo (2005) assumes maize, cassava planting and tree logging as major drivers of land-use change. 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 per hectare.

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

3.7.2 Indirect effect of the rubber price

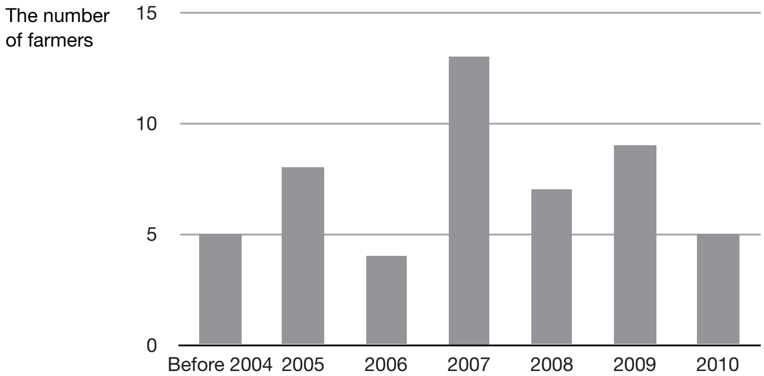

Figure 3.2: Number of households commencing rubber tree planting

Table 3.6: 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

In our field survey, we found that 46 out of 51 farmers planted rubber trees after 2005 (Figure 3.2). 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 3.6). Since the international rubber price has been increasing recently, this might affect the crop choice of farmers. An increase in rubber planting means increase in the NPV of agricultural development in this area. We must take the change in farmers' behavior into account when designing a workable implementation of REDD+.

Throughout the former section, we assumed that the share of rubber production is fixed at 3/5. However, the share can be changed by the number of farmers who start the rubber cultivation responding to the increase of rubber price. To consider the impact of this behavioral change, we regress the number of farmers who start planting rubber on various factors that potentially affect it including the price of rubber. Estimated model is represented as follows;

$$S_t = \alpha_t + \beta P_t^r + \gamma P_t^q + \delta F_t + \eta Year + \epsilon_t, \tag{3.7.1}$$

where S_t denotes the number of farmers who start planting rubber in year t, P_t^r and P_t^q denotes the price of rubber and rice in year t and $Year$ captures a time trend. Since widespread fires are frequent in this area and this might inhibit planting multiyear crops, the experience of fire damages in year t, F_t, is also included in the model. α, β, γ, δ, and η are parameters to be estimated and ϵ is the error term. The information when farmers started planting rubber tree and when they experienced fire damage are collected through our field survey discussed in Section 3.3. The historical data of the price of rubber and rice are taken from the FAO statistics and adjusted to 2007 price by using the average consumer price index. The data period is from 1991 to 2010.

Estimation result by OLS is summarized in Table 3.7. The coefficient of the rubber price is positive and statistically significant, indicating that the higher rubber price is associated with the higher number of farmers starting the rubber production. To be more precise, one dollar increase in the rubber price can result in 8 farmers to start the rubber production.

By using this information, we can extend the sensitivity analysis to include the indirect effect of the rubber price. Analysis in the previous section revealed that the 100 % increase in the rubber price could result in the increase of BEP as large as 121 % on the assumption that the share of rubber production was 3/5. The BEP will be further increased, when we consider the indirect effect of the rubber price through the change in the share of rubber production. We firstly multiply 8.02 (the coefficient of the rubber price in Table 3.7) with 0.92 (100 % increase in the rubber price) and obtain 7.38 as the increase in the numbers of farmers that start planting rubber. Then we divide 7.38 by 134 (the number of sample in the regression analysis) and obtain 5.5 % as the increase of farmers in percentage. Next, by adding 5.5 % to 60 % (=3/5), we have 65.5 % as a newly assumed share of the rubber production. Using this new assumption, the increase of BEP with 100 % increase in the rubber price becomes 140 %. This is 19 % point higher than the sensitivity analysis on the rubber price in the previous section that omit the indirect effect of changing share of rubber production.

Table 3.7: Decision to start planting the rubber trees

Independent variable	Coefficient (Standard Error)
rubber price	8.028** (0.386)
rice price	7.71 (9.116)
fire damage	0.266* (0.149)
year	0.792*** (0.252)
Adjusted R^2	0.683
The number of sample	19
Durbin-Watson statistics	2.55

≥≥≥, ≥≥, ≥=statistically significant at 1%, 5%, and 10%. We used a Breusch-Godfrey LM test and could not reject the null hypothesis of no serial correlation.

3.7.3 Oil palm expansion

Oil palm expansion-based industries are an another emerging threat of deforestation in Central Kalimantan, and a more serious one than small household agricultural expanding in Central Kalimantan. Oil palm expansion has been suppressed by an agreement signed by Indonesia and Norway. In 2011, the governments of Indonesia and Norway formed an alliance, agreeing to a two-year moratorium on the clearing of additional forest for oil palm plantation. This agreement, however, expired in 2013, and forestland in Indonesia now faces the risk of deforestation given the strong economic incentive of oil palm plantation. It may be difficult to implement a carbon payment policy for this highly productive crop because the cost of forest protection is high. We must estimate this new situation in Indonesia.

The above analysis does not consider the opportunity cost of oil palm plantation. When we include the revenue from oil palm development, the BEP becomes much higher than the price of the carbon credit. With high productivity and the creation of employment in rural communities, oil palm plantation has played a significant role in Indonesian economic growth and poverty mitigation of small households in previous decades (Susila 2004). Indonesia has increased the production of palm oil in response to increased demand: world crude palm oil production has increased 460 percent, from 4.5 million tons in 1980 to 20.9 tons in 2000 (Koh and Wilcove, 2007; Rist, 2010). Large scale-oil palm plantation implementation by oil palm companies yields large profits and contributes to changes in land use and land cover: agricultural land for oil palms has increased from 3.6 million hectares in 1961 to 8.1 million hectares in 2009 (Grieg-Gran, 2008; Donald, 2004).

To evaluate the impact of oil palm expansion on the changing cost of forest protection, we rewrite our BEP estimation model as follows:

$$R_h = \sum_{t=j}^{T} \left(\frac{1}{1+r}\right)^t * \ V_h, \tag{3.7.2}$$

where R_h is the average agricultural revenue of palm oil per hectare over 30 years and V_h is the net revenue from palm oil plantation per hectare. We assume $j = 7$: the oil palm can be harvested after seven years. The other parameters has been adopted from the above estimation.

According to Grieg-Gran (2008), large scale oil palm plantation accounts for 20 percent of deforestation and yields \$3,340 per hectare in net revenue in Indonesia. We omit the small-scale oil palm cultivation implemented by small households because it accounts for only 6% of deforestation. Oil palms require adequate knowledge and investment to be properly cultivated in terms of fertilizer use, water management, planting in appropriate areas, and observance of the law. Small households often lack of these capabilities.

