Impacts of the *Hutan Kamasyarakatan* (HKm) Social Forestry Program in the Sumberjaya Watershed, West Lampung District of Sumatra

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Abstract

This paper assesses the economic impacts of the *Hutan Kamasyarakatan* (HKm) social forestry program in the Sumberjaya watershed in West Lampung District of Sumatra, Indonesia, which began in 2001 to provide farmer groups permits to use already deforested state Protection Forest (PF) land in exchange for protecting remaining forests, planting timber and agro-forestry trees in their coffee plantations, and using soil and water conservation measures. The study is based on analysis of a survey conducted in 2005 for 640 plots in the watershed, selected using a stratified random sample of land of different tenure categories, and their operator households, and surveys of communities with PF land and HKm groups in the watershed. We find that HKm permit holders are poorer on average than owners of private land, but have comparable wealth to users of other eligible PF land who have not applied or received HKm permits, and users of National Park (NP) land, which is not eligible for HKm. Compared to eligible non-participants, households with a HKm permit by 2005 have greater education, are more involved in producer organizations, and have better access to markets, roads and technical assistance. Many communities and households are not aware of the program or its requirements, including some of those who in HKm groups. Program participants and applicants perceive that it substantially increases tenure security, land values, land investments, and incomes. Econometric analysis and propensity score matching methods using the survey data provide only limited support for these perceptions, showing that the program had statistically insignificant impacts on land purchase values, soil and water conservation investments, soil fertility management practices, and profits. The program did significantly increase planting of timber and multi-purpose agroforestry trees, but these have offsetting impacts on profits, with multi-purpose trees contributing to higher profits and timber trees causing lower profits because timber harvesting is not allowed. These findings indicate that the program has potentially important pro-poor benefits, though realization of these benefits is limited by potential beneficiaries' lack of access to necessary human and social capital, markets and technical assistance; lack of awareness about the program; and program restrictions that require planting of timber trees but prohibit timber harvesting.

In 2000, the government of Indonesia initiated a new social forestry program, called *Hutan Kamasyarakatan* (HKm), which provides farmer groups licenses to continue farming on deforested state protection forest (PF) land in exchange for provision of environmental services. This program marked a radical departure from the Suharto era policies towards agricultural use of state forest land, when farmers were forcibly evicted from such lands, and in many cases their coffee trees were uprooted. Such efforts were largely unsuccessful in providing lasting protection or restoration of forest areas, which were subsequently ravaged by fires and illegal encroachments.

The HKm program is an innovative example of using increased tenure security as a mechanism to provide rewards for environmental services (RES). The impacts of this approach are not yet known. The purpose of this study is to assess such impacts, focusing on a case study of HKm implementation in the Sumberjaya watershed of the West Lampung District on the island of Sumatra.

The HKm Program

The objective of the HKm program is to empower local communities to practice sustainable forest management, in order to sustain forest functions and the environment and to improve social well being. Under the program, groups of households in local communities may apply for licenses for managing state forest land. To obtain a license, groups must establish internal regulations to ensure management of the forest area according to several requirements. In West Lampung district, Forest Department (FD) officials have interpreted these requirements as being satisfied if groups protect remaining natural forest, plant non-coffee trees (at least 400 non-coffee trees per hectare) as part of a multi-strata agroforestry system and use appropriate soil and water conservation (SWC) measures in cultivated forest areas.

HKm licenses can be provided in two stages; first a provisional license for up to five years, followed by a definitive license valid for up to 25 years and extendable. For approval of a definitive license, the group must obtain formal legal status as a cooperative and must demonstrate adequate performance of its management plan and adherence to regulations during the period of provisional license. As of June, 2006, no definitive licenses had yet been issued to any HKm groups in the study site of Sumberjaya watershed, West Lampung District, although the first provisional licenses had been provided in 2001.

The Study Site: Sumberjaya Watershed

The Sumberjaya watershed was selected for this study because it is the site of intensive study of prospects for RES approaches by the World Agroforestry Centre (ICRAF), and because it is a location where the HKm program has been implemented since 2001 with support from ICRAF and local non-government organizations (NGOs).

The Sumberjaya watershed is located in the West Lampung District of southern Sumatra (figure 1). An estimated 60,000 people live in this watershed, which has an average population density of about 150 persons per square km. The watershed is very mountainous, with about 40% of the land area classified as Protection Forest (PF), 10% in a National Park (NP), and the remainder private land. Nevertheless, only about 10% of the area is forested, as most of the PF and NP land has been deforested. The primary use of sloping land (mostly PF and NP land) is for coffee production, while paddy is the main use of flatter private lands at lower elevations. Other land uses include shrub or fallow land, and other annual crops besides rice, such as vegetables.

Sumberjaya has been inhabited since the late 19^{th} century, when Sumendo people from nearby areas first settled in the area and practiced shifting cultivation. The development of Sumberjaya started in 1951 with the national transmigration program in which people from the densely settled island of Java were moved to different islands. Sumberjaya's three main ethnic groups are Javanese and Sundanese (both from Java) and Sumendo (from southern Sumatra).

In the 1980s, as coffee prices rose, coffee plantations spread to PF and NP areas in the watershed. In the early 1990s the Suharto government forcibly evicted people from much of the PF area. Upon eviction, many local people retaliated by burning the remaining vegetation. In the late 1990s the convergence of several factors led settlers to return to the areas from which they had been evicted. The Asian financial crisis left many people jobless, the world price of coffee rose sharply due to production problems in Brazil, and the Suharto government fell, replaced by a new, reform-oriented government. The new government introduced a reform program which aimed to be more decentralized and people-friendly. The HKm program was subsequently adopted to encourage greater security and empowerment of local communities in managing forest lands.

By mid-2006 the area under HKm was very small. The first contracts in West Lampung District were signed in 2001 in Sumberjaya; with around 10 in force (6 in Sumberjaya) by June 2006. Out of about 40-50,000 ha eligible state forest area in the district, only about 2000 ha was under HKm agreements by June 2006, with an additional 13,000 ha in Sumberjaya in the process of applying for HKm. Nationwide, the total area under HKm was only 50,644 ha by June 2006.

Research Approach and Methods

Data sources

We investigate the impacts of the HKm program in Sumberjaya watershed using data collected from community, group and household interviews. Community and group level interviews were conducted with village leaders and other village representatives using a semi-structured format, focusing on the processes that determine how communities learn about the program, form into groups to apply for the program, go through the application process, obtain the license, and carry out their responsibilities, and the group members' expectations about impacts of the program. The community survey was conducted in all of the villages in Sumberjaya watershed where there is protection forest (21 of the 29 villages in the watershed). The group survey was conducted with all of the groups that have obtained HKm permits or are applying for HKm permits, and subgroups within the HKm groups. By the time of the survey in 2005, 29 groups had formed for HKm permits, of which 6 had obtained the permit, 2 had formally applied, 9 had begun preparing the application but had not yet submitted it, and 12 were just beginning the process.

The household survey was conducted with operators of plots randomly selected using an area-based sample frame that included eight different strata (figure 2): 1) private land; 2) National Park land;

3) and 4) PF land with a HKm permit (with and without past evictions); 5) and 6) PF land with a HKm permit application in process (with and without past evictions); and 7) and 8) PF land eligible for HKm where no application has been made (with and without past evictions).

Separate strata were included for private and NP land, for HKm land with a permit and where a permit was in process, and for PF land with or without past evictions, because these different scenarios may result in differences in tenure security and hence in farmers' incentive and ability to invest in planting trees and in SWC measures. We expect private land to be the most secure and NP land to be the least secure, while land without a past eviction is expected to be more secure than land with a past eviction, and land with a HKm permit is expected to be more secure than land with a permit in process, which is expected to be more secure than NP land where no application for a permit has been made.

In all cases, only cultivated or shrub land in sloping areas was included in the sample frame; no paddy or natural forest land was included. 80 points were randomly selected from each stratum, and the plot including those points was identified by key informants. The operator of that plot was interviewed using a household survey, which collected information on household demographic composition, education, assets, participation in HKm and other programs and organizations. For the selected plots, information was collected on tree planting and cutting, investments in SWC measures, use of land management practices and inputs and production. In addition, measurements were taken of various plot characteristics, including plot area, altitude, slope, slope length, position on the slope, topsoil depth, soil color, soil texture, and distance of the plot to the farmers' residence and to the nearest road.

Conceptual Framework

The conceptual framework draws upon the framework of Feder, et al. (1988) regarding the impacts of increased tenure security on land investments, augmented to consider also the investment requirements of the HKm program (figure 3). The HKm program may increase farmers' incentive to invest in land improvements through several mechanisms. It may increase farmers' incentive to invest in PF land by increasing their tenure security (linkages 1 and 4 in Figure 3). By increasing tenure security, the value of PF land may increase, which may further increase farmers' investment incentives (linkages 3 and 5) by increasing the return to such investments (if the value of such investments is capitalized into land values).[1] To the extent that farmers' incentives to invest are increased, both prescribed investments (e.g., planting non-coffee trees, SWC measures) and non-prescribed investments (e.g., planting coffee trees, use of compost and fertilizer) may increase (linkages 6 and 7). In addition, the requirements of the HKm program, if enforced, will tend to increase prescribed investments (linkages 2 and 8). The impact of these increased investments, if such investments are profitable to farmers, should be to increase farmers' production, profits and income, as well as providing environmental services (linkages 9 and 10).

Analysis

Assessment of the impacts of the HKm program is based on this conceptual framework. We investigate the different linkages in figure 3 using descriptive analysis of farmers' perceptions as well as econometric analysis and propensity score matching, controlling for various potentially confounding factors.

We investigate these linkages first by considering farmers' awareness and perceptions of the HKm program. We then investigate the extent to which program participants think it affects tenure security and land values, as well as assessing impacts on actual land sale values using an econometric hedonic land price regression. We investigate the impacts of the program on land investments and land management practices and on profits using econometric regressions and propensity score matching. We also investigate the potential distributional impacts of the program by analyzing the characteristics of the people who participate or not in the program. Impacts on the sustainability of resource use and environmental indicators are investigated in other research.

Specification of the econometric models used and issues addressed is discussed in the particular sections below where these models are used.

Results

In this section we discuss the results of the community and household surveys with regard to the issues

[1] We do not consider the impact of increased tenure security on the collateral value of land and farmers' access to credit, as in Feder, et al.'s framework, because PF land may not be used as collateral for loans.

highlighted in the conceptual framework. We review evidence on the characteristics of who is participating in the HKm program, their awareness of the program and its requirements, and the impacts of the program on tenure security, land values, investments in tree planting, soil and water conservation (SWC) measures and other land management practices, and on profits at the plot level.

Potential Impacts on Poverty: Who Participates in HKm?

Operators of plots with a HKm permit or HKm application pending tend to be poorer than owners of private land. For example, the mean value of land owned in 2000 was about 23 million Rupiah for operators of HKm permit plots and 18 million Rupiah for operators of plots with a HKm application pending, compared to 42 million Rupiah for owners of private plots (table 1). The value of buildings, equipment and livestock owned was also much larger for owners of private plots.

