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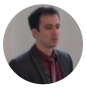
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Spillover effects of market-based instruments under revenue uncertainty in Jambi Province, Indonesia

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Abstract

In the case study of Indonesia we investigated possible effects of different types of market-based instruments (MBI), including rewards and taxes, on larger farmer (landlord) that adopts MBI and spillovers on working on his land under sharecropping arrangement another farmer (tenant). Multi-period expected value model with Monte Carlo simulation and Brownian motion was used. Findings showed that high prices of MBI would increase incomes of landlord but would reduce incomes of tenant through reduced working activities at landlord due to less cultivation of labor demanding crops. In most cases the incomes of landlord would be the under the MBI scenarios than in the business-as-usual scenario. If uncertainty in revenues is considered then MBI would reduce variability in incomes of both landlord and tenant. Rewards for increasing supply rather than taxation for reducing provision of ecosystem services resulted in higher rural incomes and provision of ecosystem services.

1. Introduction

Deforestation is one of the main contributors to global greenhouse gas emissions; in addition, it results in ecosystem degradation, which in turn reduces population welfare. Indonesia has one of the highest deforestation rates in the world (van Noordwijk et al., 2012a). As few primary forests are left in Indonesia, maintaining agroforests is one of the land use options to enhance the provision of various ecosystem services (ES), e.g., carbon (C) sequestration (Tomich et al., 2004; Villamor et al., 2014a). However, the low returns of rubber agroforestry results in conversion of this land use into the oil palm and rubber monoculture plantations (Akiefnawati et al., 2011). The market-based instruments (MBI) could be options to increase the financial benefits of such environmentally friendly land uses (van Noordwijk et al., 2012b). For example, the MBI rewards can be obtained from the C stored in wood biomass of agroforestry systems and revenues obtained from mechanism like reducing emissions from deforestation and forest degradation. Another reward for ES that land users may obtain is the eco-certification that target the raw materials from crops produced in biologically diverse systems (Bennett, 2008; Villamor et al., 2011a; Villamor et al., 2014a). Yet, to boost the provision of ES not only rewards options can be suitable but also sanctions such as Pigovian tax, which is tax paid by the polluter or actor that is reducing provision of ES. All these policies can be suitable for increasing the provision of ES and overall rural welfare. However, the effects of MBI on rural livelihoods can be mixed. For instance, Shuifa et al. (2010) claimed that C forestry projects would lead to increase of job opportunities in China. In contrast, Glomsrød et al. (2011) in the case of Tanzania showed that C forestry projects have limited ability to reduce poverty and mainly the non-poor rural and urban households would benefit. However, due to heterogeneity among rural population the conservation policies might have different effects on livelihoods (Villamor et al., 2014a). The implementation of MBI schemes would impact not only farmers that are adopting them but also would have a spillover effects on other farmers through their rural interdependencies. Djanibekov et al. (2013a) showed that when farmers plant tree plantations on marginal cropland for boosting ES the indirect impacts occur on other groups of rural households through their wage-labor contracts. Accordingly, the effects of these tree plantations are different over the years, i.e., having positive and negative effects on rural households' incomes in some years. In the case of Indonesia, some farmers (landlord) are typically unable to manage their farms through their own labor inputs, and consequently share land with other farmers (tenant) that are abundant in labor. To accomplish farming activities landlord and tenant form a contractual arrangements typically in the form of sharecropping, where landlord gives his land to the tenant for managing it and then depending on agreement they share input costs and crop output.

Variability in land use revenues may cause uncertainty in effects of MBI schemes on rural livelihoods (Djanibekov and Khamzina, (in press)). The uncertainty in land uses can stem from the fluctuations in yields and prices. Ambarawati (1995) concluded that fluctuations in the world market price for rubber were one of the main factors affecting price instability of Indonesian rubber. In this vein, study by Castro et al. (2013) showed that the payments needed to preserve shaded coffee plantations were much greater under uncertainty in revenues than those estimated under the assumption that did not consider variability. Accordingly, uncertainty in land uses revenues may have uncertain effects on farmers and other groups of rural population and may be a barrier to adopt the long-term land uses (Koundouri et al., 2006).

Subsequently, while implementing MBI the interdependencies among rural population that may change due to the new policies and uncertainty in income of these policies need to be considered (Rodríguez et al., 2006; Affholder et al., 2010). Thus, for analyzing the economic and environmental attractiveness of land uses with MBI the interrelationship among land users and variability in revenues need to be taken into account. In this study, we investigated the farm management decisions such as selecting crop types, sharecropping arrangement, uncertain crop prices and production that also affect input costs through the labor demand for harvest and various discount rates for different farmers (i.e., landlord and tenant). The objectives of the study were to: (1) analyze the direct and spillover effects of MBI rural interdependencies, i.e., change in sharecropping contract between landlord and tenant, under uncertainty; and (2) develop policies and land use management practices that would increase rural incomes.