The results of our estimation described in Table 3.8 indicate that in terms of NPV, oil palm cultivation has a higher productivity (\$16,334.26) than rice (\$600.8) and rubber (\$5,393.7) cultivation, indicating that oil palm plantation is an attractive and profitable use of land for developers or stakeholders.

Table 3.8: BEP estimation with oil palm plantation

Parameter	Result
Oil palm net revenue per hectare (V_h)	\$ 3,340
NPV of palm oil per hectare	\$ 16,334.26
BEP of Carbon (P^*)	\$ 72.60
BEP of CO_2	\$ 19.78

The BEP is estimated to be as large as \$72.60 per ton of carbon or \$19.78 per ton of carbon dioxide. The average carbon price of the EU ETS in 2011 is \$23.86 per ton of carbon or \$6.5 per ton of carbon dioxide (World Bank 2012). The result suggests that the revenue from oil palm plantation outweighs the carbon revenue in Central Kalimantan. Thus, the REDD+ scheme will not be able to fulfill its objective of avoiding deforestation caused by oil palm expansion. This BEP can be observed in the situation in which all deforestation occurs because of oil palm expansion. This is extreme assumption, however, as rice and rubber cultivation are still causes of deforestation (Grieg-Gran, 2008). However, the high productivity of oil palms should increase the rate of oil palm expansion. When giving the carbon value and oil palm expansion the competition, it is necessary for a REDD+ scheme to be implemented to combine the carbon value with other forest protection or law enforcement values. The value of forest protection in our estimation excludes some factors that increase the value of forest protection. Payments for environmental services (PES) or bellow-ground carbon would increase compensation from protecting the forest by decreasing the BEP. Another possibility is that the government can freeze oil palm expansion; the moratorium that the governments of Indonesia and Norway singed is an certain example of this.

3.8 Conclusion

This chapter investigated the effectiveness of a REDD+ mechanism in Central Kalimantan. The BEP in Central Kalimantan is estimated to be \$15.45 per ton of carbon or \$4.21 per ton of carbon dioxide and this is below the average carbon price of EU ETS in 2009 (\$46.48 per ton of carbon or \$12.7 per ton of carbon dioxide, reported in the World Bank (2010)). 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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Chapter 4

What Factors Promote Peatland Fire Prevention? Evidence from Central Kalimantan, Indonesia

This study evaluates the impact of a REDD+ pilot project on farmers' behavior. We combine household survey data and satellite information to investigate the effects of the Kalimantan Forests and Climate Partnership (KFCP) project on fire prevention in carbon-thick peatland of Central Kalimantan, Indonesia. We find that the project fails to promote farmers' fire prevention. This can be attributed to the fact that KFCP has not changed the incentives for households to prevent fire at their agricultural plots. On the other hand, the impact of other economic factors as the value of labor allocation for rubber production and the impact of non-economic factors as traditional mutual assistance, called *Goton-royong* were statistically significant. The results of our analysis suggest that a design for effective REDD+ policy should contain appropriate combination of economic and non-economic incentives.

4.1 Introduction

REDD+ has been a focus of international discussion as an efficient climate change policy. The basic function of REDD+ is to offer developing countries an opportunity for financial support from developed countries in response to avoiding carbon emissions through forest conservation thereby reducing the conflict between developed and developing nations regarding global warming negotiations. Deveny et al. (2009) assess the capacity for implementing REDD+ in each country using the Forest Carbon Index (FCI). They give Indonesia a high evaluation along with Brazil, Russia, Peru, Bolivia, and Colombia.

One of the key issues for implementing REDD+ in Indonesia is the high risk of peatland fire. Forestland in Central Kalimantan, Indonesia is composed of thick peat swamp and 2,000-6,000 metric tons of carbon per hectare (t C/ha), compared to the average 225 t C/ha in moist tropical forests in southeast Asia (Page et al., 1999; IPCC, 2006). Once peat has been ignited, the burning of its organic-rich materials is hard to put out and it releases its carbon into the atmosphere. For example, during a large-scale peatland fire in 1997, the total carbon dioxide emission from Indonesia was estimated to be between 0.81 and 2.57 gigatons, which is equal to 13–40 percent of the mean annual global carbon emissions from fossil fuels (Page et al., 2002). The combination of fire and the vast amount of carbon released made Indonesia the third largest Greenhouse Gas (GHG) emitter in the world (Myers Madeira, 2008).

In 2008, the governments of Indonesia and Australia jointly announced the Kalimantan Forest Carbon Partnership (KFCP), one of the world's first REDD+ pilot projects. The project aimed to reduce GHG emissions from deforestation and peatland fires by involving farmers in fire prevention and reducing the use of fire at individual plots. With a significant budget, KFCP was expected to be effective REDD+. However, the impact of the project is currently unclear, and has yet to be thoroughly evaluated. The results obtained by our analysis suggest that KFCP might not have offered appropriate incentives for farmers to promote fire prevention behavior at individual plots.

While fire prevention is an important aspect of forest and climate policy, it has not been seriously addressed in economic literature. An exception is Bowman et al. (2008) who investigated household decision making concerning fire prevention in the Brazilian Amazon. They explored the factors that affected household decisions on fire prevention and found that economic factors (e.g., the value of labor allocation for agriculture) plays a significant role in promoting individual fire prevention. As the value of labor allocation to agriculture increases, households become more productive in crop production; hence, there is a greater expected benefit of fire prevention.

This study extends prior research by estimating a household labor allocation model. The main contributions of this study are as follows. Firstly, we evaluated the impact of the KFCP project and found that this program was insufficient to change household decisions on fire prevention. KFCP was one of the earliest of the 15 REDD+ pilot projects undertaken throughout the world prior to 2009 (Carlson, 2009). While some studies have addressed the consequences of REDD+ pilot projects using descriptive approach (Resosudarmo et al., 2012; Olbrei and Howes, 2012), there are no studies that evaluate the impact of REDD+ pilot projects at the household level using an econometric analysis. Secondly, we estimated the household labor allocation model by combining data from the household survey with global NASA/MODIS satellite data. Satellite information is useful for considering fire risk objectively and investigating fire prevention comprehensively. In our analysis, the number of hot spots observed by satellite is used as a variable explaining the degree of fire risk. Thirdly, we hypothesized that social factors, not only economic factors, play an important role in fire prevention. We focused on the mutual assistance custom called *Gotong-royong* as being an important factor in the decision making regarding household labor allocation for fire prevention. *Gotong-royong* includes a wide range of group activities in the community, such as providing labor to clear agricultural plots, the construction and repair of public infrastructure, guarding the village, and financial support. This behavior provides the community with social norms and serves as a determinant of social capital based on the norms that are generally observable in urban and rural Indonesia (Bowen, 1986).