Although poorer than owners of private plots, operators of HKm plots have comparable wealth to that of operators of PF plots who have not applied for a HKm permit and operators of NP land. Thus, HKm appears targeted towards poorer households because of the nature of the households using PF land, while differences in wealth among such households appear not to be responsible for determining who obtained access to the program by 2005. We investigate this issue further below.

There are also differences between operators of different types of land in terms of ethnicity, age of the household head, family size and dependency, length of residence in the village, access to social capital, markets, infrastructure, credit and technical assistance, as shown in table 1. For example, owners of private land tend to be the oldest and longest settled in the village, and have the best access to markets, formal credit, and technical assistance from the Agriculture Department. Households with a HKm permit are more likely to be of the Sundanese ethnic group, have been settled in the village longer, and tend to have more education, greater involvement in coffee producers' and labor sharing groups, and better access to the nearest output market and to technical assistance from the FD, ICRAF and NGOs, compared to users of PF land without a HKm permit and users of NP land. These differences suggest that access to education, markets, technical assistance and social capital are important factors enabling the early participants in the HKm program to organize and obtain access to the program.

There are also differences across plot tenure types in how the plots were acquired and in their quality. Purchasing is the most common way that current operators acquired access to plots of all tenure types, but especially for NP and private plots. Inheritance is the second most common means of plot acquisition, except for NP plots, which probably have been occupied more recently than others. Past evictions affected nearly a third of plots with a HKm permit, and smaller shares of plots with a HKm application pending or no application. Apparently the experience of a past eviction encouraged recipients of HKm permits to apply earlier than other land users. Nevertheless, the experience of having trees uprooted in a prior eviction was most common on plots where a HKm application is still pending. Surprisingly, past evictions were reported on 10% of plots classified as private plots. This may reflect some lack of agreement between farmers and the government about which plots are actually private plots.

Land quality differs among the different tenure categories, with NP and PF plots generally on steeper slopes and at higher elevation than private plots. Initial conditions also differ among the tenure types, with PF plots more likely to be fallow or shrub plots prior to HKm than private or NP plots, while the average number of coffee trees in 2000 was highest on HKm permit plots. It is not clear that the quality of soils on private plots or any other tenure category is generally superior to the other categories. Below, we test for the impacts of such differences in determining HKm permit status and control for such differences in testing for the impacts of HKm.

Awareness of HKm program and its requirements

Among operators of plots with a HKm permit, nearly 20 percent were not aware of the permit. This proportion was slightly higher for HKm plots where no evictions had occurred in the past, possibly because operators of such plots are less concerned about tenure insecurity. Consistent with this, we also find that among plots for which a HKm permit application was pending, a larger proportion of those where no past eviction had occurred were unaware of the application than those where a past eviction had occurred. In both cases, however, more than 50% of the operators were unaware of the HKm application.

These results are consistent with findings of the HKm group survey reported by Kerr, et al. (2006), which show that many HKm applicants and permit holders are not fully aware of the requirements of the program. That survey found that although nearly all groups were aware of requirements to protect remaining natural forest, more than half of the groups that had applied for HKm permits were unaware of the composition of trees required by the program, and a significant fraction were not aware of soil and water conservation (SWC) requirements. Awareness of such requirements was substantially higher among groups that actually have a HKm permit, although a few groups were not fully aware of the tree composition and SWC requirements (Ibid.).

The lack of program awareness, even among permit holders, suggests that there are problems of inadequate information dissemination within HKm groups, especially prior to receipt of a permit. Land users are much better informed about HKm once their group has a permit, but still a significant proportion are unaware of the program. The group-based nature of HKm agreements may be partly responsible for this, since even farmers who do not fully understand the program can be involved in a group and perhaps benefit from the RES mechanism. This is in contrast to programs based on individual participation, of which potential beneficiaries must be informed in order to benefit. Nevertheless, such lack of awareness can undermine achievement of the objectives of the program.

Impacts on Tenure Security

Respondents in the community survey reported their perceptions concerning tenure security on PF land, expressed as a percentage of the security of private land, before and after the reforms began in the late 1990s, and at present with and without a HKm license. Their responses suggest that the reform policies in general and the HKm program have had substantial positive impact on perceived tenure security on PF land, with security increasing from less than 20% of private land prior to the reform period to 30-40% immediately after the reforms began, to more than 40% by 2005 if applying for a HKm license, 70-80% with a provisional license, and nearly 90% (hypothetically) if a definitive 25 year license were granted.

Similar results were found in the household survey, in which operators of plots with a HKm permit were asked to rate tenure security of these plots. According to these respondents' perceptions, both the reform and the HKm program have had a major impact in increasing tenure security on PF land, with an average increase in perceived security of 20 percentage points after the beginning of the reforms and an additional 26 percentage points after the HKm permit was obtained. The perceived impacts of both the reform policies and the HKm program were much larger on plots where there had been an eviction in the past, as perceived tenure security was much lower on these plots prior to the reforms, but was slightly higher on HKm plots with a past eviction than on HKm plots without a past eviction.

These results suggest that the HKm program has had a major impact on the tenure security of farmers using PF land, especially for those who experienced evictions in the past. Next we investigate whether this has translated into higher land values.

Impacts on Land Values

Consistent with the perceptions about impacts of the reform policies and the HKm program on tenure security, respondents in the community survey perceived that values of PF land increased dramatically after the reforms began in 1998 and, although reported average prices had fallen by 2005 for PF land without a HKm license (probably due largely to the decline in coffee prices between 1998 and 2005), expected prices in 2005 were substantially higher for plots with a HKm license. If plots had been subject to a definitive HKm 25 year license, the expected price would be about double the price without a HKm permit.

Data from the household survey on actual purchase prices of plots acquired through purchase tell a more mixed story. PF plots purchased since 1998 had an average price about one-fourth of the price of private plots purchased during this period, while the price of plots with a HKm license was slightly higher than PF plots without a license (table 2). Surprisingly, however, the price of PF plots was lower even than plots purchased in the National Park. These results are less supportive of the view that tenure security increased dramatically as a result of the HKm program, although they suggest some positive impact of the program on land tenure security and hence land prices. Part of the discrepancy may be due to differences in the quality of purchased PF plots relative to other purchased plots. Furthermore, the impact of an HKm permit on land values at the time of purchase of plots may have been less than the impact after people have become more familiar with the program. To address these issues, we use a hedonic regression to control for other factors expected to affect the price of land.

The regression specification for determinants of land prices is as follows:

1) $\ln(P_{pt}) = \beta_0 + \beta_t \ln(t) + \beta_T T_{pt} + \beta_X X_{pt} + u^P{}_{pt}$

where P_{pt} is the purchase price of plot p purchased in year t, T_{pt} is a vector of dummy variables reflecting the tenure and HKm status of the plot at the time of purchase, X_{pt} is a vector of quality characteristics of the plot, β_0, β_t, β_T, and β_X are vectors of parameters to be estimated, and $u^P{}_{pt}$ is an error term reflecting unobserved factors affecting land prices. The tenure variables (T_{pt}) include whether the plot was private, NP, or PF land with a HKm permit at the time of purchase (PF land without a HKm permit is the excluded category), whether there were any evictions from the plot in the past and if so, whether trees were uprooted. The plot quality characteristics (X_{pt}) include the area and average altitude and slope of the plot; the position of the plot on the slope (whether on top, middle, bottom of the slope, or some combination); the topsoil color (black, brown, red, or yellow), texture (clay, loam, sandy, or some combination), and depth; the access of the plot to the village center, the farmer's residence and to roads and pathways (walking time to each); and the types of trees on the plot at the time of purchase (mature coffee monoculture, mature coffee with shade trees, mature coffee with timber trees, mature coffee with fruit trees, mature coffee in a mixed multi-strata agroforestry system, young (pre-harvest) coffee, defective (unhealthy) coffee, and bushes or shrubs. Logarithmic transformations of all continuous explanatory variables (year of purchase, plot area, mean altitude and slope, soil depth, and walking time to the village, residence, road and footpath) were used to reduce problems of nonlinearity in residuals and outliers (Mukherjee, et al 1998).

We expect that HKm permit plots should be worth less than private plots, more than PF plots without an HKm permit, and more than NP plots, as a result of having less tenure security than private plots but more security than PF land without HKm or NP land. We expect that past evictions and uprooting of trees during evictions will reduce the value of land by increasing the perception of tenure insecurity. Irrespective of its impacts on tenure security, uprooting of trees also can reduce the value of land by reducing the stock of valuable trees, though this should be reflected in the effects of the tree stocks. We expect that plots with mature healthy coffee will be more valuable than plots with young coffee, defective coffee, or bush and shrubs. Other land quality characteristics such as altitude, slope and soil type may affect land quality to the extent that these characteristics affect the productivity of the plot. Better access of the plot to town, roads and the farmer's residence are expected to increase plot value.

Three regression models were used: ordinary least squares (OLS) estimation, OLS including village level fixed effects (FE), and instrumental variables (IV) estimation. OLS estimation may be subject to bias if the error term is correlated with any of the explanatory variables, perhaps because of omitted or because some of the explanatory variables may be endogenous (particularly the HKm permit status of the plot). The problem of potential omitted variable bias was addressed by including village level fixed effects, which controls for any unobserved factors that differ across villages. The potential endogeneity problem was addressed by estimating an IV model, instrumenting for the HKm permit status of the plot. We could not estimate the IV model with village fixed effects because all of the instrumental variables are village level variables. However, using village fixed effects helps to control for components of the error term that could be correlated with the endogenous regressor, helping to address any endogeneity bias.

The instrumental variables used to predict the HKm status, in addition to the other plot quality characteristics, included several village level indicators of bridging social capital collected in the community survey (whether a FD official lives in the village, whether anyone in the village has friends in the Forest Department, whether other government officials live in the village, whether anyone in the village is friends with anyone from Watala (a NGO providing promotion and technical assistance for the HKm program), whether anyone in the village works for any other NGO, or whether anyone in the village is friends with someone from any other NGO). These indicators were selected as instrumental variables because such bridging social capital indicators are associated with participation in the HKm program (Kerr, et al. 2006), but are not expected to affect land values directly, controlling for participation in the HKm program and plot quality characteristics.

The regression results are reported in Table 2. We omit the coefficients of many of the plot characteristics in Table 2, to save space and to focus on the impacts of land tenure and tree stocks. The OLS model fits the data well, explaining 69% of the variance in land values. A test for non-linearity in the regression residuals (the Ramsey RESET test) did not reveal any significant problem, and inspection of the graph of the residuals vs. fitted values supports this.[2] The maximum variance inflation factor (VIF) for the explanatory variables was 6.6, and the rest were less than 5, indicating that multicollinearity is not a major problem in this regression (Mukherjee, et al. 1998).