2. Methods

2.1 Study area

The study area is located in Jambi province, Sumatra Island, Indonesia. The study area is once covered by lowland forests and in the 1900s the Dutch introduced *Hevea braziliensis* or commonly called rubber, which successfully thrived due to its tropical climate conditions. After its introduction, in the 20th century, rubber agroforests become the dominant land use in the study area. Majority of the farmers are small-scale farmers. There are farmers who are interconnected to each other through the sharecropping arrangement, where one farmer (i.e., landlord) has more land to manage himself and another farmer (i.e., tenant) has insufficient land but abundant in labor. These two actors depending on external environment (e.g., policies, market prices), their characteristics and land uses select certain sharecropping arrangement (Colfer et al., 1988; Villamor et al., 2015). In addition, their land use decisions and contracts may change due to the uncertainty in land use revenues. The main land uses are rice, jungle rubber agroforest (hereafter referred to as agroforestry), and rubber monoculture; oil palm is a newly emerging crop in the study area. The agroforestry system also includes fruit trees such as durian, jengkol, petai and other indigenous trees. The rice is the main staple food of the people, whereas rubber is traditionally considered by farmers as the main income generating crop. The most labor demanding crop is oil palm followed by the rubber monoculture, and one of the least labor requiring crop is the rubber agroforest. Due to high profitability of oil palm (Budidarsono et al., 2012), in the neighboring areas, particularly in the lowlands, farmers converted agroforests into oil palm. In the province, the average growth period of oil palm and rubber monoculture is about 30-40 years, whereas agroforestry can reach to about 70-80 years.

2.2 Simulation of variability in yields and prices

To capture uncertainty in yields we used the Monte Carlo simulation to generate various parameters. As the planting one crop would affect the yield of another closely planted crop the stochastic dependency between yields are considered by allowing their multivariate normal distribution:

$$\bar{Y}_t = Y + \sigma CSND \qquad (1)$$

where $\tilde{Y}_t$ is multivariate distribution of yield over each analyzed year (*0, 1, 2, …,T*, where *T=40*), Y is the average yield of crops, σ is the standard deviation of yield, and $CSND$ is the correlated standard normal deviated for yields.

To address fluctuations in prices we employed the geometric Brownian motion with drift, which is a stochastic process that has independent increments and the change in the process in any period is normally distributed with a variance that increases linearly with time (Dixit and

Pindyck, 1994). We selected this approach as the prices can be affected by different local and international factors depending on crop type, and consequently multivariate distribution for prices may not be a suitable approach. Accordingly, we assumed that the prices have the following stochastic process:

$$\bar{P}_t = P_0\, exp\left(\left(\mu - \frac{\sigma}{2}\right) t + \sigma W_t\right) \tag{2}$$

where $\bar{P}_t$ is the price with the geometric Brownian motion path, P_0 is the initial value, W_t is a Brownian motion, μ is the is the percentage drift and σ is the percentage volatility and both are constants.

2.3 The model

To investigate the impact of introducing MBI on rural incomes and environmental sustainability under revenue uncertainty an integrated model of landlord and tenant was developed based on the multi-period expected value model. The model supports the choice of optimal production planning of interdependent landlord and tenant that maximizes their annual profits. In the model, we assumed that these two actors face a problem in selecting land uses under certain resource availability, knowing that the decision for one land use will affect other land uses. Also, landlord and tenant have to decide in which land use activities to invest under different states of nature (S) corresponding to different levels of yields and prices. In order to address the risk involved, we applied the expected value approach:

$$Max\ EV = \sum_{s=1}^{S} U(NPV^{landlord,tenant}{}_{s})\pi(P_s) \tag{3}$$

$$= \frac{\bar{p}_{jt}\bar{y}_{jt}X_{jt} + \bar{p}_{jt}\bar{y}_{jt}XS_{jt} - c_{jt}X_{jt} - c_{jt}CSH_{jt}}{(1+d)^t}$$

where the objective is to maximize expected net present value (NPV) of landlord and tenant with the probability $(\pi(P_s))$ for state of nature (s), where each outcome has the same probability and the number of states of nature (S). The state of nature of profit changes with respect to area of selected land use activities from land managed by the actors themselves and sharecropped land, uncertain prices $(\bar{p})$ and yields $(\bar{y})$ of land use (j), yields from sharecropping arrangement (XS), crop returns input costs (c) for own managed (X) and sharecropped land (CSH) which also change according to labor required for the uncertain output over 40 years (t), and discounted (d) under three rates, i.e., 5, 12 and 20%.

The constraints of the model included restrictions on area. It is assumed that durian, petai and jengkol are planted at rubber agroforest land uses. According to this constraint landlord arable land area (b), which amounts to 7 ha, is allocated for own managed (X) and sharecropping land uses (SH). The sharecropping area at landlord is jointly decided with the tenant:

$$\sum_j X_{jt} + SH_{jt} \leq b_t \tag{4}$$

The land area of tenant amounts to 1 ha and it is t solely managed by the tenant. Tenant can use the land of landlord under sharecropping arrangement and share the yield of crop.

We relied on the real options approach to consider the flexibility of landlord's land (both own managed and under sharecropping arrangement with tenant) decisions regarding the use of perennial crops (i.e., rubber agroforest, oil palm and rubber monoculture) over time. We considered several types of flexibility, such as: plant perennial crops, delay the conversion of agroforest into oil palm and rubber monoculture, to keep the area of perennial crops over years, and to maintain oil palm and rubber monoculture cultivation with implementing rotations. Oil palm and rubber monoculture can be rotated at any year. The establishment of these crops can be also changed, where oil palm can be converted to rubber monoculture and vice versa.

