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

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ABSTRACT

This paper investigates the impacts of a social forestry program in Indonesia, *Hutan Kamasyarakatan* (HKm), based on analysis of a survey of 640 HKm and comparable non-HKm plots in the Sumberjaya watershed of southern Sumatra, and of the households operating those plots. The HKm program provides groups of farmers with secure-tenure permits to continue farming on state Protection Forest land and in exchange for protecting remaining natural forestland, planting multistrata agroforests, and using recommended soil and water conservation (SWC) measures on their coffee plantations. Using farmers' perceptions, econometric techniques, and propensity score matching, we investigated the impacts of the HKm program on perceived land tenure security, land purchase prices, farmers' investments in tree planting and SWC measures, and plot-level profits.

A significant fraction of HKm group members are not aware of the program or fully aware of its requirements. Although farmers who are aware of the program perceive its strong effects on tenure security and land values, we found insignificant impacts on the actual purchase prices of plots. Nevertheless, our survey revealed that the HKm program has contributed to increased planting of timber and multipurpose trees. We did not find significant impacts on investments in SWC measures or on soil fertility management practices. HKm has had mixed impacts on profits, with timber trees reducing profitability because timber harvesting is not allowed and multipurpose nontimber trees contributing to increased profits.

The policy implications of these findings are also discussed in the paper.

Keywords: rewards for environmental services, land tenure contracts, social forestry, Indonesia, impact assessment.

1. INTRODUCTION

In 2001, the government of Indonesia initiated a new social forestry program called *Hutan Kamasyarakatan* (HKm), which provides farmer groups with permits to continue farming on deforested state land designated as Protection Forest (PF) or Production Forest[1] in exchange for sustainable management of forests and provision of environmental services by the farmers. This program, enacted as part of the *Reformasi* (reform) policies adopted after the fall of the Suharto government, marked a radical departure from previous policies toward agricultural use of state forestland. In the past, farmers were forcibly evicted from such lands, and in many cases, the coffee trees they had planted were uprooted. Those 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. The impacts of this approach on the sustainability of use of PF land or on poverty in Indonesia are not yet known. This study assessed those impacts, focusing on a case study of HKm implementation in the Sumberjaya watershed of the West Lampung District on the island of Sumatra.

[1] Protection Forest land is state property designated as forestland to protect watershed functions. Production Forest land is state forestland used mainly for production of timber or other forest products. The other category of state forestland in Indonesia is Conservation Forest land (with a main function of preserving biodiversity and ecosystems); plots in that category are not eligible for HKm permits.

2. THE HKM PROGRAM

The HKm program was established by Decree No. 31/Kpts-II/2001 of the Ministry of Forestry in 2001. The objective of the program is to empower local communities to practice sustainable forest management, thereby sustaining forest functions and the environment and improving social well-being. Under the program, groups of households in local communities may apply for permits for managing state forestland. To obtain a permit, a group must establish internal regulations to ensure management of the forest area according to prevailing laws; use participatory procedures for decision making, conflict resolution, and organizational management; be recognized by the community through the village administrative head; and prepare a location plan indicating the area to be managed, protection and cultivation blocks, and the period and plan for managing the area.

Protection blocks are areas where natural forest should be protected and rehabilitated because of hydrology or land conservation considerations, such as areas within 500 m of a dam or lake, 200 m from a water spring, or 100 m from a riverbank or land with a slope of more than 40 percent. Cultivation blocks are areas where intensive forestry and agroforestry activities are allowed, as long as they are done in a sustainable manner that preserves and improves the environmental services provided by the area. In a protection block, tree cutting and other activities that would open the forest canopy are not allowed, and a group of farmers with an HKm permit must maintain and cover the forest floor with vegetation, enrich the species of trees producing nontimber forest products in areas needing rehabilitation, and avoid construction of roads or other physical infrastructure. In a cultivation block, an HKm-permitted group is required to maintain the production potential of wood and nonwood forest products and to avoid activities that might cause soil erosion, change the land structure, or otherwise change the natural extent or disturb the protection functions of the area. In all areas, groups must protect the area from damage by illegal users, fires, livestock, pests, and other threats.

In West Lampung District, Forest Department officials have interpreted these requirements as being satisfied if farmers plant noncoffee trees as part of a multistrata agroforestry system in the cultivation block and protect the natural forest in the protection block. A group of farmers with an HKm permit is required by the Forest Department to plant at least 400 noncoffee trees per hectare and to use appropriate soil and water conservation (SWC) measures in the cultivation block.

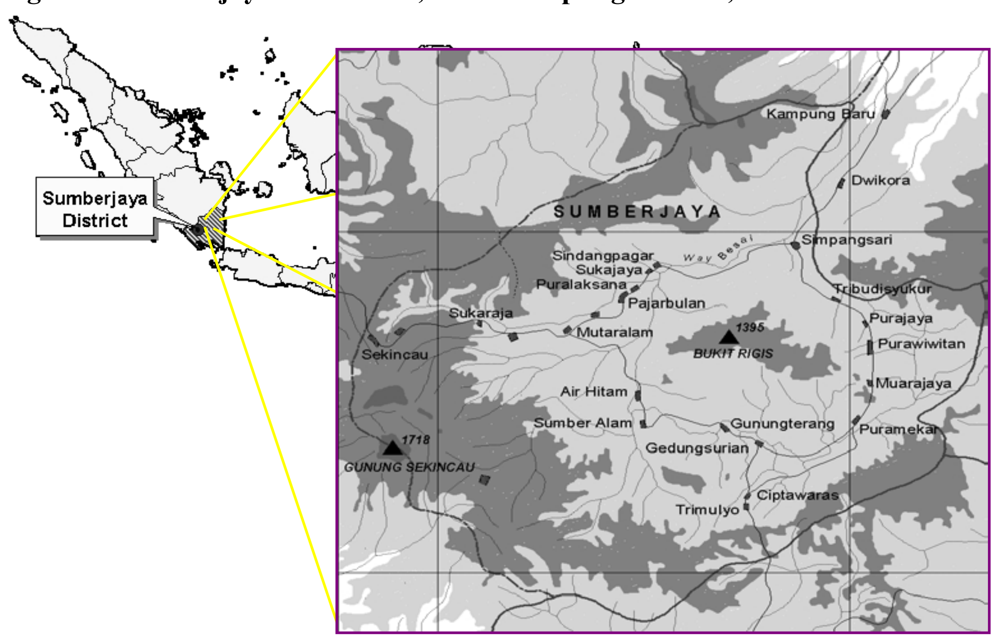
A group can acquire an HKm permit in two stages: first a provisional permit is granted for three to five years, after which the group can get a definitive permit valid for up to 25 years and extendable. Permits are provided by the district head, after approval of the group's management plan by the Forest Department. A provisional permit is granted to the group leader. For approval of a definitive permit, 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 the provisional permit. As of June 2006, no definitive permits had been issued to any HKm groups in the study site of the Sumberjaya watershed, West Lampung District, although the first provisional permits had been granted in 2001. One reason for the delay in providing definitive permits was that the Forest Department had not yet approved the regulations for granting the permits.

3. THE STUDY SITE: SUMBERJAYA WATERSHED[2]

The Sumberjaya watershed was selected for this study because it is the site of intensive study of prospects for approaches by the World Agroforestry Centre (ICRAF) to provide rewards for environmental services under the multicountry project called Rewarding the Upland Poor for Environmental Services (RUPES), and because the HKm program has been implemented there since 2001 with support from ICRAF and local nongovernmental organizations (NGOs).

The Sumberjaya watershed comprises about 40,000 ha of the Sumberjaya subdistrict of the West Lampung District of southern Sumatra (Figure 1). More than 82,000 people live in the subdistrict of Sumberjaya, which has a population density of about 150 people per square kilometer. Assuming the same population density within the Sumberjaya watershed, an estimated 60,000 people live in this area. The watershed is very mountainous, with about 40 percent of the land area classified as Protection Forest (PF), 10 percent is in a national park (NP), and the remainder is private land. Nevertheless, only about 10 percent of the area is forested, because 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,[3] while paddy is the main use of flatter lands at lower elevations (private land). Other land uses include shrub or fallow land and other annual crops besides rice, such as vegetables.

Figure 1. Sumberjaya Watershed, West Lampung District, Sumatra



Source: ICRAF GIS unit, Bogor.

[2] This section draws heavily from the description provided in Kerr et al. (2006).
[3] Because of the watershed's low altitude, Sumberjaya farmers grow low-grade Robusta coffee varieties.

Sumberjaya has been inhabited since about 1884, when Sumendo people from nearby areas of present-day Lampung Province 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 various islands. Sumberjaya's three main ethnic groups are Javanese and Sundanese (both from Java) and Sumendo (from southern Sumatra). Migrants often follow their ethnic kin, and many villages are mostly ethnically homogeneous, but others are more mixed.

In the 1980s, as coffee prices rose, coffee plantations spread to PF and NP areas in the watershed. In the early 1990s, the government of Indonesia, under the former president Suharto, forcibly evicted people from much of the PF area. This action coincided with the construction of a small hydroelectric plant in the river at the outlet of the watershed and aligned with the perception that agriculture in the upper watershed would cause problems for the hydroelectric plant. The key fears were that agriculture would reduce the flow of water available for the plant and cause siltation that could damage the turbines.[4] The evicted 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 in reaction to production problems in Brazil, and the Suharto government fell, replaced by a new, reform-oriented government. The new government introduced a program of *Reformasi* (reform), which aimed to be more decentralized and people friendly. The HKm program was subsequently adopted to encourage greater security and empowerment of local communities like the farmers of Sumberjaya in managing forestlands.