In the FE model, the explanatory power was significantly greater (explaining 79% of the variance), and a Wald test for the joint significance of the village effects was significant (p-level of 0.0559). These results provide some support for preferring the FE model. However, the FE model is beset by serious problems of multicollinearity, which undermines the ability to identify the impacts of variables such as tenure status on land values.[3]

In the IV model, tests of the instrumental variables show that they are relevant (i.e., the excluded instrumental variables are strong predictors of the HKm permit status variable as shown by the partial R^2 of the excluded instruments and Anderson's canonical correlation LR test) and support the assumption that they are exogenous and valid to exclude from the regression (i.e., the Hansen's J test of overidentification restrictions is statistically insignificant) (Baum, et al. 2003; Davidson and MacKinnon 2004). A C test of the exogeneity of the HKm permit status supports the assumption of exogeneity (i.e., the test statistic is statistically insignificant). These results support the validity of the IV model, but indicate that the OLS model is preferred, since HKm status is statistically exogenous and the OLS model is more efficient.[4]

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[2] By contrast, a linear version of the model (using untransformed versions of the dependent and continuous explanatory variables) showed serious non-linearity in the residuals, and failed the Ramsey RESET test.
[3] In the FE regression, the maximum VIF is greater than 90, the VIF is greater than 10 for many variables, including two of the land tenure variables (National Park and Private land), and the VIF for HKm permit status increased to nearly 4, compared to a VIF of 1.45 in the regression without fixed effects.
[4] OLS is generally more efficient than IV estimation, but this is particularly true in this case since many observations are lost in the IV model due to lack of availability of the instrumental variables for plot owners who live outside of the watershed.

None of the regression results shows a statistically significant difference in land values between PF land with a HKm permit and such land without a permit, controlling for plot quality, year of purchase and other factors. In all regressions, NP land has a higher value than PF land, although this result is statistically significant only in the IV model. As expected, private land has a much higher value than PF land in all regressions, although this result is not statistically significant in the FE model. The lack of significance of this coefficient in the fixed effects regression is probably due to high multicollinearity.

Past evictions have a negative association with land values in all regressions, as one would expect, although the association is statistically significant only in the IV model. Whether trees were uprooted in a past eviction has a weakly statistically significant (at 10% level) negative impact only in the FE model. It appears that whatever impact past evictions may have had on tenure security when it occurred, the effect of this on land values was attenuated by 1998.

Of course, uprooting trees can also influence the value of land by affecting the stock of trees on the plots. In all of the regressions, we find that plots covered with bush or shrubs are worth substantially less than plots having mature coffee stands. For example, the coefficient of -1.434 of bush and shrub land in the OLS regression in Table 1 implies that, controlling for other factors, bush and shrub land is worth only about 24% ($e^{-1.434} = 0.238$) of the value of plots having mature coffee. Thus, uprooting of trees had a major negative impact on the wealth of some users of PF land, even if the tenure insecurity of this was mitigated by the reforms. As one would expect, plots with defective stands of coffee are worth less than those with mature healthy coffee (in all models). We also find some evidence that farmers value plots with multi-strata coffee-agroforestry systems less than coffee monoculture, with a negative coefficient of this variable in all regressions, although it is (weakly) statistically significant only in the fixed effects regression. Nevertheless, this suggests that farmers may perceive that multi-strata coffee-agroforestry systems result in economic tradeoffs. We investigate this issue further below in assessing the determinants of plot level profitability.

These results do not support the hypothesis that the HKm program has increased land tenure security and hence land values, although they do demonstrate the greater tenure security and value of private tenure. The finding of higher value of NP than PF land (though significant only in the IV regression) was unexpected, and suggests that use restrictions are not well enforced on the NP land, resulting in tenure being at least as secure on that land as on PF land. Although HKm has not clearly improved land tenure security and land values, to the extent that it prevents future efforts to uproot trees it will help to prevent future losses in wealth of HKm permit holders. Furthermore, HKm still may have impacts on tree planting and SWC investments as a result of enforcement of the requirements of HKm licenses. We investigate this in the following sections.

Impacts on Tree Planting

The estimated mean number of trees per hectare planted between 2000 and 2005 for coffee, timber trees, multi-purpose trees, and shade trees for each tenure category are shown in table 1. According to these estimates, the most trees were planted on plots with a HKm permit, with coffee trees being most commonly planted, followed by multi-purpose and timber trees. The mean number of coffee trees planted was greater on private plots than other (non-HKm permit) PF plots and NP plots, while planting of timber and multi-purpose trees was greater on plots with a HKm application pending than other (non-HKm permit) plots. Consistent with our expectations, tree planting was least common on PF plots without a HKm permit or application and NP plots.

Coffee planting has been greatest on plots with a HKm permit or HKm application in process where there was an eviction in the past, and least on HKm plots where was no past eviction. Apparently farmers are planting coffee in response to past evictions, and the HKm process may be facilitating this.

Timber trees are the least common type of trees in all strata. The lowest stocks of timber trees and least amount of planting occurred on NP, private land, and PF land without a HKm license or application pending but with a past eviction. It thus appears that the HKm process is promoting timber tree planting. However, most of the increase in timber stocks has occurred since 2003, when the GNRHL reforestation program began to be implemented. This program provides farmers seedlings of timber and other non-coffee forest trees, along with incentives for planting. Given the timing of tree planting activities, it appears that the GNRHL program has had a larger effect than the HKm program in promoting planting of timber trees, since all of the HKm permits that have been received in the Sumberjaya watershed were issued by 2002.

The situation is similar for multi-purpose trees. Planting of these trees has been greatest on plots with a HKm permit or a HKm application in process, with or without a past eviction. As with timber trees, however, most planting of multi-purpose trees has occurred since 2003, coinciding with the GNRHL program.

The stock of shade trees is largest and planting has been greatest on plots with a HKm application in process or a HKm permit, where there was a past eviction. The pattern of shade tree planting is more even over time, probably because shade trees are associated with coffee planting where shade coffee is grown, and because the GNRHL program does not promote shade trees.

Evidently differences in tree planting may result from differences in past evictions, the stock of trees already on the plot, and other programs such as GNRHL, as well as from differences in land tenure and HKm status. It is important to control for differences in such factors to be able to assess the impacts of HKm on tree planting. We do this next using econometric analysis of the tree planting data.

The model for tree planting is of the following form:

$$\text{2)}\quad \begin{aligned} &TP_{pt05} = TP*_{pt05} \equiv \delta_0 + \delta_T T_{pt05} + \delta_X X_{pt0} + \delta_G GNRHL_{pt05} + \delta_Z Z_{ht0} + u^{TP}{}_{pt05} \; if \; T*_{pt05} > 0, \\ &and \; TP_{pt05} = 0 \quad otherwise \end{aligned}$$

where TP_{pt05} is a vector representing the number of trees planted per ha of different types (coffee, timber, multi-purpose trees and shade trees) between 2000 and 2005; $TP*_{pt05}$ is an index function indicating the demand for tree planting (which equals TP_{pt05} when this is positive, but which results in zero tree planting otherwise); T_{pt05} represents the tenure and HKm status of the plot during the 2000 – 2005 period; X_{pt0} represents the quality characteristics and stocks of trees on the plot in 2000; $GNRHL_{pt05}$ is a dummy variable representing whether assistance was available under the GNRHL reforestation program for the plot during 2000 - 2005; Z_{ht0} represents household level factors (as of the year 2000) affecting the household's incentive and ability to invest in tree planting; δ_0, δ_T, δ_X, δ_G and δ_Z are vectors of parameters to be estimated; and $u^{TP}{}_{pt05}$ is an error term assumed to be normally distributed with zero mean.

The vector of tenure and HKm variables (T_{pt05}) is similar to that used in equation (1), except that it reflects whether a HKm permit had been obtained or applied for by 2005, rather than only HKm permit status at the time of purchase, and includes dummy variables representing how the plot was acquired (i.e., by inheritance, purchase, sharecropping or exchange (encroached plots are the omitted category), since we are considering more than just purchased plots in this case. We expect that having an HKm permit or having applied for an HKm permit should increase investment in tree planting in general if this has increased land tenure security. HKm status may also increase tree planting because of the requirement to plant a minimum number of non-coffee trees (mainly timber and multi-purpose trees) per hectare. If these requirements, rather than increased tenure security, are the main cause of increased tree planting, we would not expect as much impact of HKm status on planting of coffee or shade trees as on timber and multi-purpose trees. Past evictions may reduce the incentive to plant trees if they increase perceived tenure insecurity on the plot.

The plot quality characteristics (X_{pt0}) are also similar to those used in equation (1), except that the land use (if not planted to trees), whether the plot had been cleared, and the estimated stocks of the different types of trees in 2000 are used as indicators of the initial state of the plot, rather than dummy variables for the tree types on the plot at the time of purchase. We expect that greater initial stocks of trees is likely to reduce subsequent tree planting investment, unless there are complementarities between investments in different types of trees (e.g., between coffee and shade trees).

The household level factors influencing the household's incentive and ability to invest in trees include its endowments of physical, human, natural, financial and social capital in 2000, and access to technical assistance during 2000-05. The indicators of these endowments include the value of land of different types owned by the household (paddy land, coffee land, other land); the value of livestock, transportation equipment, other equipment and buildings owned by the household; the age, gender, occupation (whether agriculture is the primary occupation), and ethnicity of the household head; the household size and dependency ratio; the mean number of years of education of males and females; the number of years the household had been settled in the area by 2000; whether any household members participated in a coffee producers' group or labor sharing group; the distance from the household residence to the nearest output market; whether the household had access to formal sector credit; and access of the household to technical assistance from the Forest Department, the Agriculture Department, or ICRAF. To save space and to focus on the impacts of the tenure and tree stocks variables, we do not report or discuss below the coefficients for household characteristics or other plot level variables.

The econometric model used to estimate equation (2) is a maximum likelihood tobit censored regression model.[5] As in estimation of equation (1), we tested the model with and without village fixed effects. In all cases (except for timber tree planting, for which the fixed effects model did not converge) we found that the village fixed effects coefficients were highly statistically significant, indicating that the fixed effects model was the better model. Thus, we report only the results of the fixed effects models (except for timber tree planting). The test for multicollinearity revealed that the maximum VIF in the regressions with fixed effects was 8.6, considered in econometrics textbooks to be within the acceptable range (e.g., Mukherjee, et al. 1998), although higher than for the model without fixed effects (maximum VIF = 4.4 in that model). Except for the village intercept coefficients in the fixed effects model, few variables have VIF greater than 5 (only the tenure variables for private and HKm application in process, and the altitude of the plot). Thus, for most variables, the level of multicollinearity appears to be acceptable even with fixed effects included, although the ability to identify impacts of some variables with statistical confidence is impaired in this model.

We also tested for exogeneity of the HKm permit status (whether received or applied for) using the exogeneity test of Smith and Blundell (1986) for censored regression models. The same instrumental variables used to predict HKm status in estimating the IV model for equation (1) were used as instrumental variables for the HKm status variables in the exogeneity tests for equation (2). In all cases the test supports exogeneity of these variables.