Recent studies on development recognize the importance of social capital in the self-governance of common property resources (Ostrom, 1990). Indonesia is a suitable place to evaluate the impact of social capital on REDD+ schemes because households have traditionally been involved in the community through *Gotong-royong*. Policy makers in Indonesia have noted the importance of *Gotong-royong* on social improvement, and have used this involvement to improve health care, education, sanitation and financial support (Wibisana et al., 1999). Since the effect of fire prevention behavior depends in part on the behavior of neighbors, it is important to take into account the relationships within the community. While many studies have considered the role of social capital in development and environmental policy (Feigenberg, 2010; Sujarwoto, 2013), no studies have examined its effect in the context of REDD+.

4.2 Household model

We develop a subsistence household model to determine the factors that encourage households to allocate their time for fire prevention. Households are assumed to allocate family labor for rice cultivation, rubber cultivation, off-farm work, fire prevention, and leisure (Beukering, 2008; Yamamoto and Takeuchi, 2012). In our model, a household is both a producer and a consumer of agricultural goods, and thus, labor allocation depends mainly on consumption needs (Fisher et al., 2005). Households have a quasi-concave utility function:

$$\max_{C_r, C_m, l} U = U(C_r, C_m, l; \Omega), \tag{4.2.1}$$

where C_r, C_m, l, and Ω are the consumption of rice, that of composite purchased goods, that of leisure time, and the household's characteristics, respectively. The utility is maximized subject to the production functions for rice, rubber and off-farm work, a full income constraint, a time constraint, and non-negativity constraints:

$$\begin{aligned}
Q_r &= Q_r(L_r, K_r; \Omega), && (4.2.2)\\
Q_g &= Q_g(L_g, K_g, L_p; \Omega), && (4.2.3)\\
Q_o &= Q_o(L_o; \Omega), && (4.2.4)\\
Y &= P_r(Q_r \quad C_r) + P_{gj} Q_g + P_o Q_o \quad P_m C_m, && (4.2.5)\\
l &= T \quad L_r \quad L_g \quad L_o \quad L_p, && (4.2.6)\\
& \quad C_r, C_m, l, Q_r, Q_g, Q_o, L_r, L_g, L_p, L_o \Leftrightarrow 0. && (4.2.7)
\end{aligned}$$

Equations (2) and (3) describe, respectively, the production of rice and rubber, which are assumed to be functions of labor (L_r and L_g), capital (K_r and K_g), household characteristics (Ω), and, for rubber production, labor input for fire prevention (L_p). Households can reduce their risk of fire damage and increase the associated benefit of rubber production by allocating labor for fire prevention. Fire prevention (L_p) does not enter into the production function for rice because households in this area have adapted to the risk of fire, changing their period of cultivation to avoid fire damage. They have less risk of fire in the rainy season (from October to March) and typically cultivate rice in this period.

Equation (4) describes the off-farm work function requiring labor input (L_o).[1] We assume that the production functions for rice $Q_r(\cdot)$, rubber $Q_g(\cdot)$, and off-farm work $Q_o(\cdot)$ have decreasing returns to scale. Equation (5) describes a household's full income constraint. A household can be either a net seller or buyer of rice ($Q_r > C_r$ or $Q_r < C_r$). Households sell their rubber crops at the local price P_{gj}, but do not buy any rubber crops. They can also earn P_o by allocating off-farm work Q_o. Households buy composite goods (C_m) at market price (P_m). Equation (6) describes a household's time constraint.

The Lagrangian of the household's maximization problem is represented as

$$\begin{aligned}
\mathcal{L} &= U(C_r, C_m, l; \Omega) \\
&\quad - \lambda[Y - P_r(Q_r(L_r, K_r; \Omega) - C_r) - P_{gj}Q_g(L_g, K_g, L_p; \Omega) \\
&\quad - P_oQ_o(L_o; \Omega) + P_mC_m] + \gamma(T - L_r - L_g - L_o - L_p). \qquad (4.2.8)
\end{aligned}$$

The first-order conditions can be derived as

$$\frac{\partial \mathcal{L}}{\partial L_p} = \lambda P_{gj}\frac{\partial Q_g}{\partial L_p} - \gamma = 0, \qquad (4.2.9)$$

$$\frac{\partial \mathcal{L}}{\partial L_o} = \lambda P_o\frac{\partial Q_o}{\partial L_o} - \gamma = 0, \qquad (4.2.10)$$

$$\frac{\partial \mathcal{L}}{\partial C_r} = \lambda P_r, \qquad (4.2.11)$$

[1] We define off-farm work here as work hours spent outside of ones' own agricultural plot. This includes working on the another's plot, hunting, logging, driving boats or motorcycles, construction and working for the KFCP project.

$$\frac{\partial\{}{\partial C_m} \quad = \quad \lambda P_m. \tag{4.2.12}$$

Equations (9) and (10) show that at the optimum, households allocate labor for each activity until the expected marginal benefit is equal to the marginal opportunity cost of household time (γ). This suggests that marginal benefit and cost are prime candidates to be determinants of fire prevention.

Slutsky equations help us understand the implications of the models. It is possible to divide the total effect of a slight change in marginal benefit of fire prevention into substitution and income effects:

$$\frac{\partial L_p}{\partial W_p} \quad = \quad \left.\frac{\partial L_p}{\partial W_p}\right|_{U=\bar{U}} + \frac{\partial L_p}{\partial Y} Q_g, \tag{4.2.13}$$

where W_p stands for the marginal benefit of labor allocation for fire prevention ($P_{gj}\frac{\partial Q_g}{\partial Lp}$). The first term on the right-hand side of Equation (13) is a substitution effect; the second term is an income effect. The substitution effect must be positive because a higher marginal value of prevention would increase net benefit of rubber production. The sign of the income effect is ambiguous; it depends on the relationship between income and leisure time. Findings from empirical studies on agricultural production suggest that the substitution effect outweighs the income effect in developing countries; therefore, the total effect might be positive (Fisher, 2005; Shively, 2004). The effect of a slight change in the marginal benefit of off-farm work on the labor allocation for fire prevention can be described as follows:

$$\frac{\partial L_p}{\partial W_o} \quad = \quad \left.\frac{\partial L_p}{\partial W_o}\right|_{U=\bar{U}} + \frac{\partial L_p}{\partial Y}(Q_o), \tag{4.2.14}$$

where W_o is the marginal benefit of labor allocation for off-farm work ($P_o\frac{\partial Q_o}{\partial Lo}$). The substitution effect of the first term is non-positive, while the income effect of the second term is indeterminate. This is because the term $\partial L_P/\partial Y$ can be either positive or negative depending on the demand for off-farm work and leisure time. Findings from previous empirical studies suggest that the total effect might be negative, and that increasing off-farm wages decreases engagement in agricultural work in developing countries (Jolliffe, 2004; Shively and Fisher, 2004).[2] With this point in mind, we empirically

[2]Previous studies find that increasing off-farm wages decrease the deforestation ra-

investigate the relationship between the marginal benefit of labor allocation for rubber production or off-farm work and labor allocation to fire prevention.