To date, the area permitted under HKm is very small. The first permits in West Lampung District were granted in 2001 in Sumberjaya; around 10 permits are now in force (6 in Sumberjaya), with others under negotiation. Out of about 40,000 to 50,000 ha of eligible state forestland in the district, as of June 2006 only about 2,000 ha were under HKm permits, with an additional 13,000 ha in Sumberjaya included in HKm permit applications in process. Nationwide, the total area under HKm permits was only 50,644 ha as of June 2006.

The HKm process is more advanced in Sumberjaya than in other areas, most likely because of the involvement of ICRAF, which received a grant to help promote the program and support negotiations between communities and government through the RUPES program.

[4] Recent ICRAF research suggests that both of these fears were misplaced. First, agricultural land yields more water downstream through runoff and subsurface flow than does natural forestland; second, filtering effects in the landscape mean that erosion in the upper reaches does not necessarily reach the river. Silt in the river originates largely from land use in the lowlands closer to the river and from erosion of unpaved roads in the watershed. Ironically, the government's action most likely increased erosion, because ICRAF's research suggests that well-established coffee plantations do not erode much (M. van Noordwijk, ICRAF, pers. comm., November 2004; Van Noordwijk et al. 2004).

4. RESEARCH APPROACH AND METHODS

Data Sources

We investigated 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 semistructured, mostly qualitative format. The interviews focused on the processes that determine how communities learn about the program, form into the groups that are required to apply for the program, go through the application process, obtain the permit, and carry out their responsibilities. Another focus of the interviews was the expected impacts of the program.

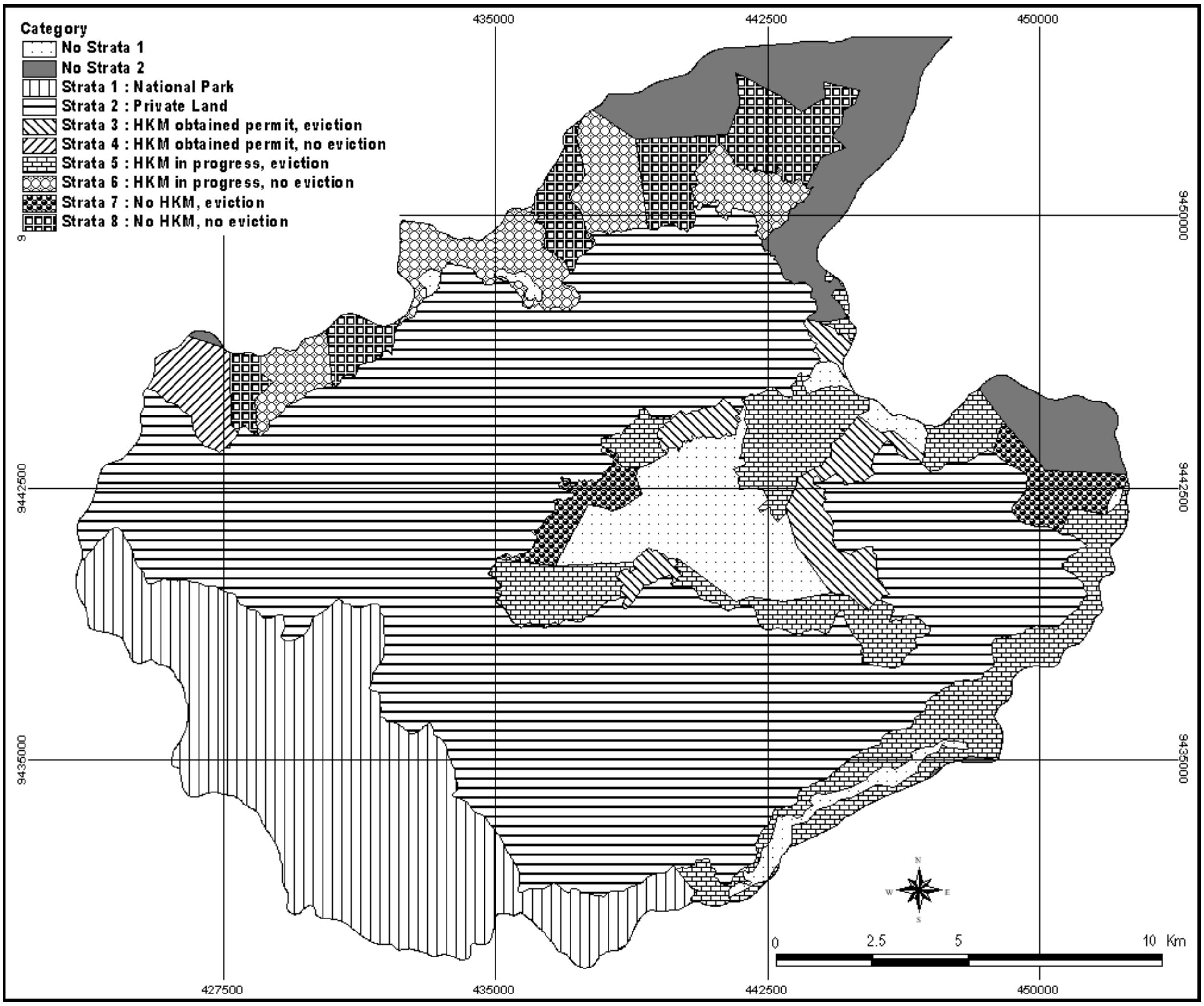
The community-level survey was conducted in all the villages in the Sumberjaya watershed where forest has been classified as Protection Forest (21 of the 29 villages in the watershed). The group survey was conducted with all the groups that have obtained HKm permits or are applying for HKm permits, and 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 permits, 2 had formally applied, 9 had begun preparing applications but had not yet submitted them, and 12 were just beginning the application process.

The household survey was conducted with operators of plots randomly selected using an area-based sample frame that included eight strata (Figure 2):

- Private land
- NP land
- PF land with an HKm permit (with and without past evictions)
- PF land with an HKm permit application in process (with and without past evictions)
- 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 or where a permit was in process, and for PF land with or without past evictions, because those scenarios could result in differences in tenure security and hence in farmers' incentive and ability to invest in planting trees and in SWC measures. We expected private land to be the most secure and NP land to be the least secure. Land without a past eviction was expected to be more secure than land with a past eviction. We expected land with an HKm permit to be more secure than land with a permit in process, which we expected to be more secure than PF land where no application for a permit had been made.

Figure 2. Strata for household and lot survey



Source: ICRAF GIS unit, Bogor.

In all cases, only cultivated or shrub land in sloping areas was included in the sample frame; no paddy or natural forestland was included. Eighty 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, and participation in HKm and other programs and organizations. For the selected plots and one other randomly selected plot (where applicable), information was collected on tree planting and cutting on the survey plots, investments in SWC measures, use of land management practices, and inputs and production.[5] In addition, we took measurements on the selected plots of various plot characteristics, including 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.

[5] The randomly selected second plot did not necessarily have the same tenure status as the sampled plot.