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[5] We also attempted to estimate equation (2) using censored quantile regressions, which are robust to violations of distributional assumptions. However, we were unable to obtain convergence of these regressions at quantile levels below 95%, and thus could not gauge the robustness of this approach. We therefore report only the tobit results.

The econometric results are reported in table 3. We find that timber tree planting between 2000 and 2005 was greatest on PF plots with a HKm permit or a HKm application pending, controlling for other factors. Planting of multi-purpose trees was greater on all kinds of tenure compared to NP land, but largest on plots with an application for a HKm permit pending. Planting of shade trees is also greater on plots with a HKm permit application pending than on NP land, although this difference is only significant at the 10% level. We find no significant differences in coffee planting on plots of different tenure and HKm status.

These results, combined with the results of the land value regressions, suggest that the impacts of the HKm program on tree planting may be due to the tree planting requirements of the program, rather than its impact on tenure security. If the program's impacts were due primarily to increased tenure security, we would expect to also find significant impacts of the program on planting of trees not specifically required by the program, such as coffee.

Consistent with this explanation, we find that past evictions have insignificant impacts on tree planting, suggesting that tenure insecurity associated with past evictions is not having a large differentiated impact on HKm vs other plots. However, we do find that planting of timber, multi-purpose and shade trees was significantly greater on plots where trees were uprooted. This may be because farmers believe planting such trees will help to increase their tenure security.

As expected, the GNRHL program has a positive impact on planting of multi-purpose trees. We do not find a statistically significant impact of GNRHL on planting of other types of trees.

The stock of trees on the plot in 2000 has significant impacts on subsequent tree planting, as expected. Surprisingly, however, greater initial stocks of timber, multi-purpose and shade trees are associated with higher subsequent investment in each of these types of trees (but the result is only weakly significant for shade trees). For coffee, by contrast, we find that coffee planting is lower on plots with larger initial coffee stocks (result weakly significant). The differential impacts of initial tree stocks on subsequent planting may be because for coffee, farmers are already well aware of the benefits of coffee planting and plant only when the stocks are relatively low. For other types of trees, farmers generally plant few of these types of trees, and may be more prone to plant if they have already planted some of these and become more aware of how to manage them and what their benefits are. There are also apparently positive interactions between several different types of trees, or perhaps a tendency of some farmers to diversify their stock of trees. For example, farmers with more multi-purpose trees in 2000 subsequently planted more timber and coffee trees. Farmers with more coffee trees in 2000 planted more timber and multi-purpose trees (weakly significant in both cases) subsequently.

Next we investigate the impacts of the HKm program on farmers' investments in land improvements and use of land management practices.

Impacts on Land Investments and Land Management Practices

The most common land investments applied to hillside plots in the Sumberjaya watershed are sediment pits (found on about 15% of plots between 2000 and 2005), followed by land clearing and terraces (each about 6% of plots) (table 1). Annual soil fertility management practices include application of inorganic fertilizer (47% of plots) and compost (14% of plots). Investment in sediment pits was most common on private plots, followed by plots with a HKm permit. Investment in land clearing was most common on plots with a HKm application pending. Terrace investment was most common on HKm permit plots. Use of fertilizer was most common on private and HKm permit plots. Use of compost was most common on private and NP plots.

The econometric model for land investments or use of land management practices between 2000 and 2005 is given by the following:

$$\text{3)}\quad \begin{aligned} &LM_{pt05} = 1 \quad if\ LM^*_{pt05} \equiv \gamma_0 + \gamma_T T_{pt05} + \gamma_X X_{pt0} + \gamma_G GNRHL_{pt05} + \gamma_Z Z_{ht0} + u^{LM}{}_{pt05} > 0, \\ &and\ LM_{pt05} = 0 \quad otherwise \end{aligned}$$

where LM_{pt05} indicates whether an investment was made or land management practice was used between 2000 and 2005; LM^*_{pt05} is an index function determining the demand for making land investments or using land management practices; T_{pt05}, X_{pt0}, $GNRHL_{pt05}$ and Z_{ht0} are as defined in equation (2); γ_0, γ_T, γ_X, γ_G, and γ_Z are vectors of parameters to be estimated; and $u^{LM}{}_{pt05}$ is an error term assumed to be normal with a mean of zero and standard deviation of 1. Maximum likelihood estimation of equation (3) results in a probit model. As in estimating equation (2), we include village fixed effects when the model is estimable with fixed effects, and test for the significance of the fixed effects. We also test the exogeneity of the HKm status variables using the method of Smith and Blundell (1986).

The results of the probit models for land investments and land management practices are presented in table 4. We do not include regressions for determinants of terrace investment due to the small number of positive observations of this variable (32 observations), leading to unreliable results of the probit model. We find that land clearing is less common on private plots and plots without HKm than on NP land, and use of compost is less common on plots with a HKm application pending or no HKm. In general, some land management practices are more common on NP plots than we expected, suggesting that tenure security is more favorable on NP plots than we originally expected, consistent with earlier results on land values and tree planting.

As expected, past evictions have a negative impact on all types of land investment and management practices except land clearing, although the coefficient is highly significant only for compost.

The types of trees on the plot in 2000 also influenced subsequent investment and land management practices. Construction of sediment pits and use of compost was greater on plots where more multi-purpose trees were found, suggesting a complementarity between such trees and organic land management practices. Land clearing, fertilizer use and compost use were more common on plots with more shade trees, suggesting that farmers with shade coffee farm more intensively, using both purchased inputs and labor intensive practices. Plots with more coffee trees were less likely to have land clearing investments (probably because clearing was not needed) and less likely to have compost applied. This suggests that producers focused more on mono-culture coffee are less likely to use such organic practices.

On plots where GNRHL reforestation efforts occurred, land clearing was more common and use of compost was less common. Such reforestation efforts may conflict with use of organic practices and preservation of existing ground cover.

Impacts on Profitability of Land Management

Almost all HKm groups in the Sumberjaya watershed expect participation in HKm to increase their income (Kerr, et al. 2006). This is consistent with the expectations reported by individual operators of HKm plots and PF plots with a HKm application pending in the household survey, most of whom expect their income from the plot to increase as a result of HKm, and a substantial fraction of whom expect a large increase (more than 10%) in plot income. Respondents in the community survey (Kerr et al., 2006) said they expected income to increase with HKm because they would cultivate more intensively and plant more coffee and fruit trees under HKm. Some respondents further explained that increased tenure security would make them feel more confident about intensifying their cultivation.

Descriptive statistics on the mean profits per hectare from plots of different tenure and HKm status are not fully consistent with these perceptions (table 1). Mean profits are much higher on private plots than other plots, followed by NP plots, plots with a HKm application pending, HKm permit plots, and PF plots without HKm.

The econometric model for determinants of profits per hectare uses a very similar specification to equations 2) and 3):

4) $\pi_{pt} = \phi_0 + \phi_T T_{pt} + \phi_X X_{pt} + \phi_G GNRHL_{pt} + \phi_Z Z_{ht} + u^{\pi}{}_{pt}$

where π_{pt} is the profit per hectare on plot p in year t (2005 in the regression); T_{pt} is a vector of tenure characteristics of the plot; X_{pt} is a vector of quality and other characteristics of the plot; $GNRHL_{pt}$ is the access of the plot to reforestation assistance under the GNRHL program; Z_{ht} is a vector of household characteristics; φ_0, φ_T, φ_X, φ_G, and φ_Z are vectors of parameters to be estimated; and $u^{\pi}{}_{pt}$ is an error term with zero mean. The vectors of explanatory variables are very similar to those used in equations 2) and 3), except that values of assets and other time-varying explanatory variables in 2005, rather than 2000, are used. Two additional variables are included in the vector of plot level variables (X_{pt}) that were not included in earlier specifications (because these were unavailable for the earlier period); these are the percentage of organic carbon in the topsoil, which was measured using soil laboratory analysis, and the average age of coffee trees on the plot in 2005.

We estimate the model using three specifications: 1) ordinary least squares with village level fixed effects (OLS-FE), 2) median regression with village level fixed effects (Median-FE), and 3) instrumental variables regression without fixed effects (IV-No FE). We estimate the median regression with fixed effects because of concerns about outliers of the dependent variable (e.g., a substantial proportion of negative values), which may undermine the robustness of the results of OLS estimation. We estimate the IV model because of concerns about possible endogeneity of the HKm status variables, and use this model to test the exogeneity of these variables. As in earlier IV regressions, the IV model was not estimable with village fixed effects because the excluded instrumental variables used for identification are village level variables.

The results of the econometric models for determinants of profits per hectare are reported in Table 5. As in previous sections, our results support the validity and relevance of the excluded instrumental variables used to estimate the IV model, and support the exogeneity of the HKm permit and HKm application variables. Thus, OLS is preferred to IV estimation as the more efficient model, and we do not refer to the IV results in our subsequent discussion.

The results of the OLS-FE and Median-FE models show statistically insignificant impacts of HKm status on profits per hectare, controlling for other factors. Although land tenure and HKm status have limited direct impacts on profitability, these variables may have indirect impacts by influencing tree planting and other land investments, as demonstrated in previous subsections. In both the OLS and median regressions, we find that the stock of multi-purpose trees has a positive impact on profits (+1270 Rupiah per multi-purpose tree in OLS model). Since we found earlier that HKm contributes to planting of multi-purpose trees, this provides evidence of indirect positive impacts of HKm on profitability.

Since the HKm program also promotes increased planting of timber trees, and these trees are found to have a negative impact on profit in the OLS regression (-1320 Rupiah per timber tree), these negative impacts may offset the positive profit impact of HKm via its effects on multi-purpose tree planting. The negative impact of timber planting on profitability is reasonable to expect, given that timber trees can have negative impacts on coffee production by competing for light, water and nutrients, and because farmers are not allowed to harvest timber products on HKm land. However, we are less confident of the negative impact of timber tree planting on profits since this coefficient is statistically insignificant in the median regression.

Assessment of impacts using propensity score matching (PSM)

Although we have controlled for the influences of many confounding factors using econometric methods, the validity of these methods are dependent upon the parametric assumptions that underlie them. One method of addressing these weaknesses is to use propensity score matching (PSM). As a method of impact assessment, PSM involves selecting "treatment" and "control" observations that are as similar as possible in their observable characteristics, so that estimated differences in outcomes of interest between these groups can be attributed as much as possible to differences in the treatment of interest. This is not equivalent to experimental random assignment, which assures that the groups are similar in terms of unobservable as well as observable characteristics, but is similar to standard regression analysis in assuming that unobservable differences in outcomes are conditionally independent (conditional on the observable characteristics) of the selection of the observations into treatment and control groups. As in an OLS model (but unlike an IV model which can control for biases resulting from selection on unobservables), failure of this conditional independence assumption can cause the results of PSM to be biased (Heckman, et al. 1998). Unfortunately, this assumption is not directly testable (Ibid.). However, since our test of exogeneity of the HKm status variables in the previous sub-section supported the assumption of exogeneity, this strengthens our confidence in use of PSM to compare across different HKm and land tenure groups.