Economic incentives offered by policy intervention can play a similar role as a marginal increase in the value of rubber production. A certain economic incentive for fire prevention (ρ) offered by a policy (KFCP, for example) increases the a household's expected marginal benefit of allocating labor for fire prevention activities ($\lambda(P_{gj})\frac{\partial Q_g}{\partial L_p} + \rho(L_p)$). The KFCP project announced that 30 million US dollars had been funded to mitigate deforestation in 14 communities in Blocks A and E of Kapuas Regency, this comprises 120,000 hectares of heavily degraded peatland and forests. KFCP was designed to promote household forest conservation and fire prevention activities by providing economic incentives. The project design document of KFCP describes three categories for incentives: (1) input-based incentives, such as building dams, planting trees, growing nursery plants, and eliminating fire use on peat soils; (2) performance-based incentives, such as maintaining dams to keep water levels high, protecting forests from encroachment, and reducing the incidence and extent of fires; and (3) outcome-based incentives, such as payment for actual reduced GHG emissions (KFCP, 2009, p.24). When insufficient economic incentives have been provided, the impact of KFCP is zero: $\rho(L_p) = 0$. In our interview conducted from October to December in 2012, all households in Blocks A and E reported that they had not received any economic incentives from KFCP for fire prevention at their plots, while some of them reported that they had received incentives for preparing nurseries for reforestation or for planting on project plot. This suggests that input-based incentives is offered rather than performance-based or outcome-based incentives.

Non-economic factors might also affect household fire prevention decisions. The role of social capital has received a great deal of attention in the context of effective management of common property resources (Ostrom, 1990). Fire prevention by individual farmers has the characteristics of the private provision of public goods because it might reduce the risk of peatland fire on surrounding farmland. The existence of the mutual assistance cus-

tio because they assume that off-farm work and agriculture are substitutional work and that additional agriculture work increases the ratio of deforestation. This factor is not considered in this paper.

tom *Gotong-royong* allows us to evaluate the impact of social capital on fire prevention. *Gotong-royong* is a traditional community involvement and co-operative agricultural activities. For example, farmers jointly clear grass and harvest rice with nearby family as labor exchange or cooperation (Bowen, 1986). It also involves a wide range of reciprocal activity, from providing labor for infrastructure construction to financial support. This tradition affects individuals to exhibit a normative behavior for community. We examine the effect of *Gotong-royong* on fire prevention by using a dummy variable of participation in this activity.

4.3 Data

We collected household data via face-to-face interviews in twenty-nine communities in Kapuas Regency, Central Kalimantan, Indonesia (Figure 4.1). The communities were selected to obtain a balance of ethnicities and degree of involvement in the KFCP project. The communities consisted of 11 transmigrant and 18 Dayak tribe communities. Of the 18 Dayak communities, six were involved with the KFCP project. Table 1 summarizes the composition of the communities.[3]

In the interviews, respondents were asked about their economic status, type of agriculture, demographic characteristics, experience of fire damage, and fire prevention activities. Although we collected information from a total of 288 randomly selected households, in order to focus on the decisions of household heads, we excluded 73 responses by non-household heads and 35 responses with incomplete data.[4] Thus, the final number of observations for

[3]Two types of people have settled in Kapuas Regency: indigenous Dayak tribes that have traditionally lived there, and transmigrants that moved from other islands of Indonesia or other parts of Kalimantan (Fearnside, 1997). Transmigration to this area was promoted by government policy, especially during the Mega-Rice Project (MRP) in the 1990s. Although the government abandoned the MRP, a number of transmigrants continued to live in the area as rice farmers. Both communities rely on agricultural produce as their main source of income (De Jong et al., 2001).

[4]For example, we left out respondents who do not engage in agriculture or who do not own any agricultural plots.

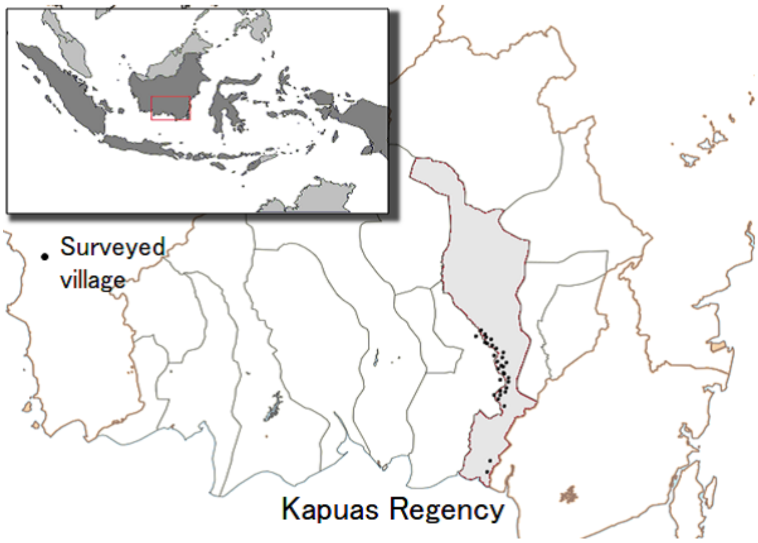

Figure 4.1: Geographical representation of Kapuas Regency.

the analysis was 182. Table 2 summarizes the descriptive statistics of the sample, which was divided into households that engage in fire prevention more than 60 days a year and those that do not, as well as those that were involved in the KFCP project and those that were not.

Table 4.1: Settlement composition

No.	Name of Village	Ethnicity		KFCP site
		Dayak	Transmigrant	
1.	Sei Ahas			
2.	Katimpun			
3.	Sei Kayu			
4.	Mampai			
5.	Sei Tatas			
6.	Sei Pitung			
7.	Sei Kayu			
8.	Mandomai			
9.	Mambulau			
10.	Dahirang			
11.	Sei Pasah			
12.	Penda Katapi			
13.	Lamunti A2			
14.	Lamunti B1			
15.	Lamunti B2			
16.	Dadahup G3			
17.	Dadahup G1			
18.	Dadahup G2			
19.	Dadahup A1			
20.	Dadahup A6			
21.	Dadahup A5			
22.	Palingkau SP1			
23.	Palingkau SP2			
24.	Jangkang			
25.	Kalumpang			
26.	Tumbang Mangkup			
27.	Tarantang			
28.	Pulau Kaladan			
29.	Mantangai Hulu			