In the study area labor availability is another vital input for land use decisions of farmers. It was assumed that the labor use for land use activities (k) depends on varying crop output $(\bar{y})$ and is subject to constraint of landlord's and tenant's household members available for farmland (l), which are 350 days year^{-1} by landlord and 1000 days year^{-1} by tenant. The labor availability changes with respect to the annual growth rate of 1.14% which was observed in Indonesia between 2000 and 2012:

$$\sum_j k_{jt}\bar{y}_{jt}X_{jt} \leq l_t \tag{5}$$

Similar applies to the labor required for the sharecropped land.

The contractual arrangements between landlord and tenant is determined through the share (SH) of crop returns $(\bar{p}\,\bar{y})$ from the sharecropped land and labor time required for crops (k)

cultivated at sharecropped land (XS) and share of other input costs for the sharecropped land (CSH):

$$\sum_j \bar{p}_{jt}\bar{y}_{jt}SH_{jt} = k_{jt}\bar{y}_{jt}XS_{jt} + c_{jt}CSH_{jt} \quad (6)$$

The cost sharing arrangement for the sharecropped land (XS) is defined through the input costs shared by the landlord (CSH) and tenant ($CSH°$):

$$c_{jt}CSH_{jt} + c_{jt}CSH°_{jt} = c_{jt}XS_{jt} \quad (7)$$

The commodity balance of landlord defines that the crop output (j) from own managed (X) and sharecropped land (XS) is harvested at different states of yield ($\bar{y}$) which can be sold (M), given under the sharecropping arrangement (SH), and in the case of rice consumed by own household (f) which is assumed to be 200 kg/capita:

$$\sum_j \bar{y}_{jt}X_{jt} + \bar{y}_{jt}XS_{jt} - \bar{y}_{jt}SH_{jt} = M_{jt} + f_{jt} \quad (8)$$

In the case of tenant commodity balance defines that the crop output (j) from own managed land ($X°$) is harvested and obtained from sharecropping arrangement land (SH) at different states of yield ($\bar{y}$) which can be sold ($M°$), and in the case of rice consumed by own household ($f°$) which is assumed to be 200 kg/capita:

$$\sum_j \bar{y}_{jt}X°_{jt} + \bar{y}_{jt}SH_{jt} = M°_{jt} + f°_{jt} \quad (9)$$

2.4 Data sources

We used the primary household data from Villamor (2012), which was collected between February and March 2010. A total of 95 randomly selected farm households were surveyed in the study area. The objective of the survey was to explore farm's production and its household characteristics, preferences, and behaviors. Some of the important characteristics of the survey are given Table 1. In terms of landholdings, some of the respondents have farm area up to 25 ha while the others have none, suggesting the sharecropping agreement really exists. We also collected data on prices and yields from the Ministry of Agriculture of Indonesia (2012). The C sequestered amount was obtained from Rahayu et al. (2005). It was assumed that the C stock amount at these land uses vary with respect to their yield (e.g., depending on yield of rubber in agroforestry system the amount of carbon storage). The labor requirements vary depending on crop type during the establishment, harvest and clear cut period. In addition, the labor cost depends on crop yield and was assumed to be 1 USD t^{-1} of crop yield. To eliminate the effects of inflation rates the prices were converted to real prices using the USD exchange rate.

<insert Table 1 here>

2.5 Scenario settings

In our study, we considered that MBI can be additional incentive to follow sustainable land uses practices at landlords land. Hence, MBIs are given to or taxed from the landlord. In the model we analyzed five scenarios:

(1) Business-as-usual (BAU), where no MBI policy interventions were included;
(2) Eco-certification scenario (Eco-certification) where subsidies are given to the landlord for the yield of rubber from agroforestry systems. In this scenario we considered three levels of additional payments for rubber yield, which are 200, 500 and 2000 USD t^{-1};
(3) The scenario of payments for C stored in rubber agroforest (Carbon). To analyze the effects of C prices on farming activities the three different levels of C price were assumed, i.e., 5, 20 and 100 USD t^{-1}. The payment for C sequestration can be only in the years 10, 15, 20, 25, 30 and 35.
(4) Pigovian tax scenario (Pigovian tax), which is the tax paid for the C emitted from converting the land into the oil palm and rubber monoculture. In this case, the difference between C stored in rubber agroforest with the oil palm and rubber monoculture is considered. To analyze the effects of taxes amount on farming activities the three different levels of taxes were assumed, which level is similar to the C rewards, i.e., 5, 20 and 100 USD t^{-1}. The Pigovian taxes function when oil palm and rubber monoculture are established and are paid in the years 1, 5, 10, 15, 20, 25, 30, 35, 40 and after the conversion (2nd rotation) starting from year 6 and every five years.
(5) Joint scenario of eco-certification, payments for C stored in rubber agroforest and Pigovian tax (Combined). Thus, in this scenario all MBI-related schemes (including both rewards and taxes) were analyzed.