The advantage of PSM over econometric regression analysis is that it seeks to compare only comparable observations and doesn't rely on parametric assumptions to identify the impacts of a treatment. According to the work of Heckman, et al. (1998), the bias resulting from comparing non-comparable observations can be much larger than the bias resulting from selection on unobservables.

In our application, we used kernel matching with the normal kernel function for weighting the control observations. We used PSM to make binary comparisons of dependent variables for three pairs of comparisons on PF land with different HKm status: 1) plots with a HKm permit vs. a HKm application pending, 2) plots with HKm permit compared to plots without a HKm permit or application, and 3) plots with a HKm application compared to plots without HKm. PSM was not feasible for other possible comparisons involving non-PF land (e.g., plots with a HKm permit or application compared to NP land or private land) because of a lack of sufficient number of observations with common support for these comparisons. The first stage of each analysis involved a probit regression for the plots included in the binary comparison (e.g., plots with a HKm permit or application in analysis 1) We used the full set of explanatory variables in equation (2) to predict whether plots were in one or the other state of the binary comparison, except for the GNRHL variable, since HKm status was determined in all cases in the Sumberjaya watershed prior to initiation of the GNRHL program in 2003. We also excluded the village fixed effects in this model, as the model was not estimable with them included. The rationale for including all other variables is that any variable that affects farmers' incentive or ability to plant trees would be expected to affect their incentive to participate in the HKm program.

The results of these probit models are presented in table 6. We find that PF plots where a past eviction occurred are more likely to have obtained a HKm permit than either those having a HKm application pending or those with no application by the time of our survey. However, plots where trees were uprooted were less likely to have a HKm permit than either of these alternatives. It is not surprising that past evictions increase the likelihood of groups pursuing a HKm permit, but surprising that uprooting trees in an eviction reduces this likelihood. Perhaps people have become more distrustful of the government in areas where trees were uprooted and less likely to apply for HKm as a result.

Several household characteristics are associated with differences in access to the HKm program. Households with more coffee land were, not surprisingly, more likely to be part of a group that applied for a HKm permit, while those with more paddy land were less likely to have applied, probably because they were less concerned about coffee production on PF land. Javanese households were more likely to be part of a group that applied or obtained a HKm permit than Sumendo households, while Sundanese households were more likely to have already obtained a permit than to have an application pending.

Older household heads, households with a higher dependency ratio, and households with more educated males were also more likely to have already obtained a permit. Larger households were less likely to have either applied for or obtained a permit. Households closer to an output market were more likely to have obtained a permit. Households with access to technical assistance from the Forest Department were more likely to have obtained a permit. This finding is consistent with the results of our community survey showing that communities with a HKm permit were more likely to have FD staff or friends of FD staff living in the village (Kerr, et al. 2006). In general, these findings are consistent with the descriptive results discussed earlier and suggest that social and human capital and access to markets and technical assistance are important determinants of participation in the HKm program.

There are also some differences in plot quality characteristics between PF plots of different HKm status. Plots with a HKm permit are at higher altitude than either plots with a HKm application pending or no HKm, while those with an application pending tend to be at lower altitude than PF plots without HKm. HKm plots had greater stocks of multi-purpose trees in 2000 than non-HKm plots, and both plots with HKm permits and HKm applications were more likely to have been cleared than non-HKm plots by 2000. HKm permit plots are closer to the nearest road than PF plots with either a HKm application or no-HKm plots. These results suggest that farmers were more apt to pursue a HKm permit for plots with prior investments and good road access.

In Table 7, we present the mean pairwise differences between PF plots having different HKm status, using PSM to match plots that have similar propensity scores using the results of the probit regressions presented in Table 6. We find statistically insignificant differences in tree planting between plots with a HKm permit and those with an application pending, while we find that planting of both timber and multi-purpose trees was greater on HKm permit plots than no-HKm plots, and that multi-purpose tree planting was (weakly significantly) greater on plots with a HKm application in process than no-HKm plots. These results are qualitatively similar to the econometric regression results presented in table 3, which showed that planting of both timber and multi-purpose trees was greatest on plots with a HKm permit or a HKm application pending. Unlike in the regression results, we are unable to compare tree planting on HKm plots to planting NP or private land using PSM, because there was an insufficient number of comparable observations of HKm plots and NP or private plots. This finding indicates that the regression results in tables 3, 4 and 5 comparing HKm plots to these other types of tenure are based on comparing non-comparable observations, and thus may be subject to biases.

Combining the regression and PSM results, we have robust evidence that the HKm program contributes to increased planting of timber and multi-purpose trees. Since we do not find comparable evidence that the program contributes to increased planting of other, non-prescribed types of trees, it appears that these impacts are due more to the tree planting requirements of the program than to increased tenure security.

We also investigated differences in land investments and management practices between different categories of PF plots using PSM (table 7). We find only one statistically significant difference in land investment or management on plots having different HKm status: land clearing is more common on PF plots with a HKm application pending than on plots without HKm. This result is consistent with the probit regression results reported in table 4, and suggests either that increased tenure security associated with the HKm program promotes land clearing, or that farmers who wish to clear PF land are more motivated to seek a HKm permit.

The results of comparisons of profitability are also presented in table 7. We find no significant difference in profitability in comparing HKm permit plots to similar plots with a HKm application pending or PF plots without HKm, but we do find significantly higher profits on plots with a HKm application pending to PF plots without HKm. The insignificant differences between plots with a HKm permit and other PF plots are consistent with the insignificant direct impacts of HKm status found in table 5. However, as noted earlier, a HKm permit should have indirectly increased profitability by promoting planting of multi-purpose trees. Since the PSM model controls for differences in stocks of trees and other factors as of the year 2000, but allows for subsequent differences in tree planting to affect profitability, the estimates in the PSM model are able to reflect the indirect impact of HKm on profitability via its impact on tree planting after 2000. The fact that we do not find a significant difference between plots with a HKm permit and PF plots without HKM in the PSM analysis may be due to the fact that timber tree planting, which is also promoted by HKm, appears to reduce profitability, as noted previously. Thus the positive profitability impacts of HKm permits via the impact on planting multi-purpose trees may be offset by the impact on planting timber trees.

According to the PSM results in table 7, a HKm permit resulted in households planting an estimated 473 more multi-purpose trees per hectare than on comparable plots without a HKm permit. Based on the OLS coefficient estimates in table 5, these additional trees increased profits by an estimated 1270 Rupiah per additional tree, so the estimated additional profit resulting from additional multi-purpose trees as a result of a HKm permit is about 600,000 Rupiah per hectare. This represents a significant increase in farmers' incomes resulting from a HKm permit. However, the increased number of timber trees on HKm permit plots (327 more timber trees per hectare) results in an estimated loss in profits of 432,000 Rupiah per hectare (using the OLS results in table 5), largely offsetting the positive impact of increased planting multi-purpose trees.

Since the process of applying for a HKm permit apparently has less impact on farmers' decisions to plant timber trees than it does on planting multi-purpose trees (see tables 3 and 7), this may explain why we find higher profits on plots with a HKm permit in process. As with HKm permit plots, more multi-purpose trees have been planted on these plots, contributing to higher profitability, while there has been less timber planting than on plots with HKm permits, with less offsetting negative impacts on profitability.

Conclusions and Implications

Several key findings have emerged from our analysis of the HKm program in Sumberjaya:

- Operators of plots with a HKm permit or HKm application pending are poorer on average than owners of private land, but have comparable wealth to users of PF land who haven't applied for a HKm permit and users of NP land. Thus, HKm appears to benefit poorer households because of the nature of the households who use eligible PF land, and not because of any targeting in the implementation of the program.

- Households who have obtained a HKm permit have more formal education, have been settled somewhat longer in the village, are more likely to be involved in a coffee producers' group or labor sharing group, and have better access to markets, roads, and technical assistance than operators of PF plots who haven't applied for a permit. Most of these differences were confirmed as statistically significant in the econometric analysis, after controlling for other factors. Thus, human and social capital and access to markets, roads and technical assistance appear to contribute to the ability of households to participate in the HKm program.
- A significant fraction of members of HKm groups are not aware of the HKm program or the program's requirements concerning the composition of trees to plant with coffee plantations or soil and water conservation measures. Awareness is higher among members of groups that have received a permit than those that have applied but not yet received a permit, suggesting that awareness improves in the process of, or after, obtaining the permit. Nevertheless, imperfect awareness among even permit holders may limit the impacts of the program.
- HKm groups and households believe that participation in the HKm program will have substantial impacts in increasing their land tenure security, land values, land investments and incomes. Statistical analysis of the data suggests more modest but some positive impacts of the program. We do not find significant evidence that the program has contributed to higher land values or increased investment in soil and water conservation or soil fertility management measures, although land clearing is more likely on PF plots with a HKm application than PF plots without HKm. We do find that HKm permits contribute to increased planting of timber and multi-purpose trees. This has mixed impacts on profitability of land use, since multi-purpose trees have a positive impact but timber trees have a negative impact on profits, resulting in insignificant differences in profits on HKm permit plots compared to comparable PF plots without HKm.

- Planting of multi-purpose trees is also higher on plots with a HKm application pending, while timber planting is less affected by the application process. Possibly as a result, plots with a HKm permit have higher profits than PF plots without HKm.

These findings indicate that the HKm program is having positive impacts on planting of non-coffee trees by HKm permit holders, and contributing in a limited way to improvement in their incomes. Since the holders of these permits are poorer on average than private land holders, the program is having pro-poor impacts, although it is not specifically targeted to poorer households. HKm permit holders tend to have more human and social capital and better access to markets and certain forms of technical assistance than users of PF land that haven't applied for a permit. This suggests that the program could benefit more poor households through increased efforts to provide technical assistance and promote social capital formation among eligible communities and households that are presently not participating. Increased efforts to raise awareness about the program and its requirements, for HKm permit holders as well as for others, would also increase the effectiveness and benefits of the program.

Planting timber and multi-purpose trees provides environmental benefits, as shown in other research by ICRAF and others. For example, other research shows that deforestation has been reduced in the remaining forest areas of Sumberjaya where HKm permits have been issued (Ekadinata, et al. 2007). Furthermore, the multistrata coffee farms provide a complex canopy and tree litter that protect the soil surface from erosion (Hairiah *et al,* 2005: van Noordwjik, *et al* 2004). Hence, the program appears to be achieving its primary objective of promoting provision of such environmental services. It remains to be seen whether such services will continue to be provided once HKm groups are provided with longer term definitive licenses. Once they feel assured of their tenure security, they may have less incentive to plant or preserve non-coffee trees in coffee plots unless such trees contribute to income. This problem is particularly likely to be of concern for management of timber trees, which we have found to reduce profitability of land use, unless farmers are allowed to periodically harvest timber, or tree planting and protection requirements are strictly enforced. Since multi-purpose trees appear to be profitable, there will be less need to enforce requirements to maintain these trees after they have been planted.