Table 4.2: Descriptive statistics for sample households

	Full sample		Households practicing fire prevention less than 60 days		Households practicing fire prevention more than 60 days		Households not involved with KFCP		Households involved with KFCP	
	$n = 180$		$n = 73$		$n = 107$		$n = 141$		$n = 39$	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Economic parameters										
Shadow wage of rubber production (IDR/day/person)	16483.94	11978.18	12536.87	13000.83	19188.41	10451.45	15712.41	13130.58	19312.87	5354.58
Shadow wage of off-farm work (IDR/day/person)	11353.17	24666.60	14021.02	29563.96	9525.21	20606.74	8496.50	17885.08	21827.64	39490.05
Total size of agricultural plot (hectare)	3.45	4.81	2.63	3.23	4.01	5.58	2.90	3.39	5.46	7.83
Agriculture as primary source of income	0.91	0.29	0.89	0.31	0.92	0.28	0.92	0.28	0.87	0.34
Households with plots for rice production (0,1)	0.79	0.41	0.81	0.40	0.78	0.42	0.81	0.39	0.72	0.46
Size of rice plantation (hectare)	1.00	0.85	0.88	0.64	1.09	0.96	1.01	0.85	0.98	0.85
Cultivated rice product last year (kg)	928.11	1328.70	876.44	897.71	963.36	1559.10	1015.25	1439.96	613.08	739.62
Household with plots for rubber production (0,1)	0.58	0.50	0.45	0.50	0.66	0.47	0.50	0.50	0.87	0.34
Size of rubber plantation (hectare)	1.218	1.69	0.73	1.09	1.55	1.93	0.94	1.41	2.23	2.19
Cultivated rubber product last year (kg)	2291.71	5387.24	876.44	897.71	3284.67	6584.77	1280.76	2907.73	5946.67	9383.95
Fire-related variables										
Experienced fire damage in last five years (0,1)	0.38	0.49	0.32	0.47	0.43	0.50	0.32	0.47	0.62	0.49
Number of hot spots observed in 2012	2.89	6.91	1.23	1.91	4.03	8.66	3.21	7.60	1.74	3.23
Number of hot spots observed from 2008 to 2012	13.82	21.19	7.34	8.98	18.24	25.60	11.45	22.60	22.38	11.78
Number of hot spots observed from 2001 to 2007	30.32	38.91	24.92	38.63	34.00	38.84	26.35	40.83	44.67	26.83
Household characteristics										
Involved with KFCP site (0,1)	0.22	0.41	0.18	0.39	0.24	0.43	-	-	-	-
Participate in *Gotong-royong* activities in last year (0,1)	0.64	0.48	0.49	0.50	0.74	0.44	0.66	0.48	0.56	0.50
Number of household members	4.38	1.69	4.19	1.33	4.50	1.89	4.19	1.46	5.05	2.22
Number of children (<6 years)	0.35	0.58	0.44	0.65	0.29	0.53	0.33	0.57	0.41	0.64
Access time to market (minutes)	59.46	70.75	61.95	75.92	57.77	67.31	38.35	31.01	135.77	111.38
Age of household head	46.76	10.95	46.16	11.20	47.16	10.80	47.48	10.91	44.13	10.80
Transmigrant (0,1)	0.46	0.50	0.51	0.50	0.42	0.50	0.55	0.50	0.13	0.34
Years on lot (year)	31.97	17.82	30.82	17.40	32.75	18.15	29.48	18.11	40.97	13.47
Engage in fire prevention in last year (0,1)	0.88	0.33	0.70	0.46	-	-	0.85	0.36	0.97	0.16
Days spent on fire prevention	129.42	153.18	23.32	21.95	201.81	162.02	126.55	152.28	139.82	157.95
Patrolling for fire prevention in last year (0,1)	0.78	0.42	0.52	0.50	0.95	0.21	0.75	0.43	0.87	0.34
Days spent for patrolling	51.17	79.97	11.03	15.20	78.56	93.68	41.80	58.62	85.05	126.35
Clearing grass for fire prevention in last year (0,1)	0.81	0.40	0.58	0.50	0.96	0.19	0.79	0.41	0.87	0.34
Days spend for clearing grasses	78.25	114.25	12.29	15.48	123.25	129.76	84.74	124.46	54.77	60.80
Engage in swidden agriculture in last year (0,1)	0.37	0.48	0.33	0.47	0.40	0.49	0.31	0.46	0.59	0.50
Size of burned plot for agriculture (hectare)	0.77	3.78	0.40	0.65	1.03	4.87	0.43	0.83	1.99	7.92
Allocate labor for off-farm work in last year (0,1)	0.65	0.48	0.78	0.42	0.56	0.50	0.67	0.47	0.56	0.50

Table 2 suggests that households in the area are faced with a high risk of fire damage. 38% of the households have experienced accidental fire damage on their agricultural plots. To reduce the risk of fire damage, 88% of the households have been engaging in fire prevention activities, either by patrolling (78%) or clearing grass (81%). We define a household as a fire prevention participator if it has engaged in patrolling or clearing grass at individual plots for fire prevention within the past 12 months prior to the interview.[5] Households engaging in fire prevention more than 60 days a year tend to be exposed to a higher risk of fire damage. Experience of fire damage and the number of total hot spots nearby are higher for them than for others. Households living in areas where the KFCP project has been implemented seem more likely to engage in fire prevention than others. This may contain a reverse causality since the KFCP project has been implemented in areas where the risk of fire is higher. As a result, the number of hot spots in the KFCP project area is typically higher than places not involved with KFCP. To take this bias to our empirical estimation, we use instrumental variable methods. The dummy variable for the KFCP site is controlled by the number of hot spots from 2001 to 2007. Since KFCP began in 2008, the risk of fire from 2001 to 2007 might be suitable to control the endogeneity of policy site choice.

The estimated mean shadow wage of rubber cultivation is 16,483 rupiahs for the full sample.[6] There are substantial differences in this figure between households that engage in fire prevention and those that do not. The estimated mean shadow wage of rubber cultivation for households that engage in fire prevention less than 60 days is 12,536 rupiahs, while that for house-

[5] The exact wording of the questionnaire is, "Do you clear grass on your land to prevent fires?" and "Do you look around your land carefully to prevent fires?".

[6] To define the opportunity cost of rubber production time, we estimated the production function. The F-statistic of the estimation is 38.17 with 127 degrees of freedom. The annual amount of rubber produced by households was used as the dependent variable. The independent variables that were statistically significant ($P < 0.01$) were household labor time (+), capital input (+), hired labor (+), chemical fertilizer input (+), years since the rubber was planted (+), and square of years since the rubber was planted ( ). Chemical input and experience of fire damage were statistically insignificant. The estimated coefficient for the household labor time variable was used as the opportunity cost of rubber production time in the analysis of this section.

holds engage in fire prevention more than 60 days is 19,188 rupiahs. The mean shadow wage of exogenous income is 14,021 for households engaging in fire prevention less than 60 days, and that for households engaging in fire prevention more than 60 days is 9,525.21 rupiahs.

We define a household as a *Gotong-royong* participators if they have participated in any mutual activities, such as agricultural cooperation, constructing infrastructure, or maintaining public facilities for the community, in the 12 months prior to the interview. Table 2 suggests that *Gotong-royong* participators are more likely to engage in fire prevention than those not involved in *Gotong-royong* (74% and 49%).