Conceptual Framework

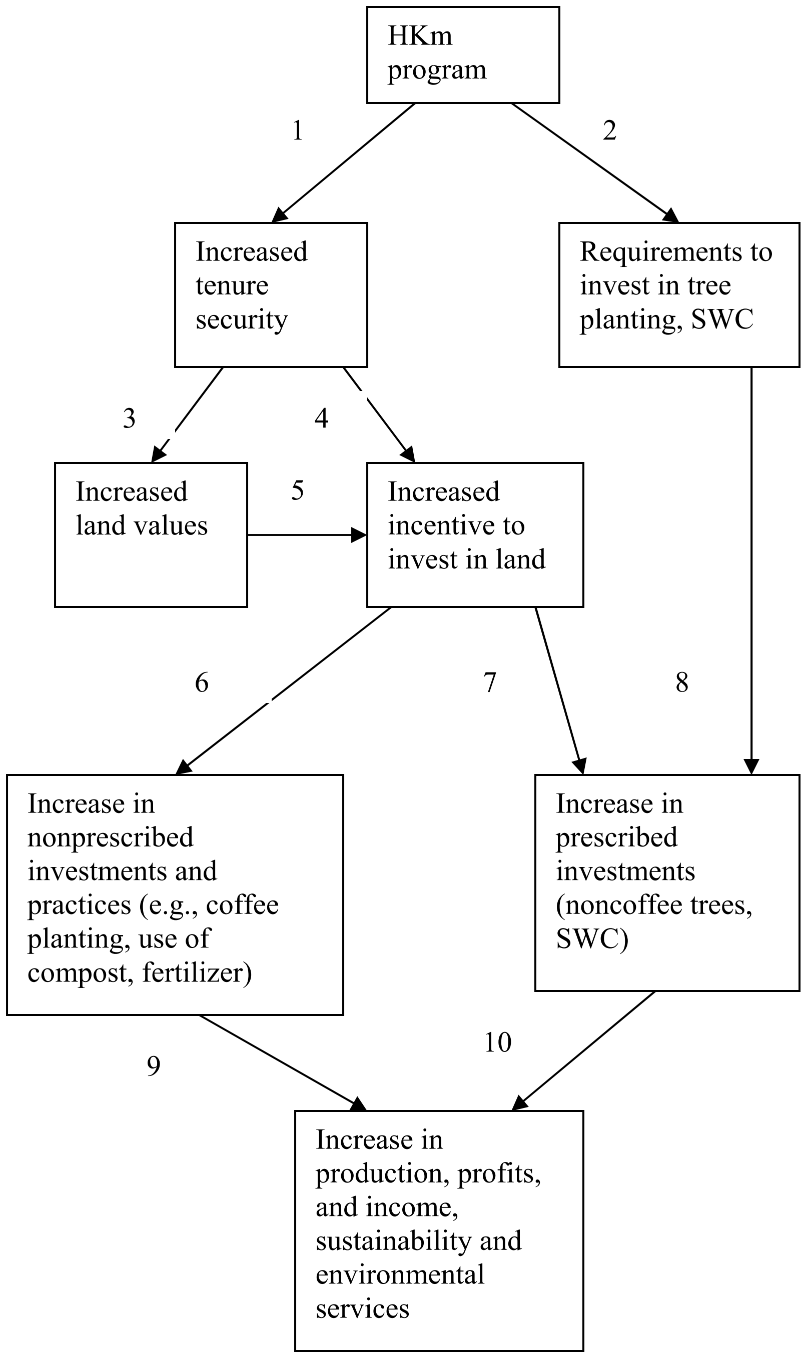
The conceptual framework for the analysis draws on the framework of Feder et al. (1988) regarding the impacts of increased tenure security on land investments, augmented to consider the investment requirements of the HKm program. The framework is illustrated in Figure 3. The HKm program can increase farmers' incentive to invest in land improvements (e.g., planting trees, constructing SWC structures) through several mechanisms. It can 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 can increase, which can 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).[6] To the extent that farmers' incentives to invest are increased, both prescribed investments (e.g., planting noncoffee trees, SWC measures) and nonprescribed investments (e.g., planting coffee trees, use of compost and fertilizer) can increase (linkages 6 and 7). In addition, the requirements of the HKm program, if enforced, can 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 was based on this conceptual framework. We investigated the different linkages in the impact pathway analysis using descriptive analysis of farmers' perceptions as well as econometric analysis, controlling for various potentially confounding factors. Exploration of this full set of relationships helped to draw more-robust conclusions about the extent and mechanisms of impact than would otherwise be possible. For example, while the effects of the HKm program on land investments could have been assessed using only econometric analysis of the determinants of such investments, it might have been difficult to tell from such analysis whether any impacts found resulted from the increased tenure security provided by the program or the requirements of the program. By also investigating the impacts of the program on perceived tenure security, we gained a better understanding of the mechanisms of impact (or nonimpact), and we could validate them by assessing impacts on land values, which should have increased if tenure security was improved. Further, by investigating impacts on both prescribed and nonprescribed investments and land management practices, we obtained a more complete sense of the impacts of the program and the extent to which the investment requirements of the program are responsible.

[6] We did 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 cannot be used as collateral for loans.

Figure 3. Conceptual framework for impacts of HKm Program



We explored these linkages first by considering farmers' awareness and perceptions of the HKm program. If members of an HKm group are unaware of the program or its requirements or do not think it increases their tenure security, their investment behavior is not likely to be influenced by the program. We then investigated the extent to which they think it affects land values, as well as assessing impacts on actual land sale values using an econometric hedonic land price regression. If land prices are not affected by the program, our confidence that the program actually increases tenure security is reduced, even if respondents report that they perceive increased tenure security. We assessed the impacts of the program on prescribed investments and nonprescribed investments and land management practices and on profits using econometric regressions and propensity score matching. We also investigated the potential distributional impacts of the program by analyzing the characteristics of both participants and nonparticipants in the program. Impacts on sustainability of resource use and environmental indicators were assessed in other research.

We discuss the specification of the econometric models used and issues addressed in the next section.

5. RESULTS

In this section, we discuss the results of the community and household surveys with regard to the issues highlighted in the conceptual framework, using both simple descriptive statistics and econometric analysis. We review our findings on the characteristics of farmers 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, SWC measures and other land management practices, and profits at the plot level.

Potential Impacts on Poverty: Who Participates in HKm?

Operators of plots with HKm permits or HKm applications pending tend to be poorer than owners of private land. For example, in 2000, the mean value of land owned by operators of HKm permit plots was about 23 million Rupiah (mostly coffee land), and the mean value of land owned by operators of plots with HKm applications pending was 18 million Rupiah compared with a mean value of 42 million Rupiah for owners of private plots (Table 1). The value of buildings, equipment, and livestock owned was also substantially 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 HKm permits and operators of NP land. Thus, the HKm program appears to target 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 discuss this hypothesis further later in the report.

With regard to other household characteristics, operators of HKm permit plots are more often Sundanese and less often Sumendo than operators of other plots. Operators of plots with HKm applications pending are of similar ethnic distribution as operators of PF plots who have not applied for HKm permits and operators of private plots, whereas operators of NP plots are much more likely to be Javanese than are operators of other plots. Apparently, Javanese immigrants have settled more in parts of the watershed bordering the national park.

Owners of private plots are slightly older than operators of other types of plots. Their families are of similar size to those of operators of most other plots, but their households have a slightly lower dependency ratio on average. Both male and female education is highest on average for operators of HKm permit plots and lowest for operators of NP plots, suggesting that education may have contributed to the ability of HKm permit holders to obtain permits sooner than other PF land users. Owners of private plots, not surprisingly, have lived in their villages longer than owners of other plots, while operators of PF plots who have not applied for HKm permits have been settled the shortest amount of time. Differences in the average period of settlement across these groups are not very large, however (ranging from 16 years for private plot owners to 11 years for operators of PF plots without an HKm permit or application pending (referred to in Table 1 and subsequently in this report as "PF plots [or land] without HKm").

Differences in social capital are associated with differences in tenure status. Owners of private plots and operators of HKm permit plots are mostly likely to belong to coffee producers' groups, while none of the operators using PF land without HKm or NP land belongs to such groups. HKm permit holders are also most likely to be involved in labor-sharing groups.

Access to markets and roads also differs across plot types. Owners of private plots and operators of HKm permit plots live closer to the nearest output market than do operators of other plots, and operators of NP plots live much further than all other categories. Consistent with this, private and HKm permit plots tend to be much closer to the nearest road, and NP plots and PF plots without HKm are much further from roads. By contrast, NP plots are closer to the operator's residence than other plots.

Access to formal credit and technical assistance also differs across these groups. Owners of private plots are much more likely to have access to formal credit than operators of other types of plots. Access to technical assistance from the Forest Department is greatest for operators of HKm permit plots, followed by operators of plots with HKm applications pending and then operators of PF plots without

HKm. Not surprisingly, technical assistance from the Forest Department is least common for operators of NP plots, because such land is not supposed to be used, even for tree planting. Technical assistance from the Agriculture Department is most common for owners of private plots, followed by operators of HKm permit plots, plots with HKm applications pending, and PF plots without HKm. Technical assistance from ICRAF and NGOs is most common for operators of plots with HKm permits or HKm applications pending. These findings suggest that access to technical assistance from the Forest Department, ICRAF, or NGOs may be an important determinant of a household's ability to obtain an HKm permit.

Also evident across plot tenure types are differences 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 have been occupied more recently than others. Encroachment is most common for PF plots with HKm applications pending or without HKm, and sharecropping is more common for PF plots without HKm than for other tenure types.

Table 1. Characteristics of users and plots of various tenures

Variable	National Park		Private		HKm Permit		HKm Application Pending		PF Land 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

Table 1. Continued

Variable	National Park		Private		HKm Permit		HKm Application Pending		PF Land without HKm	
	Mean	Std. error	Mean	Std. error	Mean	Std. error	Mean	Std. error	Mean	Std. error
Altitude (m)	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
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
- Multipurpose	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

Table 1. Continued

Variable	National Park		Private		HKm Permit		HKm Application Pending		PF Land without HKm	
	Mean	Std. error	Mean	Std. error	Mean	Std. error	Mean	Std. error	Mean	Std. error
Household characteristics in 2000										
Value of assets (millions of 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 household head										
- Agricultural	0.975	0.018	0.963	0.021	0.940	0.022	0.970	0.014	0.935	0.020

Table 1. Continued

Variable	National Park		Private		HKm Permit		HKm Application Pending		PF Land without HKm	
	Mean	Std. error	Mean	Std. error	Mean	Std. error	Mean	Std. error	Mean	Std. error
- Nonagricultural	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
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
- Nongovernmental organization	0.013	0.013	0.013	0.013	0.106	0.028	0.058	0.019	0.007	0.007

Source: Plot and household survey.
Note: ICRAF = World Agroforestry Centre.

Past evictions have affected nearly one-third of plots with HKm permits and smaller shares of plots with HKm applications pending or without HKm. Apparently, the experience of past evictions has encouraged the recipients of HKm permits to apply earlier than other land users. Nevertheless, the experience of having trees uprooted in a prior eviction is most common on plots with an HKm application pending. Surprisingly, past evictions were reported on 10 percent of plots classified as private. This may reflect lack of agreement between farmers and the government about which plots are actually private plots.