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Table 1. Characteristics of Plots and Users of Different Tenure, Investments and Profits

Variable	National Park		Private		HKm permit		HKm application pending		PF without HKm	
	Mean	Std. error	Mean	Std. error	Mean	Std. error	Mean	Std. error	Mean	Std. error
Tenure status in 2000										
Past evictions										
- Whether an eviction occurred	0	0	0.101	0.034	0.316	0.041	0.236	0.034	0.114	0.021
- Whether trees were uprooted	0	0	0.025	0.018	0.102	0.029	0.150	0.030	0.081	0.019
How plot acquired										
- Encroached	0.063	0.027	0.05	0.025	0.070	0.021	0.150	0.029	0.113	0.026
- Inherited	0.052	0.025	0.203	0.046	0.153	0.034	0.132	0.029	0.148	0.030
- Purchased	0.494	0.057	0.392	0.055	0.338	0.041	0.386	0.040	0.299	0.038
- Sharecropped	0.065	0.028	0.063	0.028	0.055	0.016	0.010	0.007	0.134	0.010
- Exchanged	0.039	0.022	0.013	0.013	0.008	0.006	0	0	0.027	0.014
Plot characteristics										
Area (ha.)	1.324	0.082	1.033	0.093	0.990	0.062	1.038	0.059	1.185	0.773
Soil color										
- Yellow	0.156	0.042	0.139	0.039	0.130	0.029	0.118	0.026	0.102	0.026
- Red	0.390	0.056	0.266	0.050	0.305	0.041	0.189	0.033	0.178	0.029
- Brown	0.156	0.042	0.165	0.042	0.204	0.034	0.275	0.035	0.355	0.040
- Black	0.275	0.050	0.438	0.056	0.272	0.038	0.367	0.039	0.309	0.037
Soil texture										
- Clay	0.390	0.056	0.354	0.054	0.454	0.044	0.359	0.039	0.334	0.036
- Sandy	0.182	0.044	0.152	0.041	0.089	0.025	0.099	0.023	0.113	0.026
- Loam	0.400	0.055	0.488	0.056	0.360	0.040	0.486	0.040	0.484	0.038
Altitude (m.a.s.l.)	1100	10.165	888.430	9.705	1001.702	3.848	980.841	6.501	1048.214	6.477
Slope (%)	48.824	2.335	31.430	2.228	43.211	1.739	45.199	1.733	43.482	1.657
Soil depth (cm)	15.682	0.743	14.908	0.674	13.807	0.493	14.342	0.596	14.492	0.500
Position on slope										
- Top	0.416	0.057	0.266	0.050	0.227	0.038	0.145	0.030	0.212	0.034
- Middle	0.416	0.057	0.278	0.051	0.426	0.042	0.561	0.039	0.620	0.039
- Top/middle/bottom	0.078	0.031	0.051	0.025	0.041	0.019	0.015	0.009	0.019	0.011
- Bottom	0.1	0.034	0.4	0.055	0.313	0.040	0.279	0.036	0.148	0.026

Variable	National Park		Private		HKm permit		HKm application pending		PF without HKm	
	Mean	Std. error	Mean	Std. error	Mean	Std. error	Mean	Std. error	Mean	Std. error
Fallow/shrub plot in 2000	0.039	0.022	0.025	0.018	0.172	0.034	0.139	0.029	0.169	0.032
Stock of trees in 2000 (no./ha)										
- Timber	3.289	1.711	25.631	7.632	143.115	32.040	80.249	14.221	52.572	11.903
- Multi-purpose	16.951	3.359	80.044	15.470	188.103	36.324	91.750	13.615	55.183	7.542
- Shade	118.513	20.562	303.013	66.199	272.969	40.910	323.726	72.938	150.567	21.406
- Coffee	2268.434	206.048	3236.59	280.368	3547.664	444.310	3032.06	207.659	2639.53	197.284
Plot cleared by 2000	0.013	0.013	0	0	0.032	0.016	0.051	0.018	0.013	0.010
Walking time from residence (min)	17.000	4.092	29.900	4.823	29.570	2.389	41.599	4.105	43.277	4.291
Walking time from road (min.)	85.312	6.764	32.950	4.222	35.851	1.875	55.157	3.593	70.996	4.000
Household characteristics in 2000										
Value of assets (million Rupiah)										
- Rice land	6.117	1.858	8.442	3.435	6.953	2.497	3.272	0.966	7.144	2.034
- Coffee land	14.149	1.950	32.351	4.886	13.917	1.782	14.612	2.810	10.901	1.620
- Other land	2.208	0.671	1.373	0.541	2.120	0.986	0.536	0.155	2.401	0.925
- Livestock	0.266	0.126	0.613	0.248	0.029	0.014	0.062	0.027	0.053	0.020
- Farm equipment	0.214	0.077	0.315	0.112	0.223	0.075	0.152	0.063	0.122	0.044
- Transport equipment	1.239	0.303	2.472	0.598	1.795	0.446	1.214	0.382	3.343	0.932
- Buildings	17.265	2.808	22.239	3.527	13.085	2.301	15.376	2.238	14.248	2.148
Ethnicity										
- Sumendo	0.113	0.036	0.188	0.044	0.104	0.026	0.260	0.036	0.245	0.035
- Javanese	0.753	0.049	0.354	0.054	0.406	0.037	0.401	0.039	0.359	0.039
- Sundanese	0.143	0.040	0.392	0.055	0.468	0.040	0.321	0.039	0.335	0.035
Age of the household head	38.143	1.343	40.620	1.414	38.709	1.143	38.165	1.032	37.077	1.029
Dependency ratio	0.362	0.027	0.347	0.025	0.362	0.020	0.370	0.019	0.363	0.018
Years of education of males	5.280	0.321	6.086	0.345	6.711	0.262	6.188	0.233	6.423	0.251
Years of education of females	4.883	0.323	5.553	0.378	6.062	0.255	5.540	0.243	5.536	0.235
Primary occupation of hh head										
- Agriculture	0.975	0.018	0.963	0.021	0.940	0.022	0.970	0.014	0.935	0.020
- Not agriculture	0.013	0.013	0.038	0.022	0.046	0.020	0.023	0.012	0.054	0.019
Male household head	0.987	0.013	0.949	0.025	0.950	0.020	0.974	0.013	0.992	0.008
Female share of labor supply	42.597	2.067	45.865	2.020	46.963	1.630	45.300	1.439	43.611	1.477
Family size	3.636	0.198	3.608	0.162	3.341	0.112	3.777	0.136	3.575	0.110

Variable	National Park		Private		HKm permit		HKm application pending		PF without HKm	
	Mean	Std. error	Mean	Std. error	Mean	Std. error	Mean	Std. error	Mean	Std. error
Years household settled in village	12.909	1.182	16.278	1.765	13.930	1.413	12.079	1.190	10.963	1.016
Participation in groups										
- Coffee producers' group	0	0	0.076	0.030	0.074	0.025	0.013	0.009	0	0
- Labor sharing group	0.091	0.033	0.051	0.025	0.132	0.031	0.046	0.018	0.024	0.014
Distance to output market (km)	8.642	0.762	1.445	0.224	1.675	0.144	2.567	0.246	2.806	0.252
Access to formal credit	0.403	0.056	0.722	0.051	0.408	0.044	0.422	0.040	0.366	0.039
Access to technical assistance										
- ICRAF	0.000	0.000	0.013	0.013	0.065	0.024	0.065	0.021	0.000	0.000
- Forest Department	0.026	0.018	0.089	0.032	0.422	0.044	0.253	0.036	0.145	0.030
- Agriculture Department	0.013	0.013	0.139	0.039	0.099	0.026	0.063	0.021	0.054	0.018
- Non Governmental organization	0.013	0.013	0.013	0.013	0.106	0.028	0.058	0.019	0.007	0.007
Trees planted 2000 – 2005 (#/ha)										
- Timber trees	5.4	2.9	9.7	3.9	1507.1	660.3	474.1	108.8	92.2	40.6
- Multi-purpose trees	5.1	2.7	147.6	69.9	1676.4	556.8	414.6	97.8	103.8	27.5
- Shade trees	60.8	26.5	341.4	166.6	298.6	94.0	540.8	193.7	290.8	113.9
- Coffee trees	582.3	234.9	2209.0	978.9	3316.9	1115.8	1967.3	526.5	1695.5	650.6
Land investments and land management practices used in 2000 – 2005 (prop. of plots)										
- Land clearing	0.050	0.025	0.025	0.018	0.131	0.030	0.172	0.031	0.067	0.021
- Sediment pits	0.062	0.027	0.212	0.046	0.135	0.030	0.079	0.023	0.062	0.020
- Terraces	0.037	0.021	0.075	0.030	0.106	0.027	0.023	0.013	0.028	0.012
- Fertilizer	0.462	0.056	0.525	0.056	0.502	0.039	0.335	0.039	0.331	0.037
- Compost	0.150	0.040	0.175	0.043	0.051	0.020	0.035	0.016	0.062	0.020
Profits per ha. in 2005 (Rupiah/ha)	1019.6	114.7	1968.8	201.4	767.6	145.0	991.9	110.7	405.0	89.3

Table 2. Determinants of Land Purchase Prices per Hectare, Plots Purchased since 1998 (selected results)[a]

	OLS model		FE model[b]		IV model	
Variable	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error
Land tenure status (cf., PF land without HKm permit)						
- National Park	0.225	(0.296)	0.537	(0.472)	1.625***	(0.462)
- Private	1.238***	(0.307)	0.768	(0.516)	2.016***	(0.218)
- HKm permit	-0.055	(0.248)	-0.374	(0.384)	1.121	(0.715)
Past evictions						
- Whether any eviction occurred	-0.264	(0.262)	-0.308	(0.381)	-0.862**	(0.374)
- Whether trees were uprooted in eviction	-0.434	(0.456)	-1.035*	(0.607)	0.571	(0.616)
Trees on the plot at time of purchase (cf., mature coffee)						
- Coffee with shade	-0.228	(0.274)	-0.475	(0.388)	-0.387	(0.336)
- Mature coffee multi-strata agroforestry system	-0.754	(0.562)	-0.771*	(0.455)	-0.43	(0.336)
- Young coffee (pre-harvest)	-0.025	(0.394)	0.137	(0.416)	0.026	(0.315)
- Bush/shrub	-1.434***	(0.269)	-1.100***	(0.316)	-1.600***	(0.297)
- Coffee with timber trees	-0.441	(0.438)	-0.804*	(0.408)	-0.308	(0.375)
- Defective coffee	-0.945***	(0.316)	-0.579*	(0.337)	-1.583***	(0.337)
- Coffee with fruit trees	0.701	(0.493)	0.631	(0.682)	0.091	(0.550)
Number of observations	171		171		119	
R^2	0.6947		0.7888		0.8163	
Wald test of village fixed effects (p-value)			0.0491			
Maximum variance inflation factor	6.62		90.46			
Partial R^2 of excluded instruments					0.2210	
Anderson's canonical correlation LR test for weak identification (p-value)					0.0000	
Hansen's J test of over-identification (p-value)					0.1164	
C test of orthogonality of HKm permit status (p-value)					0.6471	

Notes: Coefficients and standard errors adjusted for probability weights and stratification of sample, and standard errors computed using White's robust estimator. *, **, *** mean the coefficient is statistically significant at the 10%, 5% or 1% level, respectively.