4.4 Empirical Results

As Equation (9) suggests, households will not engage in fire prevention if the marginal benefit of fire prevention ($\lambda P_{gj} \frac{\partial Q_g}{\partial L_p}$) is less than the value of time (γ). This can be described as the corner solution of zero fire prevention, where $\lambda P_g \frac{\partial Q_g}{\partial L_p} < \gamma \in \; L_p = 0$. Since our sample contains households whose level of fire prevention is zero, we use a Poisson regression model and a Tobit model to consider the selection bias for estimation.

$$ln(L_p) = \beta_0 + \beta_e X_e + \beta_s X_s + \beta_f X_f, \tag{4.4.1}$$

where X_e is a vector of explanatory variables of economic factors, X_s is a vector of explanatory variables of non-economic factors, such as household characteristics, decisions and KFCP intervention, and X_f is a vector of explanatory variables of the risk of fire damage such as experience of fire damage and the number of hot spots in 2012.[7]

To evaluate the impact of KFCP, we must consider policy endogeneity since there is a possibility that households in the KFCP site are more likely to engage in fire prevention–not because of the project, but because of the higher risk of fire damage. To take this bias into account, we used the instrumental

[7] Hot spot data in our analysis cover the entire Kapuas Regency, from 114.000 to 114.450 degrees east longitude and from 2.05 to 3.40 degrees south latitude in the period from 2001 to 2012. We counted the number of hot spots on basis of 532 meshes that divided the Kapuas Regency with 0.05 degrees of longitude and 0.025 of latitude.

variable method. The instrument used in our analysis is the total number of hot spots observed by MODIS from 2001 to 2007. Since the project started in 2008, the hot spots from 2001 to 2007 can be considered as having an impact on KFCP site selection, but not on households fire prevention decision in 2012. Thus, we can mitigate the endogeneity caused by KFCP site selection. This is estimated with a IV-Tobit model.

Table 4.3: Estimation models for either patrolling or clearing grass

Independent variable	Poisson		Tobit		IV-Tobit	
	Coefficient (Cluster S.E.)	Marginal effect	Coefficient (Cluster S.E.)	Marginal effect	Coefficient (Cluster S.E.)	Marginal effect
Household involved with KFCP site	0.025(0.163)	0.045	0.061(0.360)	0.058	0.104(0.759)	0.100
Participate in *Gotong-royong*	0.323(0.132)**	0.584***	0.660(0.263)**	0.638**	0.661(0.261)**	0.638**
Shadow wage of rubber products	0.029(0.012)**	0.052**	0.052(0.023)**	0.050**	0.052(0.024)**	0.050**
Shadow wage of off-farm work	−0.016(0.007)**	−0.028**	−0.034(0.014)**	−0.033**	−0.034(0.014)**	−0.033**
Amount of rice product cultivated last year	−0.015(0.012)	−0.027	−0.032(0.028)	−0.031	−0.032(0.029)	−0.031
Number of hot spots observed in 2012	0.048(0.062)	0.086	0.083(0.135)	0.080	0.086(0.159)	0.083
Experienced fire damage in last five years	0.006(0.097)	0.011	0.028(0.217)	0.027	0.020(0.260)	0.019
Number of household members	0.131(0.146)	0.236	0.311(0.332)	0.300	0.308(0.323)	0.297
Number of children age < 6	−0.172(0.145)	−0.311	−0.426(0.317)	−0.412	−0.422(0.335)	−0.407
Access time to market	−0.003(0.060)	−0.005	−0.017(0.134)	−0.017	−0.026(0.184)	−0.025
Age of household head	0.012(0.022)	0.021	0.027(0.052)	0.026	0.028(0.052)	0.027
Square age of household head	−0.000(0.000)	−0.000	−0.000(0.001)	−0.000	−0.000(0.001)	−0.000
Transmigrant	−0.218(0.191)	−0.394	−0.421(0.437)	−0.407	−0.402(0.522)	−0.388
Number of years on lot	−0.261(0.162)	−0.472*	−0.567(0.372)	−0.548	−0.563(0.375)	−0.544
Agriculture as primary source of income	0.318(0.171)*	0.574*	0.593(0.326)*	0.573*	0.595(0.330)*	0.575*
Size of agricultural plot	0.078(0.072)	0.142	0.174(0.159)	0.168	0.172(0.159)	0.166
The size of burned plot for agriculture	0.006(0.083)	0.011	0.086(0.185)	0.083	0.082(0.208)	0.079
Constant	0.411(0.759)		1.657(1.752)		1.656(1.758)	
Fitted test Prob $> \chi^2$ (164)	0.997					
Pseudo R^2			0.125			
Log-likelihood	-266.593		-252.502		-242.568	
Akaike Information Criterion (AIC)	569.187		543.005		541.135	
Bayes Information Criterion (BIC)	626.859		603.881		630.847	
Number of observations	182		182		182	

$\geq\geq\geq$, $\geq\geq$, and $\geq$=statistically significant at 1, 5, and 10%, respectively.
Cluster standard errors are given in parentheses estimated coefficients.
Variables except for dummies are in log form.

Table 4.4: Estimation models for patrolling

Independent variable	Poisson		Tobit		IV-Tobit	
	Coefficient (Cluster S.E.)	Marginal effect	Coefficient (Cluster S.E.)	Marginal effect	Coefficient (Cluster S.E.)	Marginal effect
Household involved with KFCP site	−0.112(0.232)	−0.141	−0.171(0.427)	−0.148	0.659(0.930)	0.565
Participate in *Gotong-royong*	0.395(0.163)**	0.497***	0.583(0.244)**	0.504**	0.590(0.227)***	0.506***
Shadow wage of rubber products	0.039(0.017)**	0.049**	0.059(0.026)**	0.051**	0.051(0.028)*	0.044*
Shadow wage of off-farm work	−0.019(0.009)**	−0.024**	−0.034(0.015)**	−0.029**	−0.031(0.015)**	−0.027**
Amount of rice product cultivated last year	0.004(0.018)	0.005	0.019(0.036)	0.017	0.027(0.036)	0.023
Number of hot spots observed in 2012	0.126(0.083)	0.158	0.199(0.149)	0.172	0.259(0.181)	0.223
Experienced fire damage in last five years	0.098(0.131)	0.123	0.202(0.241)	0.175	0.058(0.276)	0.049
Number of household members	0.070(0.180)	0.088	0.121(0.316)	0.104	0.058(0.307)	0.050
Number of children age < 6	−0.183(0.192)	−0.230	−0.376(0.342)	−0.325	−0.292(0.373)	−0.250
Access time to market	0.020(0.073)	0.025	0.020(0.134)	0.017	−0.147(0.201)	−0.126
Age of household head	−0.033(0.023)	−0.041	−0.065(0.049)	−0.0561	−0.060(0.049)	−0.052
Square age of household head	0.000(0.000)	0.000	0.001(0.001)	0.000	0.001(0.001)	0.000
Transmigrant	0.005(0.244)	0.006	0.236(0.490)	0.204	0.624(0.733)	0.536
Number of years on lot	−0.055(0.224)	−0.070	−0.007(0.445)	−0.006	0.077(0.544)	0.066
Agriculture as primary source of income	0.410(0.207)**	0.516*	0.629(0.344)*	0.543*	0.670(0.355)*	0.575*
Size of agricultural plot	0.082(0.080)	0.103	0.178(0.150)	0.153	0.147(0.139)	0126
The size of burned plot for agriculture	−0.073(0.125)	−0.092	0.004(0.199)	0.003	−0.071(0.212)	−0.061
Constant	0.036(0.899)		0.951(1.866)		0.898(2.005)	
Fitted test Prob > χ^2 (164)	0.897					
Pseudo R^2			0.112			
Log-likelihood	-241.391		-252.368		-241.321	
Akaike Information Criterion (AIC)	518.782		542.735		538.641	
Bayes Information Criterion (BIC)	576.454		603.612		628.354	
Number of observations	182		182		182	