For the simplicity of the results interpretation we presented the extreme values of eco-certification and carbon storage rewards and Pigovian taxes, i.e., their highest and 0 levels.

The model was programmed in GAMS.

3 Results

3.1 MBI effect on land use change

For simplicity of results representation we present only the land use pattern in the BAU and Combined scenarios with the highest MBI levels (Figure 1). In the BAU scenario most of the land would be allocated for the oil palm followed by rice cultivation. The selection of oil palm can be explained due to its high revenues and labor demanding activity, which lead that both actors are interested in this crop. Oil palm would have two rotations, for example, in the case of when landlord manages the oil palm and when that crop is under the sharecropping contract the harvest of first oil palm and instead establishment of the second rotation would be practiced. This tree management strategy would be as a result of insufficient initial labor available, discount rate and might be due to the price dynamics that were more suitable at later years. Such management practice would increase the area of oil palm starting from year 6. For rubber monoculture, if it would be planted starting from year six and its area would be remained until the analyzed period 40. These land use changes would lead that the sharecropping arrangement for rice would decrease, but the area of own managed rice would gradually increase to satisfy the food consumption demand of households of landlord and tenant. When no MBI incentives are introduced the rubber agroforest would not be practiced. In addition, the high demand for labor and lack of labor in the initial years would result in more than two hectares of not cultivated land.

In the case of the combined scenario with the highest levels of rewards (i.e., 2000 USD t^{-1} for rubber yield from agroforestry system, and 100 USD t^{-1} for C stored the agroforest would become one of the main land uses, and would be established in both managed by landlord and in the sharecropped land. The enhancement of agroforest would be mainly by receiving payments for high C storage (the Carbon scenario is not shown here). Yet, the area of agroforest would decrease starting from year 21 which would be caused by the reduced by the discount rate the MBI returns. In comparison to the BAU scenario, the area of the oil palm would be lower, and rubber monoculture would not be preferred by land users. This trend would stem mainly from the rewards for C storage and Pigovian tax for the C emissions. However, the area of oil palm would be close to the ones in BAU case starting from year 20. This type of land use change would suggest that the MBI schemes would be efficient options to conserve rubber agroforest and mainly through the high level of reward scheme such as payments for C storage. Moreover, in the MBI policy scenario the area of sharecropped rice would be negligible, but the demand for rice consumption would be satisfied through the production of rice in own managed plots. The higher the discount rate the less would be the area of agroforest, due to obtaining its benefits in long-term. In addition, in the case when prices and yields are low land users would diversify land use pattern.

<insert Figure 1 here>

3.2 The provision and value of ecosystem services

The introduction of different MBI policies would affect the supply of ES such as C stored in biomass of agroforestry system, emissions of C due to the harvest of agroforest and instead establishment of oil palm and rubber monoculture plantations (Table 2). When there are no payments or taxes for ES, then the averaged level of C emissions would be 302 t over the analyzed 40 years. The same level of C emissions would also be under the eco-certification policy (with high price agroforestry yield), which would be as a result that the rubber yield obtained from the agroforestry is low and additional high prices would still be lower than the high profits generated from oil palm plantations. This would be an outcome for no C stock level. In contrast, the Pigovian tax policy scenario would reduce the C emissions but would not motivate land users towards agroforest and consequently there would be 0 C stored. Under this policy, oil palm would still be planted because the reduction in C emissions would cost landowner about 29,700 USD over 40 years. The carbon scenario would also lead to the reduction of C emissions, but in addition to it also motivate land users to increase the C storage by planting the rubber agroforestry. In this case, the revenues from the MBI would be highest among all five scenarios and also with its low standard deviation. The policy option that considers all MBI rewards and taxes would be the most efficient in carbon reduction and storage.

However, the taxes for C emissions would result in lower MBI returns than in the carbon scenario. The reason is that the landlord and tenant would jointly agree the highly profitable oil palm, which returns for both of these actors would overweigh the returns from the land uses. The variability in C storage and emissions would not differ much between scenarios and its standard deviation would be not high. If we consider the reward and tax under the combined and Pigovian tax scenarios respectively then the variability would be higher and differ from other policy scenarios.

<insert Table 2 here>

3.3 Sharecropping arrangement

The landlord and tenant contracts in sharecropping can represent rural interlinkages. This interrelationship would be adjusted according to the external environment such as policy changes and uncertainties in revenues from land uses. The change in employment in land use activities is important for non-participating smallholders that may have limited means to earn livelihoods except of working at another farmer. In our analysis, implementation of rewards and taxes for ES for the landlord resulted in spillover effects on tenants through their sharecropping arrangement (Table 3). Due to the no difference in the business-as-usual and eco-certification scenario the tenant working activities at landlord and revenues from the sharecropping arrangement would remain almost the same. Yet, given that less labor is required for the management of rubber agroforest than for the oil palm and rubber monoculture the MBI policies that would be adopted by landlord would result in lower working activities of tenant. For instance, the carbon scenario that generated the highest revenues for the landlord among the MBI options would lead to the reduction in tenant work under the sharecropping agreement with landlord. This would also reduce the revenues of tenant. The most drastic reduction in employment and sharecropping revenue for the tenant would be in the combined scenario. Surprisingly, in the Pigovian the tenant would generate highest revenues from the sharecropping arrangement among all other scenarios, although the tenant work would be reduced this would be as a result of increased sharecropped rice area instead of oil and rubber monoculture.