[a] Coefficients and standard errors for plot characteristics not reported to save space. Variables not reported include the plot area, year acquired, mean altitude, mean slope, position on slope (top, middle, bottom, or combinations), soil color (black, brown, red, yellow), soil texture (clay, loam, sandy, mixtures), soil depth, and the walking times from the plot to the nearest footpath, road, household residence, and village leader's office.

[b] The village fixed effects coefficients are not reported to save space.

Table 3. Determinants of Tree Planting, 2000 – 2005 (number of trees per ha)
(tobit regressions with village fixed effects – selected results)[a]

	Timber		Multi-purpose		Shade		Coffee	
Explanatory variables	Coefficient	Std error	Coefficient	Std error	Coefficient	Std error	Coefficient	Std error
Land tenure variables (T_{pt05})								
Land tenure and HKM status (cf., NP land)								
- Private	736.83	(743.65)	1128.97*	(602.13)	389.35	(992.05)	1437.84	(2489.27)
- HKm permit	2239.47***	(816.54)	1510.03*	(886.48)	1626.67	(1322.80)	-2449.67	(3603.08)
- HKm application pending	1311.36**	(641.02)	1688.26***	(590.73)	1607.63*	(975.35)	2625.93	(2474.68)
- PF land without HKm	-424.71	(709.53)	1469.41**	(665.04)	1798.2	(1102.85)	-43.69	(3271.03)
Past evictions								
- Whether an eviction occurred	-447.7	(662.53)	-35.31	(432.07)	-611.94	(697.57)	3124.71	(2540.34)
- Whether trees were uprooted	1706.54**	(833.53)	1581.17**	(625.15)	1956.85**	(990.28)	6281.86	(4078.56)
Trees on plot in 2000 (number/ha)								
- Timber trees	8.46***	(3.17)	2.72	(1.90)	1.45	(1.50)	-9.2	(8.44)
- Multi-purpose trees	6.50***	(2.07)	8.00***	(1.63)	1.58	(1.28)	21.66***	(6.94)
- Shade trees	-0.79	(0.50)	-0.22	(0.23)	0.99*	(0.57)	-0.34	(1.46)
- Coffee	0.26*	(0.15)	0.28*	(0.15)	-0.04	(0.10)	-0.87*	(0.45)
GNRHL approved ($GNRHL_{pt05}$)	651.57	(483.75)	747.48**	(350.04)	569.45	(417.25)	1564.91	(1657.75)
Number of observations	607		607		607		607	
Left censored observations	390		307		428		357	
Significance of village fixed effects	NA		0.000***		0.000***		0.003***	
Smith-Blundell test of exogeneity of HKm permit and applied for HKm variables (p-value)	0.2500		0.3472		0.4909		0.5118	

Notes: Coefficients and standard errors adjusted for probability weights and stratification of sample, and standard errors computed using White's robust estimator. Village fixed effects not estimated in timber trees regression, due to lack of convergence. Fixed effects not reported to save space.
*, **, *** mean the coefficient is statistically significant at the 10%, 5% or 1% level, respectively.
[a] Coefficients and standard errors for several variables not reported to save space: plot characteristics including how plot acquired (inherited, purchased, sharecropped, exchanged, encroached), plot area, soil color, soil texture, mean altitude, mean slope, position on slope, topsoil depth, whether plot fallow or shrub in 2000, whether plot cleared by 2000, walking times from plot to residence and nearest road; and household characteristics.

Table 4. Determinants of Land Investments and Land Management Practices between 2000 and 2005
(probit regressions with village fixed effects - selected results)[a]

Explanatory variable	Sediment pits		Land clearing		Fertilizer		Compost	
	Coeff.	Std error	Coeff.	Std error	Coeff.	Std error	Coeff.	Std error
Land tenure variables								
Land tenure and HKm status (cf., NP land)								
- Private	0.84	(0.85)	-3.25***	(0.97)	0.141	(0.43)	-0.091	(0.98)
- HKm permit	0.29	(1.09)	-1.15	(0.90)	-0.352	(0.57)	-2.422	(0.62)
- HKm pending	0.32	(0.96)	-0.02	(0.57)	0.024	(0.41)	-2.900***	(1.68)
- No HKm	0.94	(0.90)	-2.00**	(0.82)	0.281	(0.47)	-2.682***	(0.89)
Past evictions								
- Whether occurred	-0.98*	(0.54)	-1.12	(0.81)	-0.689*	(0.40)	-10.537***	(0.87)
- Trees uprooted	0.78	(0.74)	0.04	(0.96)	0.195	(0.47)	9.147	(1.13)
Stock of trees in 2000								
- Timber	0	0.00	-0.00*	0.00	0	(0.00)	-0.007*	(0.92)
- Multi-purpose	0.00**	0.00	0	0.00	0.001	(0.00)	0.005***	(0.00)
- Shade	-0.00*	0.00	0.00***	0.00	0.000***	0.00	0.001***	0.00
- Coffee	0	0.00	-0.00***	0.00	0	0.00	-0.000**	0.00
Number of observations	607		607		607		607	
Number of plots with practice	62		62		254		48	
Joint significance of village fixed effects	0.000***		NE		0.000***		0.000***	
Smith-Blundell test of exogeneity of HKm variables (p-level)	0.2889		NE		0.3764		0.1124	

Notes: Coefficients and standard errors adjusted for probability weights and stratification of sample, and standard errors computed using White's robust estimator. Village fixed effects not estimated in land clearing and terraces regressions. Fixed effects coefficients not reported to save space.
*, **, *** mean the coefficient is statistically significant at the 10%, 5% or 1% level, respectively.
[a] Coefficients and standard errors for several variables not reported to save space: plot characteristics including how plot acquired (inherited, purchased, sharecropped, exchanged, encroached), plot area, soil color, soil texture, mean altitude, mean slope, position on slope, topsoil depth, whether plot fallow or shrub in 2000, whether plot cleared by 2000, walking times from plot to residence and nearest road; and household characteristics.

Table 5. Determinants of Profits (1000 Rupiah/ha) (selected results)[a]

	OLS-FE		Median-FE		IV-No FE	
Explanatory Variable	**Coeff.**	**Std error**	**Coeff.**	**Std error**	**Coeff.**	**Std error**
Land tenure variables						
Land tenure and HKm status (cf. NP land)						
- Private	506.62	(346.83)	546.48	(402.49)	113.83	(348.05)
- HKm permit	392.94	(480.51)	53.32	(458.97)	-229.97	(337.20)
- HKm application pending	277.54	(341.78)	26.78	(373.33)	-185.52	(326.23)
- No HKm	99.03	(370.49)	-575.33	(358.87)	-596.94*	(311.72)
Past evictions						
- Whether evicted	40.74	(226.12)	-26.88	(246.85)	68.45	(207.92)
- Whether trees uprooted	443.96	(366.06)	-12.6	(394.02)	79.3	(286.02)
Stock of trees in 2005 (#/ha)						
- Timber	-1.32***	(0.50)	-0.85	(0.68)	-0.06	(0.42)
- Multi-purpose	1.27***	(0.47)	1.12***	(0.41)	0.62	(0.38)
- Coffee	-0.06	(0.14)	0.16	(0.12)	0.14	(0.09)
- Shade	0.12	(0.32)	0.09	(0.21)	0.66**	(0.27)
Average age of coffee trees (yrs)	10.12	(8.41)	14.88*	(7.58)	28.08***	(6.55)
SWC investments on plot	2.13	(181.52)	48.02	(149.92)	-73.04	(133.25)
Number of observations	547		547		373	
R^2	0.649		0.273		0.476	
Joint significance test of village dummies (P-value)	0.000***		0.000***			
Hansen's J test of overid. restrictions (P-value)					0.110	
C-test of exogeneity of HKm (P-value)					0.476	
Relevancy test of excluded instruments(P-value): -HKM with permit -HKM in process					 0.000*** 0.000***	

Notes: Coefficients and standard errors adjusted for probability weights and stratification of sample, and standard errors computed using White's robust estimator. The village fixed effects coefficients are not reported to save space.

*, **, *** mean the coefficient is statistically significant at the 10%, 5% or 1% level, respectively.

[a] Coefficients and standard errors for several variables not reported to save space: plot characteristics including how plot acquired (inherited, purchased, sharecropped, exchanged, encroached), plot area, soil color, soil texture, mean altitude, mean slope, position on slope, topsoil depth, whether plot fallow or shrub in 2000, whether plot cleared by 2000, walking times from plot to residence and nearest road; and household characteristics.

Table 6. Estimation of Propensity Scores for Binary Comparisons of HKm Status
(probit regression results)

Explanatory variables	HKm permit – HKm application pending		HKm permit – PF land without HKm		HKm application – PF land without HKm	
	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error
Tenure status in 2000						
Past evictions						
- Whether an eviction occurred	0.762**	0.359	1.298**	0.564	0.048	0.447
- Whether trees were uprooted	-0.933**	0.429	-1.814***	0.650	0.249	0.504
How plot acquired (cf., encroached)						
- Inherited	0.299	0.361	-0.226	0.407	-0.311	0.297
- Purchased	-0.009	0.229	0.096	0.267	-0.068	0.207
- Sharecropped	1.390**	0.636	0.942*	0.562	0.297	0.674
- Exchanged	NE		-1.034	0.832	NE	
Plot characteristics						
Area (ha.)	0.109	0.194	0.029	0.179	-0.033	0.160
Soil color (cf., black)						
- Yellow	0.523	0.351	0.486	0.387	-0.223	0.328
- Red	0.526*	0.275	0.667*	0.347	-0.546*	0.280
- Brown	-0.604**	0.281	-0.248	0.306	-0.214	0.250
Soil texture (cf., loam)						
- Clay	0.421*	0.237	-0.107	0.275	-0.343	0.218
- Sandy	-0.054	0.375	-0.462	0.366	-0.494*	0.287
Altitude (m.a.s.l.)	0.007***	0.001	0.004***	0.001	-0.004***	0.001
Slope (%)	-0.005	0.006	-0.005	0.007	0.005	0.005
Soil depth (cm)	0.002	0.017	0.013	0.020	-0.019	0.015
Position on slope (cf., bottom)						
- Top	0.579*	0.336	0.164	0.382	-0.513	0.324
- Middle	-0.099	0.245	-0.253	0.311	-0.139	0.257
- Top/middle/bottom	-0.499	0.725	1.957*	1.182	1.889*	1.113
Fallow/shrub plot in 2000	0.212	0.328	0.509	0.355	-0.223	0.279
Stock of trees in 2000 (no./ha)						
- Timber	0.000	0.001	0.000	0.001	0.001	0.001
- Multi-purpose	0.001	0.001	0.003**	0.001	0.000	0.001
- Shade	0.000	0.000	0.000	0.000	0.000	0.000
- Coffee	0.000	0.000	0.000	0.000	0.000	0.000
Plot cleared by 2000	-0.167	0.513	1.829**	0.793	1.218**	0.550
Walking time from residence (min)	-0.004	0.003	-0.003	0.004	0.001	0.002
Walking time from road (min.)	-0.013***	0.004	-0.021***	0.004	-0.001	0.002
Household characteristics in 2000						
Value of assets (million Rupiah)						
- Rice land	0.007	0.009	-0.005	0.007	-0.020**	0.009
- Coffee land	0	0.006	0.013*	0.007	0.018**	0.007
- Other land	0.087	0.062	-0.016	0.022	-0.067	0.050
- Livestock	-0.31	0.356	0.287	0.537	0.217	0.329