$\underline{\geq}\underline{\geq}\underline{\geq}$, $\underline{\geq}\underline{\geq}$, and $\geq$= statistically significant at 1, 5, and 10%, respectively.
Cluster standard errors are given in parentheses with the estimated coefficients.
Variables except for dummies are in log form.

Table 4.5: Estimation models for clearing grasses

Independent variable	Poisson		Tobit		IV-Tobit	
	Coefficient (Cluster S.E.)	Marginal effect	Coefficient (Cluster S.E.)	Marginal effect	Coefficient (Cluster S.E.)	Marginal effect
Household involved with KFCP site	0.171(0.161)	0.190	0.246(0.292)	0.217	0.053(0.490)	0.047
Participate in *Gotong-royong*	0.272(0.155)*	0.303*	0.440(0.228)*	0.388*	0.438(0.226)*	0.386*
Shadow wage of rubber products	0.027(0.012)**	0.030**	0.034(0.014)**	0.030**	0.036(0.015)**	0.031**
Shadow wage of off-farm work	−0.021(0.009)**	−0.023**	−0.033(0.012)***	−0.029***	−0.033(0.012)***	−0.029***
Amount of rice product cultivated last year	−0.040(0.016)**	−0.045**	−0.059(0.026)**	−0.052**	−0.060(0.026)**	−0.053**
Number of hot spots observed in 2012	−0.037(0.068)	−0.041	−0.069(0.098)	−0.060	−0.083(0.094)	−0.073
Experienced fire damage in last five years	−0.028(0.128)	−0.032	0.004(0.189)	0.004	0.038(0.219)	0.033
Number of household members	0.240(0.193)	0.266	0.397(0.311)	0.350	0.412(0.310)	0.363
Number of children age < 6	−0.355(0.210)*	−0.395*	−0.601(0.296)**	−0.530**	−0.621(0.292)**	−0.547**
Access time to market	−0.038(0.067)	−0.042	−0.061(0.108)	−0.054	−0.023(0.165)	−0.020
Age of household head	0.074(0.030)**	0.083**	0.106(0.045)**	0.094**	0.105(0.047)**	0.093**
Square age of household head	−0.001(0.000)**	−0.001**	−0.001(0.000)**	−0.001**	−0.001(0.000)**	−0.001**
Transmigrant	−0.838(0.264)***	−0.932***	−1.225(0.400)***	−1.079***	−1.312(0.348)***	−1.156***
Number of years on lot	−0.725(0.234)***	−0.805***	−1.069(0.388)***	−0.942***	−1.086(0.356)***	−0.957***
Agriculture as primary source of income	0.226(0.228)	0.251	0.233(0.297)	0.206	0.226(0.301)	0.199
Total size of agricultural plot	0.002(0.115)	0.003	−0.017(0.181)	−0.015	−0.009(0.183)	−0.008
Size of burned plot for agriculture	0.155(0.097)	0.172*	0.292(0.147)**	0.257**	0.309(0.155)**	0.272**
Constant	0.507(1.033)		1.952(1.628)		1.955(1.582)	
Fitted test Prob > χ^2 (164)	0.990					
Pseudo R^2			0.121			
Log-likelihood	-224.340		-228.728		-218.707	
Akaike Information Criterion (AIC)	484.681		495.456		493.415	
Bayes Information Criterion (BIC)	542.353		556.332		583.127	
Number of observations	182		182		182	

$\geq\geq\geq$, $\geq\geq$, and $\geq$= statistically significant at 1, 5, and 10%, respectively.
Cluster standard errors are given in parentheses with the estimated coefficients.
Variables except for dummies are in log form.

The estimation results for each category of prevention activity, patrolling and clearing grass, and both, are summarized in Table 3, Table 4 and Table 5, which show the respective specifications. The first specification (Column 1) uses a Poisson estimation and the second specification (Column 2) uses a Tobit model to take the sample selection biases into account. The third specification (Column 3) uses the instrumental variable method for the Tobit model. Table 6 shows the results of the first-stage regression for IV-Tobit models.

We found that the coefficients of KFCP are statistically insignificant in all estimations, indicating that the impact of KFCP is not enough to cause households to allocate additional time for fire prevention. This might be because KFCP has not offered payments for fire prevention on individual plots. Instead of offering performance-based or outcome-based incentives, most of KFCP project have focused on input-based incentives. For example, households reported that KFCP has rewarded them for preparing nurseries for reforestation or for planting on project plots. Such rewards can constitute an increase in households' exogenous income, which may create negative incentive for fire prevention activity. By increasing households' exogenous income, KFCP can deprive households of incentives to allocate labor for fire prevention at their own plots. As the coefficient of the shadow wage of off-farm work is negative and statistically significant, this might be plausible. Furthermore, KFCP might be insufficient in providing information and knowledge on its strategies. Resosudarmo et al. (2012) compared the knowledge of villagers between several REDD+ pilot projects and found that KFCP is relatively less acknowledged by local residents. The reason KFCP employed input-based incentives is because of the high cost of monitoring of individual behavior. The high cost of implementing performance-based or outcome-based incentive are at the center of the international discussion on REDD+ as measurement, reporting and verification (MRV) problem.