NP plots tend to be somewhat larger than plots of other tenure types, while differences among the other types are relatively small. Private plots are more likely than other tenure types to have black soil, whereas NP plots are most likely to have red or yellow soils. HKm permit plots are most likely to have clay soils, while private plots and PF plots with HKm applications pending or no applications are most likely to have loamy soils, and sandy soils are most common on NP plots. Private plots tend to be at lower elevations than other plots, whereas NP plots and PF plots without HKm tend to be at somewhat higher elevations. NP plots are the steepest on average (average slope nearly 50 percent); private plots are the least steep although still fairly steep (average slope more than 30 percent). Across tenure categories, most of the sample plots are on the top or middle of a slope, although a greater proportion of NP plots are at the top while a greater proportion of private plots are at the bottom of a slope. Differences among the tenure categories in topsoil depth are relatively small (around 14 to 16 cm for all categories). In 2000, PF plots (with or without HKm) were more likely to be fallow or shrub plots than private or NP plots. The density of coffee trees in 2000 was greatest on plots that are now HKm permit plots and on private plots, and lowest on NP plots.

These results suggest that access to the HKm program may be influenced by the human and social capital, access to markets, and access to technical assistance of households and communities. Households' incentives to apply for HKm permits may also be influenced by their past experience of evictions. Land quality differs among the various tenure categories, with NP and PF plots generally on steeper slopes at higher elevations than private plots. Initial conditions also differ among the tenure types, with PF plots more likely to have been fallow or shrub plots before HKm than private or NP plots, whereas the average number of coffee trees in 2000 was highest on HKm permit plots. It is not clear whether the quality of soils on private plots or any other tenure category is generally superior to the other categories. Later in the report, 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

Respondents' awareness of the HKm status of their plots (for those plots with either verified HKm permits or HKm applications in process) is reported in Table 2. Among the surveyed operators of plots with HKm permits, nearly 20 percent said they were not aware of the permits. The proportion is slightly higher for operators of HKm plots where no evictions had occurred in the past, possibly because those operators are less concerned about tenure insecurity and hence may feel less need to inform themselves about the HKm program. Consistent with this, we also found that among operators of plots for which HKm permit applications were pending, a larger proportion of operators said they were unaware of the applications if no past evictions had occurred on their plots than if evictions had occurred on their plots. In both cases, however, more than 50 percent of the operators expressed lack of awareness of the HKm applications.

These results are consistent with findings of the HKm group survey reported by Kerr et al. (2006), which shows that many HKm applicants and permit holders are not fully aware of the program or its requirements. 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 to be planted by the program in production areas, and a significant fraction were not aware of SWC requirements. Awareness of the requirements was substantially higher among groups that actually have HKm permits, although a few groups were not fully aware of the tree composition and SWC requirements.

These findings (both those previously reported here and those of Kerr et al. [2006]) suggest two things. First, the group-based nature of HKm permits means that even farmers who do not understand the program can join it and perhaps benefit from a mechanism for granting rewards for environmental services. This is in contrast to programs based on the participation of individuals who must be informed to benefit. Well-connected landowners are more likely to access individual-based programs, but the group nature of the HKm program and its reward of tenure security as opposed to cash mean that their less well-informed neighbors can share in the benefits.

On the other hand, lack of program awareness suggests that information dissemination within HKm groups is inadequate, especially before a group receives its 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. Such lack of awareness can undermine achievement of the objectives of the program but could be addressed fairly straightforwardly through increased informational efforts.

Table 2. Awareness of HKm Program

Variable	With Past Eviction			Without Past Eviction			All HKm Plots		
	Mean	Std. error	*N*	Mean	Std. error	*N*	Mean	Std. error	*N*
Percentage of operators of HKm permit plots not aware of permits	17.3	4.2	80	24.1	4.8	80	19.4	3.3	160
Percentage of operators of plots with HKm applications not aware of applications	57.5	5.6	80	80.0	4.5	80	66.2	3.8	160

Source: Household survey.

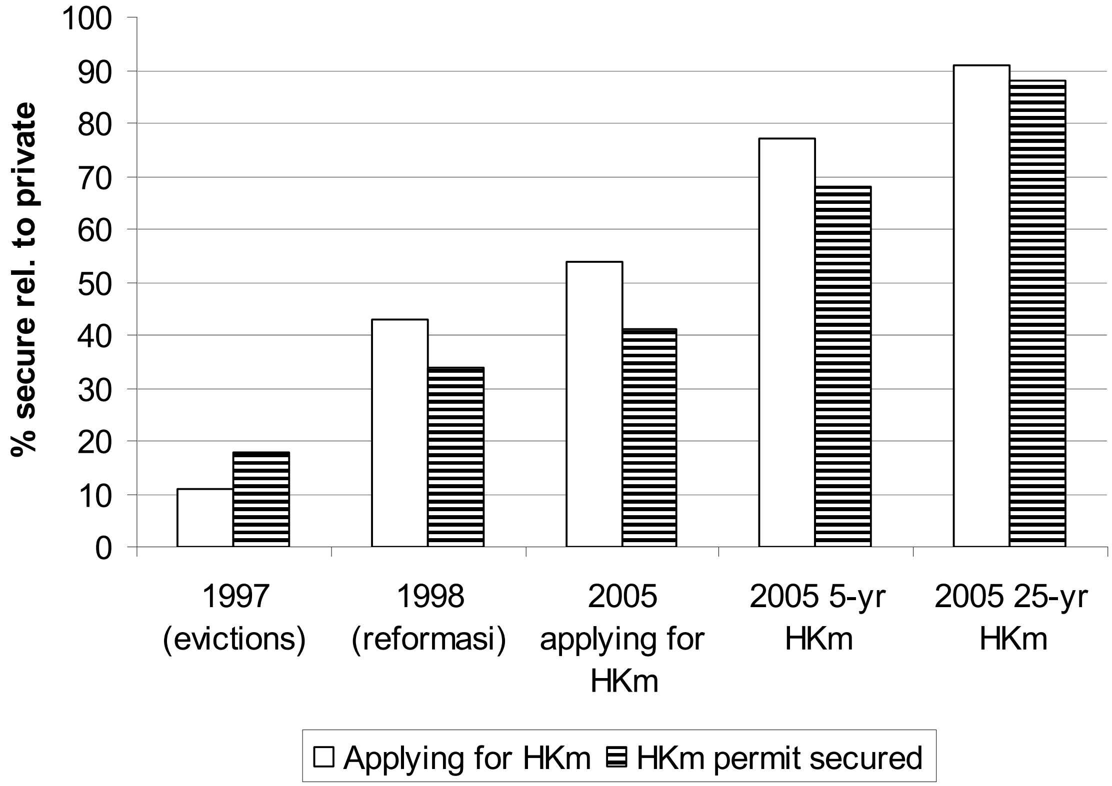
Impacts on Tenure Security

Respondents in the community survey reported their perceptions concerning the security of tenure on PF land, expressed as a percentage of the security of private land before and after the *Reformasi* began and at present with or without an HKm permit (Figure 4). Their responses suggest that both the *Reformasi* and the HKm program have had substantial positive impacts on perceived tenure security on PF land, with security increasing from less than 20 percent before the *Reformasi* to 30–40 percent immediately after the *Reformasi* period began and rising to more than 40 percent by 2005 if applying for an HKm permit, 70–80 percent with a provisional (5-year) permit, and nearly 90 percent (hypothetically) if a definitive (25-year) permit were granted.

Similar results were found in the household survey, in which only operators of plots with HKm permits were asked to rate tenure security of those plots (Table 3). According to respondents' perceptions, both the *Reformasi* 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 *Reformasi* and an additional 26 percentage points after provisional HKm permits were obtained. The perceived impacts of the *Reformasi* and the HKm program were much larger on plots where there had been evictions in the past, with perceived tenure security much lower on those plots before the *Reformasi*.

These results suggest that the HKm program has had a major impact on the tenure security of farmers using PF land. Next we investigate whether this has translated into higher land values.

Figure 4. Perceived tenure security on protection forest land relative to private land (tenure security of PF land as a percentage of security of private land)



Source: Community survey

Table 3. Perceived tenure security of HKm permit plots (% of security on private land)

Variable	With Past Eviction			Without Past Eviction			All HKm Permit Plots		
	Mean	Std. error	*N*	Mean	Std. error	*N*	Mean	Std. error	*N*
Tenure security before *Reformasi*	19.6	2.5	46	45.2	2.0	46	27.5	1.8	92
Tenure security after *Reformasi*	44.9	2.6	56	53.9	1.9	53	47.7	1.9	109
Tenure security after HKm permit	75.5	2.1	62	71.1	1.7	61	74.1	1.6	123
Change in tenure security because of *Reformasi*	25.3	3.2	46	8.7	1.7	46	20.2	2.2	92
Change in tenure security because of HKm	30.6	2.8	56	17.2	1.8	53	26.4	2.0	109

Source: Household survey

Impacts on Land Values

Consistent with their perceptions about impacts of the *Reformasi* and the HKm program on tenure security, respondents to the community survey said they believe that values of PF land increased dramatically after the *Reformasi* period began in 1998. Although prices had fallen by 2005 for PF land without HKm permits (probably due largely to the decline in coffee prices between 1998 and 2005), expected prices in 2005 were substantially higher for plots with HKm permits (Figure 5). If a plot had (hypothetically) received a definitive 25-year permit, the expected price was about double the price without an HKm permit.