Explanatory variables	HKm permit – HKm application pending		HKm permit – PF land without HKm		HKm application – PF land without HKm	
	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error
- Farm equipment	0.043	0.148	0.212	0.202	-0.047	0.211
- Transport equipment	0.006	0.036	-0.053*	0.031	-0.054	0.034
- Buildings	-0.001	0.005	0.001	0.007	0.004	0.003
Ethnicity (cf., Sumendo)						
- Javanese	0.318	0.314	0.977***	0.345	0.584**	0.262
- Sundanese	0.687**	0.320	0.494	0.351	-0.029	0.251
Age of the household head	0.030**	0.012	0.011	0.011	-0.005	0.010
Dependency ratio	2.167***	0.760	1.248*	0.752	-1.049	0.680
Years of education of males	0.137***	0.044	0.086*	0.047	-0.054	0.038
Years of education of females	0.035	0.040	0.025	0.046	0.054	0.037
Occupation non-agriculture	-0.159	0.999	1.085	0.876	-0.256	0.558
Male household head	-0.093	0.721	-1.356	1.035	-1.799*	0.959
Female share of labor supply	0.005	0.007	0.006	0.008	-0.009	0.006
Family size	-0.511***	0.136	-0.440***	0.143	0.149	0.105
Years household settled in village	-0.005	0.009	0.015	0.010	0.002	0.009
Participation in groups						
- Coffee producers' group	0.318	0.586	NE		NE	
- Labor sharing group	0.000	0.388	1.002*	0.559	0.940*	0.560
Distance to output market (km)	-0.154***	0.044	-0.061	0.050	0.052	0.034
Access to formal credit	-0.03	0.245	-0.113	0.267	0.045	0.227
Access to technical assistance						
- ICRAF	0.038	0.484	NE		NE	
- Forest Department	0.112	0.221	0.926***	0.287	0.408*	0.238
- Agriculture Department	-0.189	0.421	-0.119	0.456	-0.511	0.434
Intercept	-7.854***	1.674	-3.692*	2.030	6.054***	1.600
Number of observations	300		281		290	

*, **, *** mean the coefficient is statistically significant at the 10%, 5% or 1% level, respectively.

Table 7. Comparison of Tree Planting between Different Tenure and HKm Strata using Propensity Score Matching

Variable	HKm permit – HKm application in process		HKm permit – PF land without HKm		HKm application in process – PF land without HKm	
	Mean	Std. error[a]	Mean	Std. error[a]	Mean	Std. error[a]
Tree planting						
- Timber	201.1	556.0	326.5**	166.7	151.5	237.2
- Multipurpose trees	431.6	521.2	472.8**	234.6	204.4*	109.4
- Shade	-773.4	535.4	-41.3	261.1	37.0	904.0
- Coffee	634.3	1250.8	178.8	1924.0	-79.2	2093.1
Number of observations[b]	300		281		290	
Land investments/management practices						
- Sediment pits	0.084	0.055	0.063	0.057	-0.076	0.054
- Land clearing	0.000	0.097	0.084	0.061	0.186***	0.059
- Fertilizer	0.105	0.128	0.095	0.152	-0.017	0.125
- Compost	0.032	0.029	-0.032	0.089	-0.068	0.057
Number of observations[b]	300		281		290	
Profits per hectare	-326.1	382.0	-124.1	463.9	589.5**	292.2
Number of observations[b]	270		241		249	

Notes: Matching procedure: kernel matching with replacement, using the normal kernel.
*, **, *** mean the coefficient is statistically significant at the 10%, 5% or 1% level, respectively.
[a] Standard errors computed using bootstrapping.
[b] Number of matched observations, based on a requirement of common support of the treatment and control observation by dropping treatment observations whose propensity score is higher than the maximum or less than the minimum propensity score of the controls.

Figure 1. Sumberjaya Watershed, West Lampung District, Sumatra

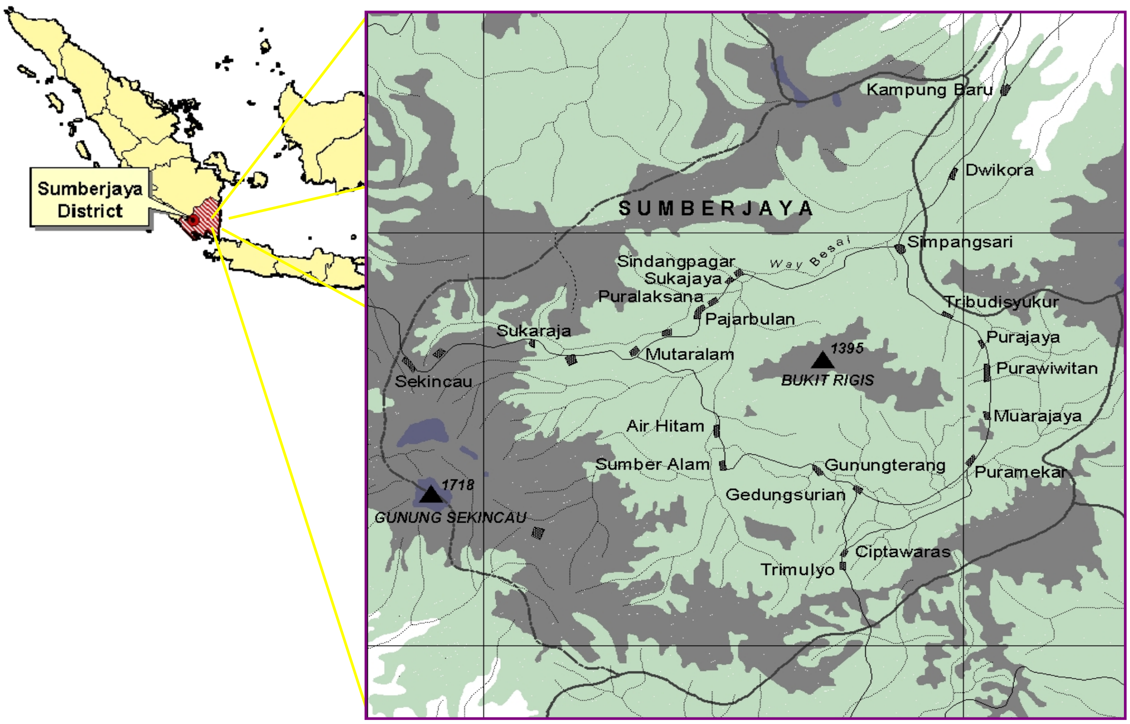

Figure 2. Strata for Household and Plot Survey

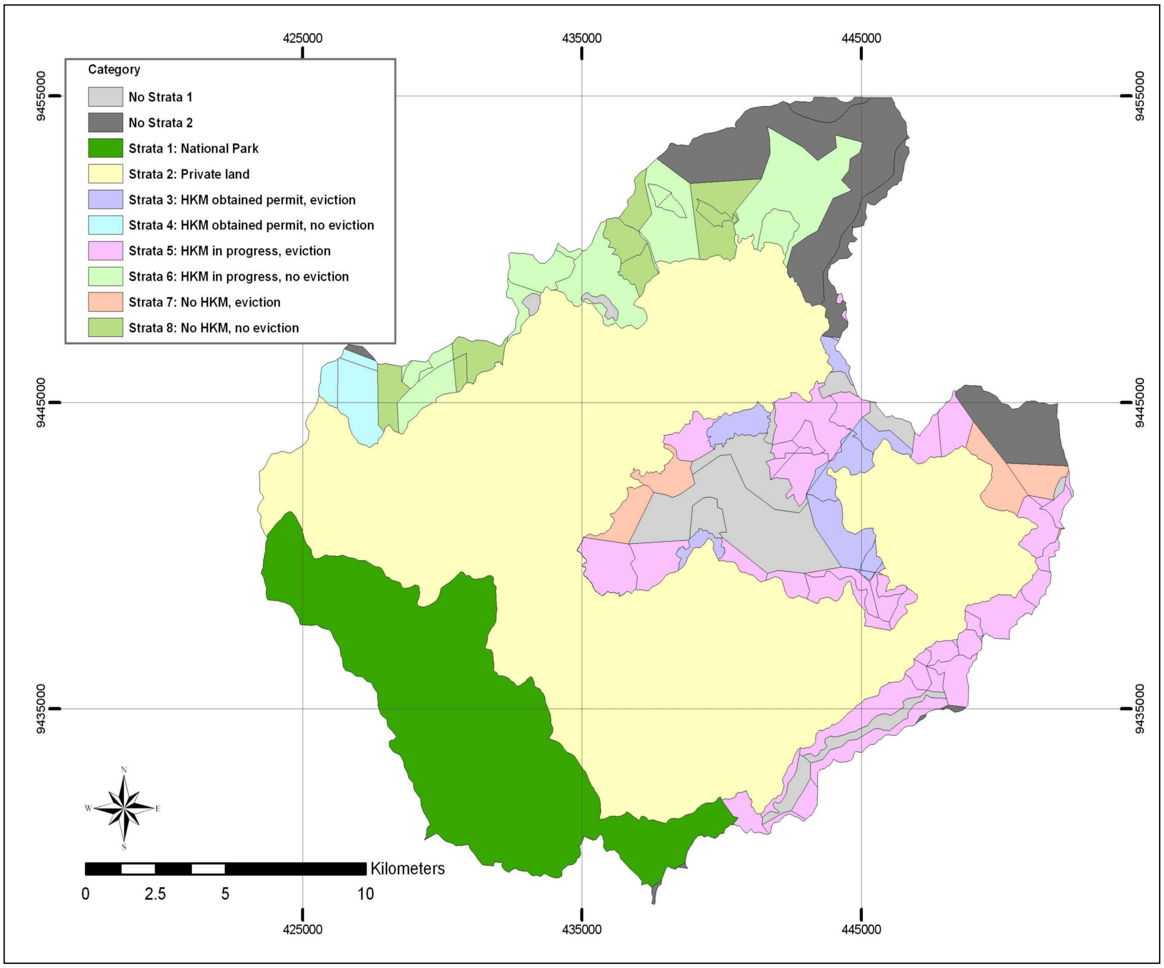

Figure 3. Conceptual Framework for Impacts of HKm Program