<insert Table 3 here>

Based on model simulation there would be no cost sharing arrangement, instead all input costs area cover solely by the landlord (Table 4). Whereas the tenant provides labor and accordingly receives payments. The MBI policies and variability caused selection of wide choice of sharecropping of land uses between landlord and tenant and accordingly share arrangements of crop output. In all the scenarios the oil palm would be the main product that would be shared between landlord and tenant; this contract would prevail be due to high profits from the palm oil, however, the share level would be highly uncertain which could be explained by high variability of returns of palm oil. The rubber from monoculture plantations would be remunerated in the BAU, eco-certification and carbon scenarios, whereas in the other two scenarios, i.e., Pigovian tax and combined, the rubber from monoculture would not be selected. Such cease of sharing this product would be that monoculture would not be planted at landlord's land due to high taxes that would need to be paid for emitting C. Instead, in high tax case the landlord and tenant would increase the share of rice. Among all policy scenarios the rubber, jengkol, durian and petai products from agroforestry would be shared in the combined scenario. In the carbon scenario all type of land use products would be shared, and hence the payment structure would be diversified.

<insert Table 4 here>

3.4 Landlord and tenant incomes

The incomes of landlord and tenant were substantially affected due to the variability in in yields and prices, different MBI policy scenarios and discount rate. Due to the initial investments into the oil palm, rubber monoculture and agroforest, the positive returns would be generated after year three. Considering the discount rate of 6% the incomes of both landlord and tenant would be higher by about 230% in comparison when the discount rate is 12%, and the similar difference was observed when comparing 12% with 20% discount rate. The higher the discount rate the lower are incomes, and lower are the preference of land users towards long-term planning, i.e., land uses. Also, raising the MBI reward and tax values to the highest simulated level would increase landlord profits especially in years 5, 10, 15, 20, 25, 30, 35, 40 (i.e., in the years when the C payments would be given).

The expected NPV of landlord in the BAU, eco-certification and carbon scenarios did not differ that substantially, although the highest NPV was in the carbon scenario (Table 5). However, the variability (i.e., variance) of NPV among these three scenarios was obvious, where the lowest variability was simulated at the carbon scenario. In contrast tenant in this scenario had lower expected and variance NPV than in the business-as-usual and eco-certification case. The increase in the incomes of landlord and decrease in incomes of tenant would be as a result of preference towards less labor requiring rubber agroforestry on landlord's land. In the case of the Pigovian tax the opposite situation where landlord received the lowest (even though with high uncertainty) and tenant the highest NPVs. In such case, the high taxes (100 USD tC^{-1} emitted) would be charged to landlord for planting C emitting crops such as oil palm and rubber monoculture, and this tax level would overweigh NPV of rubber monoculture but not of oil palm, which would be only planted perennial land use. In the combined scenario, obtaining different types of MBI rewards and taxes for reducing ES would increase landlord incomes than in the Pigovian tax policy option but still would be lowest among all other scenarios, although with the lowest income variance. The high Pigovian tax would reduce incomes but the fixed level of high ES rewards would reduce income uncertainty and make incomes higher than in the Pigovian scenario. The tenant would also have low expected and variance of NPV which would be a result of low demand for working activities at landlord and increase in sharing of less revenue fluctuating agroforestry products.

<insert Table 5 here>

4 Discussion and conclusions

Introduction of policies that have monetary reward or tax the for land uses is a vital step in commodification of scarce ES (Kallis et al., 2013). Policy makers concerned with implementation of different ES mechanisms must deal with incentivizing land users and consider the increase in rural livelihoods. When implementing rural policies the heterogeneity among rural people and networks need to be included to address potential spillover and externality effects (Djanibekov et al., 2013b; Villamor et al., 2014b; Djanibekov et al., 2015). For instance, Djanibekov et al. (2013a) showed that due to agricultural contract interrelationships rural households' livelihoods would substantially respond to the changes in land uses of other agricultural producers – farmers. Dhakal et al. (2012) found that forest policies can have negative repercussions on household income and employment, and widen inequality within Nepalese communities. Capturing the interrelations between landlord and tenant through the sharecropping arrangement, this study provided a broader overview of potential impacts of various mechanisms that are aimed to enhance the supply of ES on land use choice, C storage and emissions, rural employment, incomes and risk. The effects on land use pattern would be different depending on the MBI level and its objective. When no MBI incentives are introduced the rubber agroforest would not be practiced. Based on the landlord-tenant sharecropping relationship the benefits of receiving MBI rewards for landlord would result in negative effects on tenant. The negative effects would be as a consequence of selecting the area of rubber agroforestry, which was the least labor requiring crop and reduction in high labor demanding oil palm and rubber monoculture. In the case when the incomes of landlord were reduced due to the taxes for emitting ES the incomes of tenant were higher. Raising the MBI amount given only for agroforest would increase both C stock, and increase the area of agroforestry while reduce the area of oil palm and rubber monoculture. The MBI values would lead that land users would obtain more stable and less varying farm incomes, which would allow reducing the repercussions of farm revenue risks, but depending on the MBI policy option the incomes, may be lower than under the current conditions for landlord and/or tenant. At the same time, the viability of MBI schemes is also determined by the preferences and perceptions of land users and other stakeholders affecting land use choices (Villamor and van Noordwijk, 2011b), and hence only certain land users and stakeholders may opt for MBI for maintaining rubber agroforest. Thus, in addition to monetary incentives, such as rewards in the form of MBI, other factors impacting adoption or participation in MBI schemes have to be designed. For more efficient implementation of MBI developing extension services so as to disseminate information about its benefits, and further development of markets would be necessary. The effectiveness of implementation of MBI schemes would also depend on the institutional design in the region (Vatn, 2010). To increase the adoption of MBI options they need to be targeted to the areas and land uses that are environmentally deteriorating, e.g., in the case of Indonesia the areas where there is a high deforestation rate.