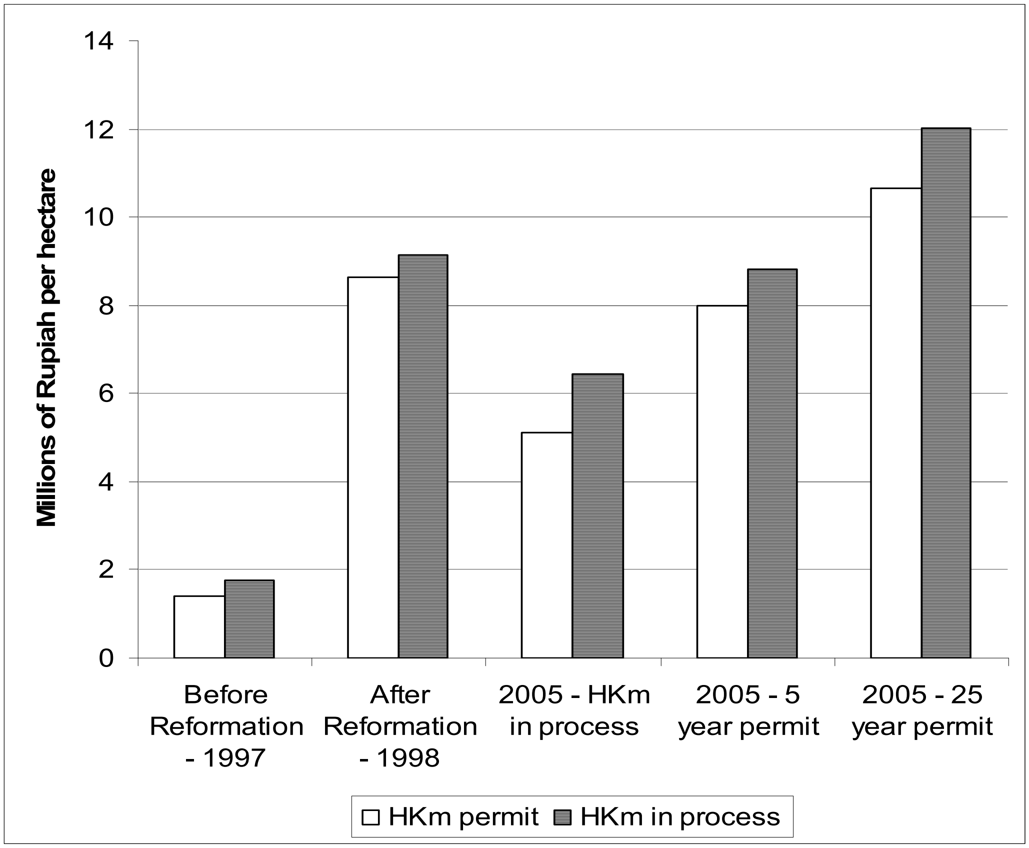
Data from the household survey on the actual purchase prices of plots acquired through purchase tell a more mixed story. PF plots purchased since 1998 have an average price about one-fourth that of private plots purchased during that period, while the price of plots with HKm permits is slightly higher than PF plots without permits (Table 4). Surprisingly, however, the average price of PF plots is even lower than that of NP plots purchased since 1998 (possibly reflecting greater likelihood that NP plots had coffee planted on them, as noted previously). These results are less supportive of the view that tenure security has 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. However, part of the discrepancy may be the result of differences in the quality of purchased PF plots relative to other purchased plots, or in the presence of coffee or other valuable trees on the plots at the time of purchase. Further, the impact of an HKm permit on land values at the time of plot purchases may have been less than the impact after people became more familiar with the program. To address those issues, we used a hedonic regression to control for other factors expected to affect the price of land.

Table 4. Price of plots purchased since 1998 (millions of Rupiah/ha)

Land type	Mean	Standard error	Number of observations
Private	14.90	2.21	8
National park	4.69	0.76	19
PF land with HKm at time of purchase	3.89	0.66	33
PF land without HKm at time of purchase	3.19	0.37	139

Source: Household survey.

Figure 5. Perceived impacts of Reformasi and HKm on values of protection forest land



Source: Community survey.

Econometric Model for Land Prices

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

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

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 an HKm permit at the time of purchase (PF land without an 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 the top, middle, or 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, to 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 multistrata agroforestry system, young [preharvest] coffee, defective [unhealthy] coffee, or bushes or shrubs). Logarithmic transformations of all continuous explanatory variables were used (year of purchase; plot area; mean altitude and slope; soil depth; and walking time to the village, residence, road, and footpath), thereby reducing problems of nonlinearity in residuals and outliers (Mukherjee et al. 1998).

We hypothesized that HKm permit plots are worth less than private plots, more than PF plots without HKm permits, and more than NP plots as a result of having less tenure security than private plots but more security than either PF land without HKm permits or NP land. Past evictions and uprooting of trees during evictions may 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 expected that plots with mature, healthy coffee trees to be more valuable than plots with young coffee trees, defective coffee trees, or bush and shrubs. Other plot quality characteristics, such as altitude, slope, and soil type, may affect land quality to the extent that those characteristics affect the productivity of the plot. Another hypothesis is that better access of the plot to the town, roads, and the farmer's residence increase plot value.

We used three regression models: 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 variables that are correlated with the explanatory variables or because some of the explanatory variables may be endogenous (particularly the HKm status of the plot, which may be correlated with unobserved village, household, or plot characteristics). The potential problem of omitted-variable bias was addressed by including village-level fixed effects (allowing for a different intercept in each village[7]), which controls for any unobserved factors that differ across (but not within) 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-level fixed effects because all the instrumental variables are village-level variables. However, using village-level fixed effects helps to control for components of the error term that could be correlated with the endogenous regressor, thus 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 Forest Department 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 (an 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 of bridging social capital were selected as instrumental variables because they 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.

Econometric Results

The regression results are reported in Table 5. The OLS model fits the data well, explaining 69 percent of the variance in land values. A test for nonlinearity in the regression residuals (the Ramsey RESET test[8]) did not reveal any significant problem, and inspection of the graph of the residuals versus fitted values supports that finding.[9] The maximum variance inflation factor (VIF) for the explanatory variables is 6.6, and the rest are less than 5, indicating that multicollinearity is not a major problem in this regression (Mukherjee et al. 1998).

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[7] In that case, β_0 is a vector of estimated village-specific intercepts rather than a single intercept.

[8] This test is sometimes referred to as a test for omitted variable bias but is more accurately described as a test of nonlinearities because it involves testing whether polynomial powers of the fitted values significantly explain variation in the residuals.

[9] By contrast, a linear version of the model (using untransformed versions of the dependent and continuous explanatory variables) showed serious nonlinearity in the residuals and failed the Ramsey RESET test.

In the FE model, the explanatory power is significantly greater (explaining 79 percent of the variance), and a Wald test for the joint significance of the village effects (not reported in the table) is statistically significant (at 5 percent *p* level). These results provide support for preferring the FE model. However, the FE model was beset by serious problems of multicollinearity, which undermined our ability to identify the impacts of variables such as tenure status on land values.[10]

Table 5. Determinants of land purchase prices per hectare, plots purchased since 1998[1].

Variable	OLS Model		FE Model[2]		IV Model	
	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error
Land tenure status (cf., PF land without HKm)						
- 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	-0.434	(0.456)	-1.035*	(0.607)	0.571	(0.616)
Plot characteristics						
ln(area)	-0.331**	(0.135)	-0.453***	(0.138)	-0.509***	(0.115)
ln(year acquired)	18.456	(96.041)	112.062	(81.360)	-112.526	(82.587)
ln(mean altitude)	-0.203	(0.878)	-0.093	(1.337)	0.224	(0.841)
ln(mean slope)	0.228**	(0.103)	0.081	(0.170)	0.246**	(0.111)
Position on slope (cf., top)						
- Middle	-0.142	(0.223)	0.027	(0.226)	-0.112	(0.204)
- Bottom	-0.092	(0.283)	-0.007	(0.338)	0.081	(0.251)
- Top/middle	0.016	(0.436)	0.087	(0.489)	-1	(0.855)
- Middle/bottom	0.327	(0.371)	0.47	(0.492)	0.361	(0.494)
- Top/middle/bottom	-0.248	(0.583)	0.211	(0.608)	-0.064	(0.304)
Soil color (cf., black)						
- Brown	-0.258	(0.238)	-0.207	(0.329)	-0.169	(0.245)
- Red	-0.431	(0.273)	-0.381	(0.321)	0.144	(0.210)
- Yellow	-0.667**	(0.328)	-0.802**	(0.344)	-0.308	(0.368)
Soil texture (cf., clay)						
- Loam	-0.529**	(0.237)	-0.427	(0.260)	-0.775***	(0.186)
- Sandy	-0.569	(0.349)	0.103	(0.584)	-0.623	(0.391)
- Loamy clay	0.35	(0.563)	0.596	(0.547)	-0.3	(0.339)

[10] 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 with a VIF of 1.45 in the regression without fixed effects. The VIF measures the factor by which the variance of a coefficient is increased by multicollinearity among the explanatory variables. For example, a VIF of 4 for a coefficient means that the variance estimate of the coefficient is four times bigger than it would be without multicollinearity, implying that the standard error is twice as big and the *t* statistic is one-half the size (for the same coefficient estimate), greatly reducing the ability to obtain statistically significant results.