The estimation results suggest that in general, economic factors have a significant effect on decision making for fire prevention. The coefficient of the shadow wage of rubber production is positive and statistically significant at the 5% level at least in most of the estimations, indicating that households with higher values of rubber work are more likely to allocate labor for fire prevention. A higher rubber product value creates an incentive for house-

Table 4.6: KFCP site selection, first stage regression

Independent variable	Probit Coefficient (Robust S.E.)	IV Coefficient (Robust S.E.)
Number of hot spots observed from 2001 to 2007	2.426*** (0.354)	0.139*** (0.038)
Participate in *Gotong-royong*	0.398 (0.813)	0.040 (0.065)
Shadow wage of rubber products	0.287*** (0.069)	0.008* (0.004)
Shadow wage of off-farm work	0.071* (0.041)	0.004 (0.003)
Amount of rice product cultivated last year	0.047 (0.078)	0.013 (0.008)
Number of hot spots observed in 2012	1.007** (0.469)	0.110** (0.048)
Experienced fire damage in last five year	2.504*** (0.443)	0.160*** (0.051)
Number of household members	1.221** (0.488)	0.016 (0.052)
Number of children age < 6	1.678*** (0.346)	0.052 (0.044)
Access time to market	2.479*** (0.372)	0.189*** (0.042)
Age of household head	0.220*** (0.079)	0.009 (0.010)
Square age of household head	0.002*** (0.001)	0.000 (0.000)
Transmigrant	4.502*** (0.612)	0.429** (0.167)
Number of years on lot	1.139** (0.473)	0.019 (0.142)
Agriculture as primary source of income	0.695 (0.734)	0.099* (0.060)
Total size of agricultural plot	0.406 (0.361)	0.017 (0.042)
Size of burned plot for agriculture	1.880*** (0.646)	0.104* (0.057)
Constant	12.566*** (3.703)	0.306 (0.518)
Number of observations	182	182
Pseudo R^2	0.853	

≥≥≥, ≥≥, and ≥= statistically significant at 1, 5, and 10%, respectively. Cluster standard errors are given in parentheses under the estimated coefficients.
Independent variables except for dummies are in log form.

holds to protect themselves from fire damage. This result is consistent with Bowman et al. (2008), who found that the shadow wage of agricultural work has positive and statistically significant effect on household decision making on fire prevention. The coefficients of the shadow wage of off-farm work are negative and statistically significant, indicating that an increasing off-farm wage increases the opportunity cost of time (γ), and a high opportunity cost leads households not to allocate their time for fire prevention. These results mean that agricultural work and off-farm work are substitutes for households in this area and the substitution effect outweighs the income effect. The total effect of Equation (13) is positive and that of Equation (14) is negative.

The coefficients of *Gotong-royong* are positive and statistically significant in most of the estimation, indicating that the households that participate in *Gotong-royong* are more likely to engage in fire prevention. Since *Gotong-royong* reinforces community's norms and ethics, it leads households to cooperate with each other. Another possibility is that *Gotong-royong* plays the role of a mutual surveillance system, allowing farmers to know what their neighbor are doing at their agricultural plots. This can function as peer pressure for more extensive fire prevention.

The coefficients of the experience of fire damage and the number of hot spots in 2012 are positive but statistically insignificant in the estimations. These results suggest that prevention activities by households might be based on subjective risk perception. Empirical findings show that households in developing countries are typically defined as risk-averse (Rosenzweigh and Binswanger, 1993; Morduch, 1995; Barrett 1999; Shively, 2001).

4.5 Conclusions

This study estimated household labor allocation models by combining household survey data and satellite information for Kapuas Regency, Central Kalimantan, Indonesia. On the basis of the results, we can conclude that peatland fire prevention can be promoted by economic and non-economic incentives. This suggests that the REDD+ intervention incentive scheme would be able to mitigate the risk of peatland fire as long as the design of the incentives is appropriate.

The effect of KFCP was not found to be statistically significant in our results. While KFCP was expected to be an ideal model to mitigate the risk of peatland fire, we found that it has no impact on household fire prevention decisions. This can be attributed to the fact that KFCP failed to develop an appropriate incentive scheme. For example, KFCP pays households planting or preparing trees for reforestation projects, but not for fire prevention. Increasing this kind of payment might decrease the amount of labor allocation for fire prevention since increasing the attractiveness of off-farm work would deprive households of their willingness to allocate labor for fire prevention.

Economic factors play a significant role in policy implementation. Increasing the productivity of rubber (the shadow wage of rubber production) would be an incentive for households to increase their labor share of fire prevention activity; however, increasing exogenous income may deprive households of their willingness to engage in fire prevention.

Non-economic factors are also important for effective policy implementation. Mutual assistance customs such as *Gotong-royong* might enhance the relationships between and the responsibility of households in the community. Thus, households that participate in *Gotong-royong* activities tend to allocate more labor and time for fire prevention at individual plots. Toghether, these findings provide policy implications for the mitigation of forest fire and deforestation in Central Kalimantan as well as in other tropical regions. The high cost of implementing incentive schemes and the difficulty in monitoring individual actions known as MRV problem are the center at international discussion on REDD+. Policy design should include mutual pressure from each household and appropriate economic incentives to secure implementation.

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Chapter 5

Conclusions

This paper investigates the economic potential of REDD+ in Central Kalimantan, Indonesia based on economic analysis and field survey data. We find that REDD+ is potentially beneficial for mitigating global climate change, although some issues are remain before international agreement can be reached.

The findings of this paper provide the policy implications of REDD+ in Central Kalimantan, Indonesia. Forests in other tropical regions face similar issues concerning wildfire, agricultural expansion, and property rights. Our implications may be applicable not only to Indonesia, but also to these other regions. The main contributions of this paper are as follows. Firstly, we review various challenges of REDD+ implementation, for example, monitoring and setting baselines that affect the benefit of each country. While various issues can make reaching an agreement difficult, REDD+ has gained momentum as a means to mitigate climate change. Secondly, we investigate the economic viability of REDD+ by estimating the BEP in Central Kalimantan. The results of our BEP estimation show that REDD+ can offer an opportunity for Central Kalimantan to reduce deforestation at current the price of carbon at the EU ETS. This indicates that REDD+ would reduce the conflict in international negotiation concerning climate change by offering incentives for developing countries to participate in its scheme. However, the increasing price of palm oil and rubber material will sharply increase the opportunity cost of forest protection in Indonesia. Farmers would change their choice of crops in response to a change in the price of crops. We must therefore pay attention to the changes in international material prices. Thirdly, we investigate the factors promoting local peatland fire prevention activities. The results show that non-economic factors play a significant role in the reduction of peatland fire. This suggests that the policy design of REDD+ should include non-economic incentives as well as economic incentives to secure implementation. Our fire prevention estimation results suggest that inappropriate incentives can lead REDD+ to failed in promoting forest protection. We evaluated the impacts of KFCP and found that it does not change farmers' activities. KFCP fails to develop an appropriate incentive scheme because monetary incentives have not been provided in the project site. Policy design must take into account non-economic incentives for implementing REDD+ effectively.

On the basis of the findings in this paper, we can conclude that REDD+ has the economic potential to reduce carbon emissions from forest sectors in developing countries. REDD+ can also contribute to the reduction of local poverty by providing economic incentives. However, REDD+ will not be able to attract developing countries (i.e. indigenous people) to participate in the scheme unless appropriate incentives are provided. While many policy designs have been assumed in its implementation, we suggest that REDD+ should also be considered in terms of setting incentive schemes to maximize the number of participators. We also find that REDD+ might be able to provide low-cost performance by including non-economic incentives. The high cost of implementing incentive schemes and the difficulty in monitoring individual actions are at the center of the international discussion on REDD+ as an MRV problem. Our findings can contribute to promoting policy agreement on REDD+.