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References

Ambarawati, I. G. A. A., 1995. The contribution of supply and demand components to the instability of Indonesian natural rubber price. Unpublished MEc dissertation, University of New England, Armidale.

Affholder, F., Jourdain, D., Quang, D. D., Tuong, T. P., Morize, M., Ricome, A., 2010. Constraints to farmers' adoption of direct-seeding mulch-based cropping systems: A farm scale modeling approach applied to the mountainous slopes of Vietnam. Agric. Syst. 103, 51-62.

Akiefnawati, R., Ayat, A., Zulfikar, F., Joshi, L., Suyitno, Mirza, S., Alira, D., 2011. Improving the quality and marketing system of smallholder rubber farms: A Report, International Food Policy Research Institute (IFPRI). Washington DC, IFPRI.

Bennett, M., 2008. Eco-certification: can it deliver conservation and development in the tropics? International Food Policy Research Institute (IFPRI). Washington DC, IFPRI.

Berg, E., Kramer, J., 2008. Policy options for risk management. In M. P. M. Meuwissen, M. A. P. M. van Asseldonk, and R. B. M. Huirne, eds., Income stabilisation in European agriculture. Wageningen: Wageningen Academic Publishers, 143–169.

Budidarsono, S., Rahmanulloh, A., Sofiyuddin, M., 2012. Economic assessment of palm oil production. World Agroforestry Centre, Technical Brief No. 26.

Castro, L. M., Calvas, B., Hildebrandt, P., Knoke, T., 2013. Avoiding the loss of shade coffee plantations: how to derive conservation payments for risk-averse land-users. Agroforest. Syst. 87 (2), 331–347.

Colfer, C. J. P., Gill, D. W., Agus, F., 1988. An indigenous agricultural model from West Sumatra: a source of scientific insight. Agric. Syst. 26, 191-209.

Dhakal, B., Bigsby, H., Cullen, R., 2012. Socioeconomic impacts of public forest policies on heterogeneous agricultural households. Environ. Resour. Econ. 53 (1), 73–95.

Dixit, A. K., Pindyck, R. S., 1994. Investment under uncertainty. New Jersey: Princeton University Press.

Djanibekov, U., Djanibekov, N., Khamzina, A., Bhaduri, A., Lamers, J. P. A., Berg, E., 2013a. Impacts of innovative forestry land use on rural livelihood in a bimodal agricultural system in irrigated drylands. Land Use Policy 35, 95–106.

Djanibekov, U., Van Assche, K., Boezeman, D., Djanibekov, N., 2013b. Understanding contracts in evolving agro-economies: Fermers, dekhqans and networks in Khorezm, Uzbekistan. J. Rural Stud. 32, 137–147.

Djanibekov, U., Van Assche, K., Boezemann, D., Villamor, G. B., Djanibekov, N., 2015. Revealing the role of agricultural contracts in rural livelihoods in Uzbekistan. In: Kimhi A., Lerman Z. (Eds.): Agricultural transition in Post-Soviet Europe and Central Asia after 25 years. IAMO, Halle/Saale, 141-158.

Djanibekov, U., Khamzina, A., (in press). Stochastic economic assessment of afforestation on marginal land in irrigated farming system. Environ. Resour. Econ. DOI: 10.1007/s10640-014-9843-3.

Glomsrød, S., Wei, T., Liu, G., Aune, J.B., 2011. How do well tree plantations comply with the twin targets of the Clean Development Mechanism? – The case of tree plantations in Tanzania. Ecol. Econ. 70 (6), 1066–1074.

Hardaker, B. J., Huirne, R. B. M., Anderson, J. R., Gidbrand, L., 2004. Coping with risk in agriculture. London, CABI Publishing.

Kallis, G., Gómez-Baggethun, E., Zografos, C., 2013. To value or not to value? That is not the question. Ecol. Econ. 94, 97–105.

Koundouri, P., Nauges, C., Tzouvelekas, V., 2006. Technology adoption under production uncertainty: Theory and application to irrigation technology. Amer. J. Agric. Econ. 88, 657–670.