Table 5. Continued

Variable	OLS Model		FE Model[2]		IV Model	
	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error
- Sandy loam	-0.52	(0.333)	-0.426	(0.441)	-1.109***	(0.371)
- Sandy, loamy clay	-1.712***	(0.458)	-1.782***	(0.606)		
ln(soil depth)	0.155	(0.186)	0.126	(0.258)	0.098	(0.169)
ln(walking time to village leader's office)	-0.152	(0.178)	-0.261	(0.231)	0.384*	(0.230)
ln(walking time to residence)	0.032	(0.068)	-0.025	(0.065)	0.018	(0.055)
ln(walking time to nearest road)	-0.149	(0.091)	-0.209*	(0.124)	-0.11	(0.112)
ln(walking time to nearest footpath)	0.123	(0.144)	0.329*	(0.189)	0.215	(0.267)
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 multistrata agroforestry system	-0.754	(0.562)	-0.771*	(0.455)	-0.43	(0.336)
- Young coffee (preharvest)	-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)
Intercept	-122.992	(730.250)	-834.57	(617.210)	867.359	(628.076)
Number of observations	171		171		119	
R^2	0.6947		0.7888		0.8163	
Wald test of village-level fixed effects (*p* value)			0.0491			
Maximum variance inflation factor	6.62		90.46			
Ramsey RESET test of powers of fitted values (*p* value)	0.2435		0.0559			
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	

[1] Coefficients and standard errors adjusted for probability weights and stratification of sample, and standard errors computed using White's robust estimator.
[2] The village-level fixed effects coefficients are not reported to save space.
FE = village-level fixed effects; IV = instrumental variables; OLS = ordinary least squares.
*, **, *** mean the coefficient is statistically significant at the 10%, 5%, or 1% level, respectively.

Tests of the instrumental variables in the IV model revealed 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). The tests also support the assumption that the instrumental variables 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 because HKm status is statistically exogenous and the OLS model is more efficient.[11]

None of the regression results shows a statistically significant difference in land values between PF land with an HKm permit and such land without a permit, controlling for other factors. 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 probably results from the high multicollinearity in this model (the VIF of private land is greater than 10 in that regression). In all regressions, NP land has a higher value than PF land, although this result is statistically significant only in the IV model.

Past evictions have a negative association with land values in all regressions, as we expected, although the association is statistically significant only in the IV model. Whether trees were uprooted in a past eviction has a weakly statistically significant (significant at the 10 percent but not the 5 percent level) negative impact only in the FE model. It appears that whatever impact a past eviction may have had on tenure security when it occurred, the effect of the eviction on the value of the land was attenuated by the *Reformasi*.

Of course, uprooting of trees can also influence the value of land by affecting the stock of trees on the plots. In all the regressions, we found that plots covered with bush or shrubs are worth substantially less than plots having mature coffee stands. For example, the coefficient of –1.434 for bush and shrub land in the OLS regression implies that bush and shrub land is worth only about 24 percent ($e^{-1.434} = 0.238$) of the value of similar 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 the land was mitigated by the *Reformasi*. As we expected, plots with defective stands of coffee are worth less than those with mature healthy coffee (in all models). We also found some evidence that farmers value plots with multistrata coffee-agroforestry systems less than they do those with coffee monoculture, with a negative coefficient of this variable in all regressions, although it is (weakly) statistically significant only in the fixed effects regression. This suggests that farmers may perceive that multistrata coffee-agroforestry systems result in economic trade-offs. We discuss this issue further later in the report when assessing the determinants of plot-level profitability.

Other factors with statistically significant impacts (at the 5 percent level) on land values in at least one of the models include plot size (negative impact in all models), slope (positive impact in the OLS and IV models), soil color (lower value of yellow soils than black soils in the OLS and FE models), and soil texture (lower value of loamy soil, sandy loam, or mixed sandy-loamy-clay soils relative to clay soils in some models).

These results do not support the hypothesis that the HKm program has increased land tenure security and thus land values, although they do demonstrate the greater tenure security and value of private tenure. Part of the reason for the limited estimated impacts of HKm permits on observed land values is likely that it takes substantial time for people to become aware of the program and develop confidence in its impact on tenure security. Most of the purchases of HKm permit plots analyzed in Tables 4 and 5 occurred by 2002, before the HKm program was long established. It may be that later purchases of HKm permit plots, after the program had been operating a few years, would have yielded higher values relative to non-HKm plots. Unfortunately, we did not have sufficient observations of more-recent purchases of HKm plots to estimate such effects.

[11] OLS is generally more efficient than IV estimation, but that is particularly true in this case because many observations were lost in the IV model as a result of the lack of availability of the instrumental variables for plot owners who lived outside the watershed.

The finding of a higher value for NP land than for PF land (though significant only in the IV regression) was unexpected and suggests that use restrictions are not well enforced on 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 losses in wealth of HKm permit holders. Further, HKm still may have impacts on tree planting and SWC investments as a result of enforcement of the requirements of HKm permits. We discuss this in the following sections.

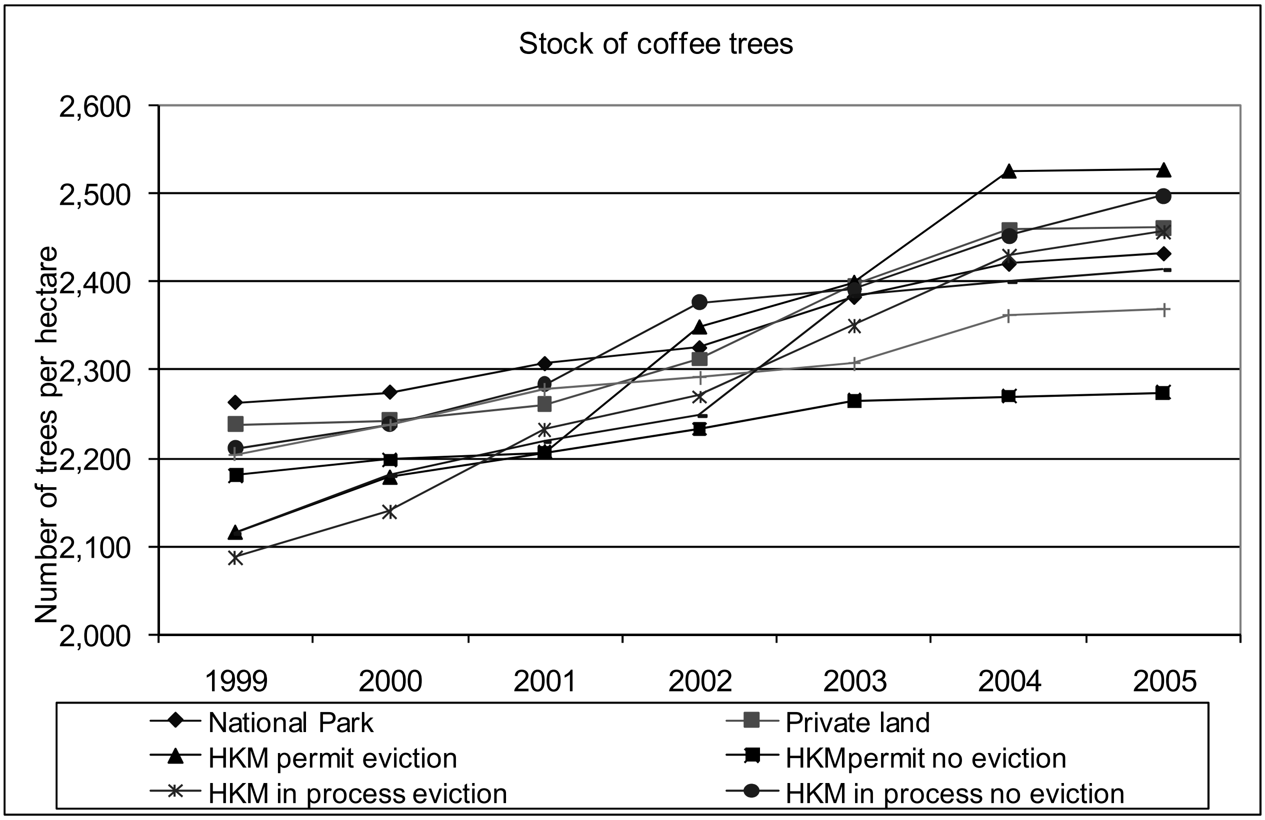
Impacts on Tree Planting

Recall information collected in the household survey on tree planting, survival, and cutting since 2000 were combined with measured stocks of trees on the sample plots to estimate changes in tree stocks since 1999.[12] The estimated mean stocks per hectare of coffee, timber trees, multipurpose trees, and shade trees for each stratum in the survey are shown in Figures 6 through 9. According to these estimates, stocks of all kinds of trees have increased throughout the various strata of the Sumberjaya watershed since 1999.

Coffee trees are more common than all other types of trees in all strata. Coffee stocks have increased in all strata but most rapidly on plots with HKm permits or HKm applications in process where evictions occurred in the past, and least rapidly on plots with HKm permits where no past evictions occurred (Figure 6). Apparently, farmers are planting coffee in response to past evictions (which involved uprooting coffee trees in some cases), and the HKm process may be facilitating their efforts.

[12] The following equation was used to estimate the stocks of trees by year: Ending stocks in year t = Ending stocks in year $t - 1$ + (Number of trees planted in year t) × (Proportion of trees planted in year t surviving) – Number of trees cut in t. Because ending stocks in 2005 were measured and the number of trees planted, the proportion surviving, and the number cut were estimated for each year between 2000 and 2005, the ending stocks could be estimated for each prior year back to 1999.