Leimona, B., Akiefnawati, R., Pasha, R., Suyanto, 2011. Improving smallholders rubber quality in Lubuk Beringin, Bungo district, Jambi province, Indonesia: an initial analysis of the financial and social benefits, International Food Policy Research Institute (IFPRI). Washington DC: IFPRI.

Ministry of Agriculture of Indonesia, 2012. Yield and price values of land use production.

Rahayu, S., Lusiana, B., Van Noordwijk, M., 2005. Above ground carbon stock assessment for various land use systems in Nunukan, East Kalimantan. In B. Lusiana, M. van Noordwijk, and S. Rahayu, eds., Carbon Stock Monitoring in Nunukan, East Kalimantan: A Spatial and Modelling Approach Bogor, Indonesia: World Agroforestry Centre, SE Asia, 21–34.

Rodríguez, J. P., Beard, T. D., Bennett, E. M., Cumming, G. S., Cork, S. J., Agard, J., Dobson, A. P., Peterson, G. D., 2006. Trade-offs across space, time, and ecosystem services. Ecol. Soc. 11, 28.

Shuifa, K., Wagner, E.J., Zhou, L., Yali, W., Yan, Z., 2010.The situations and potentials of forest carbon sinks and employment creation from afforestation in China. Internat. Forest. Review 12 (3), 247–255.

Tomich, T. P., Thomas, D. E., van Noordwijk, M., 2004. Environmental services and land use change in Southeast Asia: from recognition to regulation or reward? Agric. Ecosyst. Environ. 104, 229-244.

van Noordwijk, M., Tata, H. L., Xu, J., Dewi, S., Minang, P. A., 2012a. Segregate or integrate for multifunctionality and sustained change through rubber-based agroforestry in Indonesia and China: Agroforestry - The future of global land use. In P. K. R. Nair and D. Garrity, eds., Springer Netherlands, 69–104.

Van Noordwijk, M., Leimona, B., Jindal, R., Villamor, G. B., Vardhan, M., Namirembe, S., Catacutan, D., Kerr, J., Minang, P. A., Tomich, T. P., 2012b. Payments for environmental services: evolution toward efficient and fair incentives for multifunctional landscapes. Annu. Rev. Environ. Resour. 37, 389-420.

Vatn, A., 2010. An institutional analysis of payments for environmental services. Ecol. Econ. 69, 1245–1252.

Villamor, G. B., Le, Q. B., Vlek, P. L. G., Noordwijk, M., 2011a. Payments for agro-biodiversity: An analysis of participation in Jambi's conservation agreements for rubber agroforests, (Sumatra) Indonesia. 13th Annual BIOECON Conference on Resource Economics, Biodiversity Conservation and Development. Geneva.

Villamor, G. B., van Noordwijk, M., 2011b. Social Role-Play Games Vs Individual Perceptions of Conservation and PES Agreements for Maintaining Rubber Agroforests in Jambi (Sumatra), Indonesia. Ecol. Soc. 16.

Villamor, G. B., 2012. Flexibility of multi-agent system models for rubber agroforest landscapes and social response to emerging reward mechanisms for ecosystem services in Sumatra, Indonesia Bonn: University of Bonn Press, 181.

Villamor, G. B., Le, Q. B., Djanibekov, U., van Noordwijk, M., Vlek, P. L. G., 2014a. Biodiversity in rubber agroforests, carbon emissions, and rural livelihoods: An agent-based model of land-use dynamics in rural lowland Sumatra. Environ. Model. Softw. 61, 151-165.

Villamor, G. B., van Noordwijk, M., Djanibekov, U., Chiong-Javier, M.E., Catacutan, D., 2014b. Gender differences in land-use decisions: shaping multifunctional landscapes? Curr. Opin. Environ. Sustainability 6, 128-133.

Villamor, G. B., Akiefnawati, R., van Noordwijk, M., Desrianti, F., Pradhan, U., 2015. Land-use change and shifts in gender roles in central Sumatra, Indonesia. Int. For. Rev. 17, 1-15.

Wulan, Y. C., Budidarsono, S., Joshi, L., 2008. Economic analysis of improved smallholder rubber agroforestry systems in West Kalimantan, Indonesia-implications for rubber development. Sustainable sloping lands and watershed management conference. Luang Prabang, Lao PDR.

Table 1. Descriptive statistics of farm households (n = 95)

Variable	Mean	Standard deviation	Min	Max
Age	44	12.64	23	75
Household size	4.77	1.61	2	9
Labor availability	3.34	1.56	1	8
Gross income (USD/year)*	4,476	6,634	1.54	41,582

Note: * at the time of writing (1 USD = 9,900 rupiah); gross income from crop production.

Source: Villamor (2012).

Table 2. Averaged over 40 years the carbon (C) emission and storage, and rewards and tax for provision or decrease of ecosystem services stemming from the land of landlord.

Scenarios	Carbon emissions, tC		Carbon storage, tC		Rewards (+) and tax (-) for provision or decrease of ecosystem services	
	Mean	SD	Mean	SD	Mean	SD
Business-as-usual	302	13	0	0	0	0
Eco-certification	302	13	0	0	0	0
Carbon	287	13	91	0	12409	2
Pigovian tax	270	12	0	0	-29694	1315
Combined	253	11	173	0	8595	822

Note: the discount rate is 12%; tC is the ton of carbon; SD is the standard deviation.