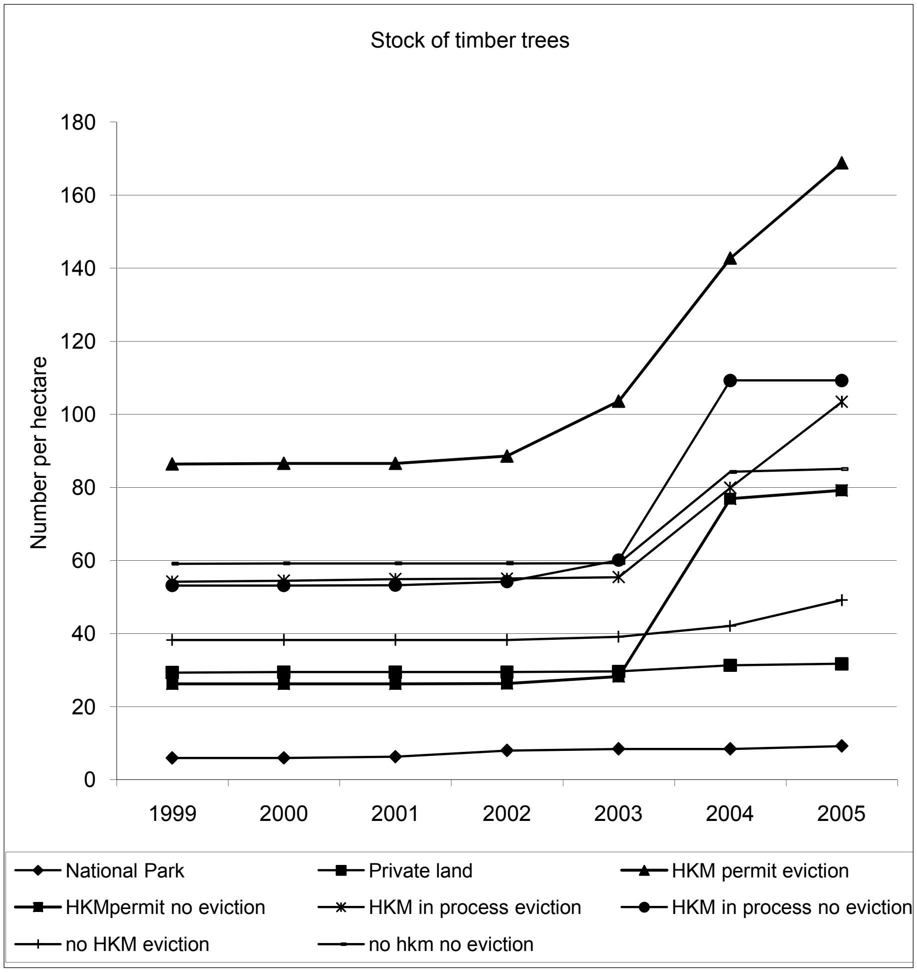
Figure 6. Estimated stock of coffee trees on various strata, 1999–2005



Source: Estimated from household survey.

Timber trees are the least common type of trees in all strata. Timber stocks are the largest and have increased the most on plots with HKm permits where evictions took place in the past, followed by other plots with HKm permits where no evictions occurred or plots with permit applications in process (with or without past evictions; Figure 7). The lowest stocks of timber trees and least amount of planting of timber trees occurred on NP land, private land, and PF land without an HKm permit 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 Gerakan Nasional Rehabilitasi Hutan dan Lahan (GNRHL) reforestation program was initiated. This program provides farmers with seedlings of timber and other noncoffee 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, because all the HKm permits received in the Sumberjaya watershed were issued by 2002 (unless the tree-planting response to HKm permits was delayed).

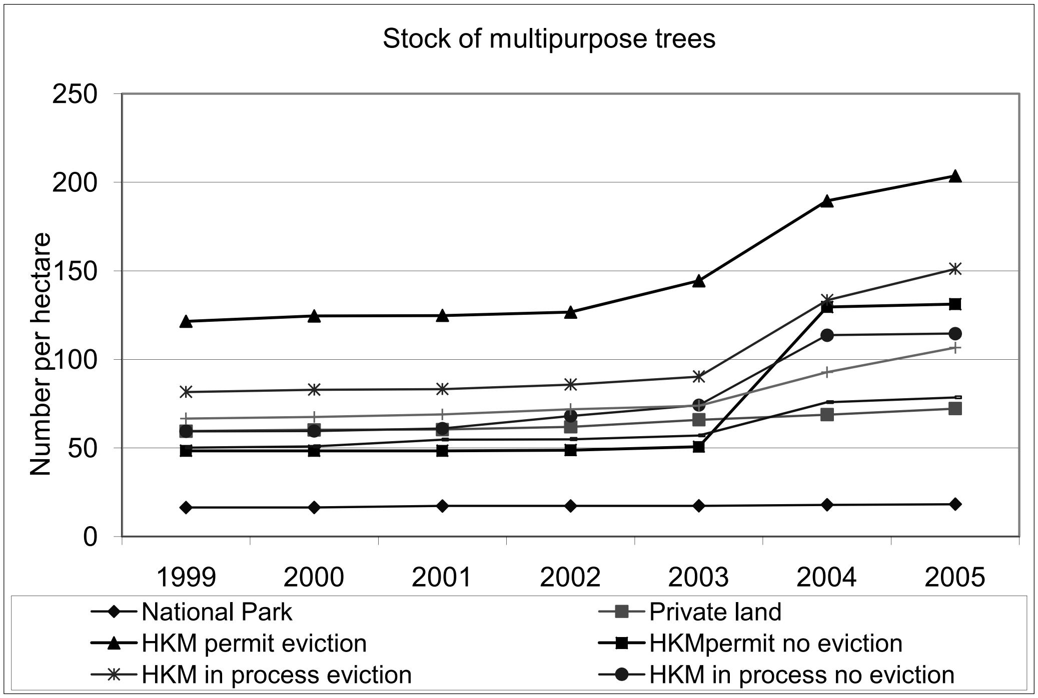
Figure 7. Estimated stock of timber trees on various strata, 1999–2005



Source: Estimated from household survey.

The situation is similar for multipurpose trees (Figure 8). Planting of these trees has been greatest and 2005 stocks were largest on plots with HKm permits or HKm applications in process, with or without past evictions. The least planting of such trees has occurred on NP land, private land, and PF land without an HKm permit or an application in process. As with timber trees, most planting of multipurpose trees has occurred since 2003, coinciding with the GNRHL program.

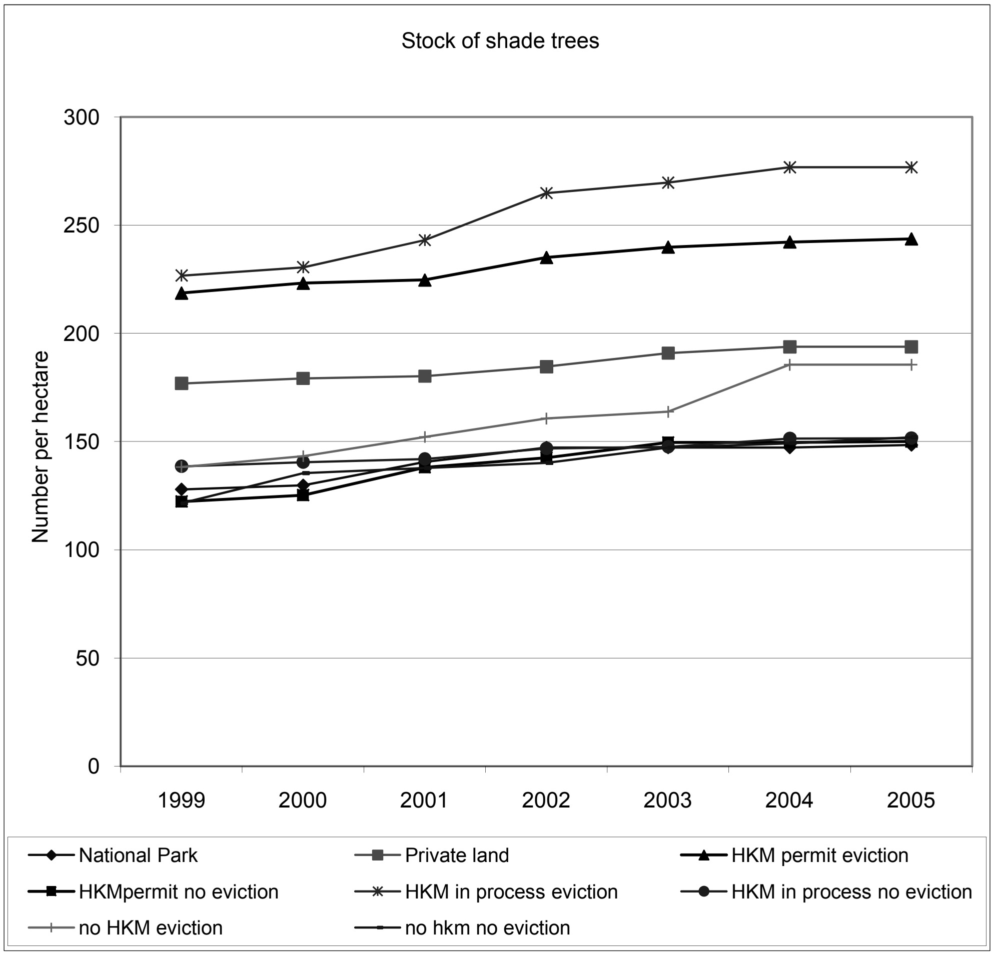
Figure 8. Estimated stock of multipurpose trees on various strata, 1999–2005



Source: Estimated from household survey.