Table 3. Summed over 40 years tenant's working days at landlord and revenues from the sharecropping arrangement.

Scenarios	Tenant work at landlord, days year^{-1}		Tenant revenues from sharecropping, USD	
	Mean	SD	Mean	SD
Business-as-usual	1023	75	6694	2029
Eco-certification	1023	75	6686	2009
Carbon	1002	74	6349	2023
Pigovian tax	1014	74	7050	1895
Combined	930	69	5481	1958

Note: tenant revenues were discounted under the 12% discount rate.

Table 4. Revenues from land use products obtained by the tenant from the sharecrop contract.

	Mean, USD	SD, USD
Business-as-usual scenario		
Rice	1118	16
Oil palm	5474	2012
Rubber from monoculture	102	60
Eco-certification scenario		
Rice	1118	16
Oil palm	5474	2012
Rubber from monoculture	94	37
Carbon scenario		
Rice	871	12
Oil palm	5378	2018
Rubber from monoculture	40	16
Rubber from agroforestry	55	20
Durian	3	3
Jengkol	1	1
Petai	1	0
Pigovian tax scenario		
Rice	1496	21
Oil palm	5553	1899
Combined scenario		
Rice	199	3
Oil palm	5137	1940
Rubber from monoculture	0	0
Rubber from agroforestry	132	47
Durian	8	8
Jengkol	2	2
Petai	3	1

Note: the discount rate is 12%; SD is the standard deviation.

Table 5. The expected and variance of the net present value (NPV) over 40 years of landlord and tenant.

Scenarios	Landlord		Tenant	
	Expected NPV, USD	Variance of NPV, USD	Expected NPV, USD	Variance of NPV, USD
Business-as-usual	166108	1025875248	7563	18522159
Eco-certification	166115	1025453427	7556	18304248
Carbon	167382	837141286	7381	17886766
Pigovian tax	137710	1013887930	7811	18264272
Combined	151285	677498994	7274	16529844

Note: the discount rate is 12%; SD is the standard deviation.

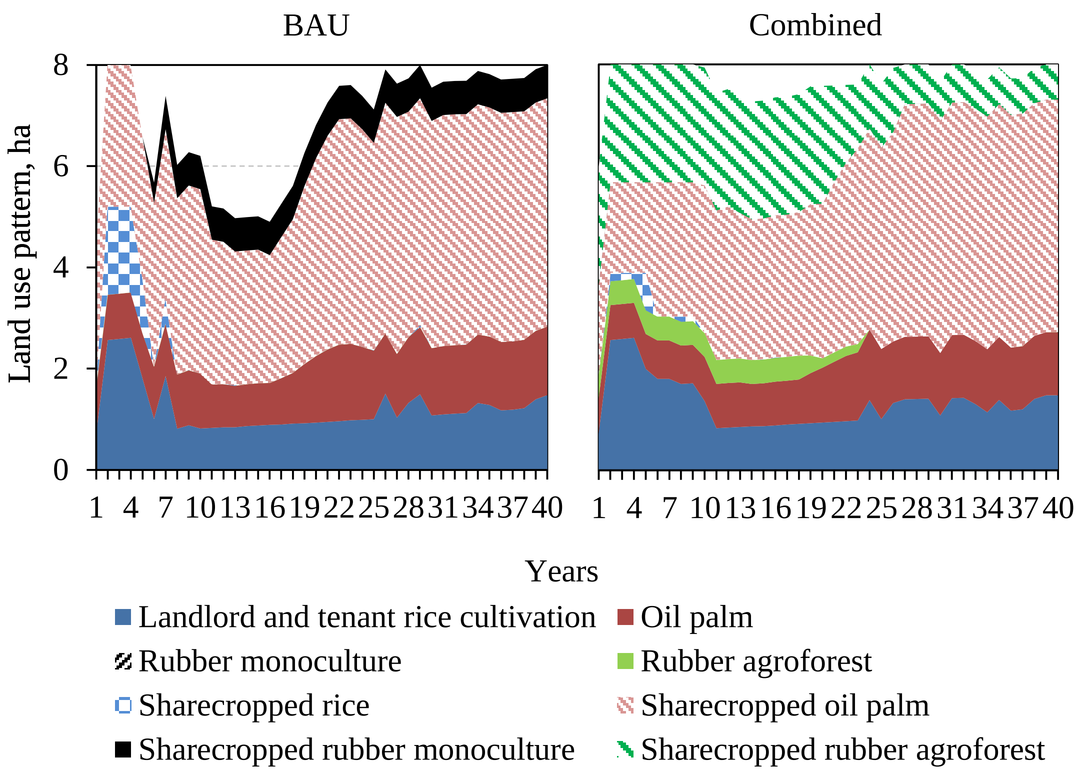

Figure 1. Land use pattern of both landlord and tenant in the scenarios of business-as-usual (BAU) and combined payments for ecosystem services (Combined) under the under the discount rate of 12%.