The stock of shade trees is largest and has increased the most on plots with HKm permits or HKm applications in process, with past evictions. Planting of shade trees is least on plots with HKm permits or application in process and no past evictions, NP plots, and private plots (Figure 9). The pattern of shade tree planting is more even over time than is the pattern for timber or multipurpose trees, probably because shade trees are associated with coffee planting where shade coffee is grown and because the GNRHL program does not promote shade tree planting.

Figure 9. Estimated stock of shade trees on various strata, 1999-2005



Source: Estimated from household survey.

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 thus important to try to control for differences in such factors to be able to assess the impacts of HKm on tree planting. We did this using econometric analysis of the tree planting data.

Econometric Model for Tree Planting

The model for tree planting is of the following form:

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

where TP_{pt05} is a vector representing the number of trees planted per hectare of different tree types (coffee, timber, multipurpose, and shade trees) between 2000 and 2005; TP^*_{pt05} is an incompletely observed index function indicating the demand for tree planting (which equals TP_{pt05} when the demand is positive but 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 of 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 here it reflects whether an HKm permit had been obtained or had been applied for by 2005 rather than HKm permit status at the time of purchase. It also includes dummy variables representing how the plot was acquired (i.e., by inheritance, purchase, sharecropping or exchange; encroached plots were the omitted category) because we considered more than just purchased plots, as we did in the analysis of land values.

We expected having an HKm permit or permit application to increase investment in tree planting in general if the permit or application had increased land tenure security. HKm status might also increase tree planting because of the requirement to plant a minimum number of noncoffee trees (mainly timber and multipurpose 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 multipurpose trees. Past evictions might have mixed impacts on tree planting; they might reduce the incentive to plant trees if they increase perceived tenure insecurity on the plot. On the other hand, on plots where trees were uprooted in past evictions, farmers might need to plant more trees. The means of acquiring the plot can also affect tree-planting investment by affecting tenure security. We expected farmers to plant more trees on plots acquired by inheritance or purchase than on plots acquired through encroachment or through temporary arrangements such as sharecropping or leasing.

The plot quality characteristics (X_{pt0}) are also similar to those 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 various types of trees in 2000 were used as indicators of the initial state of the plot rather than the dummy variables used in equation (1) for the tree types on the plot at the time of purchase. 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 2000–2005. The indicators of these endowments include the value of land of various 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.

The econometric model used to estimate equation (2) is a maximum likelihood Tobit censored regression model.[13] As in estimation of equation (1), we tested the model with and without village-level fixed effects. In all cases (except for timber tree planting, for which the fixed effects model did not converge because of inadequate variation of the dependent variable within villages), we found that the village-level fixed effects coefficients are highly statistically significant, indicating that the fixed effects

[13] We also attempted to estimate equation (2) using censored quantile regressions, which are robust to violations of distributional assumptions (Koenker and Hallock 2001). However, we were unable to obtain convergence of these regressions at quantile levels below 95 percent, and thus could not gauge the robustness of this approach. We therefore report only the Tobit results.

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 is 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 is 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 plots and plots with HKm applications 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 the 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)—that is, the bridging social capital indicators—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.

Econometric Results

The econometric results are reported in Table 6. We found that timber tree planting between 2000 and 2005 was greatest on plots with HKm permits or HKm applications pending, controlling for other factors. Planting of multipurpose trees was greater on all kinds of tenure compared with NP land but largest on plots with pending applications for HKm permits. Planting of shade trees was also greater on plots with HKm permit applications pending than on NP land, although this difference is only significant at the 10 percent level. We found no statistically 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 result from the program's tree-planting requirements rather than its impact on tenure security. If the program's impacts were primarily caused by increased tenure security, we would have expected to also find a significant impact from the program on planting of trees not specifically required by the program, such as coffee.

Consistent with this explanation, we found 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 plots compared with other plots. However, we found that planting of timber, multipurpose, and shade trees is significantly greater on plots where trees were uprooted. This may reflect farmers' belief that planting such trees will help to increase their tenure security, as argued by Otsuka and Place (2001).

As expected, the GNRHL program has had a positive impact on planting of multipurpose trees. We did not find that GNRHL has had a statistically significant impact on planting of other types of trees, however.

Table 6. Determinants of tree planting, 2000–2005 (number of trees per ha)[1]

Explanatory Variables	Timber		Multipurpose		Shade		Coffee	
	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error
Land tenure variables (T_{pt05})								
Land tenure and HKm status (cf., national park 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)
How plot acquired (cf., encroached)								
- Inherited	68.13	(516.67)	-28.26	(417.99)	-617.81	(551.18)	24.05	(1918.15)
- Purchased	713.61*	(409.89)	399.84*	(231.30)	510.17	(415.79)	3742.83**	(1571.50)
- Sharecropped	776.69	(982.54)	-487.4	(741.58)	-2411.24***	(836.63)	1560.22	(2558.56)
- Exchanged	381.24	(1310.85)	-1597.66**	(747.98)	-2836.36*	(1616.87)	12961.07***	(4693.43)
Plot characteristics (X_{pt0})								
Area (ha)	455.68	(361.92)	442.61*	(266.34)	-371.94	(303.22)	-3306.72***	(1022.77)
Soil color (cf., black)								
- Yellow	1281.02**	(546.02)	-353.28	(341.92)	-1829.77***	(624.81)	-1910.02	(2026.79)
- Red	850.05*	(470.47)	402.71	(304.25)	-1121.32**	(492.18)	458.55	(1601.30)
- Brown	570.12	(519.84)	-385.92	(336.07)	-1991.22***	(646.93)	-3935.96**	(1876.11)
Soil texture (cf., loamy)								
- Clay	-132.74	(501.09)	224.21	(320.03)	233.41	(447.76)	-664.99	(1501.60)
- Sandy	-369.74	(536.33)	562.54	(391.99)	-1159.48**	(518.69)	-1110.59	(1793.37)
Altitude (m)	6.53***	(2.36)	4.23**	(1.78)	-1.11	(2.90)	-3.47	(7.46)
Average slope (%)	3.01	(7.81)	-0.06	(6.04)	17.44**	(8.78)	-2.29	(29.03)
Topsoil depth (cm)	43.61	(29.50)	16.02	(17.54)	-14.77	(28.94)	13.05	(95.06)

Table 6. Continued.

Explanatory Variables	Timber		Multipurpose		Shade		Coffee	
	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error
Position of plot on slope (cf., bottom)								
- Top	-673.82	(549.03)	24.7	(343.33)	-268.5	(467.95)	-1648.55	(1589.78)
- Middle	711.04	(471.69)	-402.57	(292.51)	-618.45	(418.07)	209.44	(1589.27)
- Top/middle/bottom	-1610.78*	(841.85)	94.82	(593.28)	-2393.16**	(997.27)	-980.91	(3132.11)
Fallow/shrub land in 2000	-2444.32***	(836.36)	-348.73	(380.38)	259	(451.16)	3515.43*	(2072.03)
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)
- Multipurpose 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)
Land cleared by 2000	-294.74	(858.86)	280	(460.07)	2288.57***	(769.56)	3909.02	(2856.95)
Walking time from residence (min)	-0.77	(3.39)	1.3	(2.50)	1.05	(3.68)	-7.08	(15.39)
Walking time from road (min)	2.64	(4.55)	-2.36	(2.65)	5.37	(4.25)	38.57***	(13.92)
GNRHL approved ($GNRHL_{pt05}$)	651.57	(483.75)	747.48**	(350.04)	569.45	(417.25)	1564.91	(1657.75)
Household characteristics in 2000 (Z_{ht0})								
Value of assets (millions of Rupiah)								
- Rice land	-14.53	(10.62)	-15.44*	(8.25)	-21.84**	(10.75)	10.8	(29.19)
- Coffee land	-24.32**	(12.16)	-4.24	(5.09)	5.17	(11.22)	2.51	(33.84)
- Other land	0.07	(33.16)	16.56	(15.17)	-18.96	(48.47)	-92.72	(113.02)
- Livestock	-82.33	(112.33)	-59.36	(83.45)	414.70***	(157.33)	724.40**	(361.90)
- Farm equipment	91.9	(296.70)	-300.82	(187.19)	-459.28*	(263.85)	-699.5	(713.71)
- Transportation equipment	37.7	(34.09)	31.92	(20.26)	-156.58**	(62.85)	-47.86	(131.48)
- Buildings	-19.67*	(10.39)	-0.23	(4.35)	21.58***	(7.78)	37.08	(27.11)
Ethnicity (cf., Sumendo)								
- Javanese	-1437.69**	(624.13)	92.89	(347.25)	-1700.67***	(567.53)	-7810.27***	(2926.38)
- Sundanese	-1146.79**	(499.83)	794.82**	(327.14)	-566.6	(536.02)	-1208.69	(2996.08)

Table 6. Continued

Explanatory Variables	Timber		Multipurpose		Shade		Coffee	
	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error
Age of the household head	19.54	(22.68)	-25.01*	(13.99)	1.03	(20.21)	-102.53	(78.95)
Dependency ratio	810.53	(1170.40)	1034.23	(859.48)	3532.40***	(1213.32)	6768.37*	(3548.84)
Years of education of males	22.36	(72.39)	-7.43	(38.76)	-105.41	(66.17)	-123.42	(209.62)
Years of education of females	41.64	(74.12)	103.20**	(45.57)	-175.26***	(66.73)	-464.51**	(234.33)
Occupation nonagricultural	522.33	(1109.21)	1005.71	(811.35)	2835.93**	(1172.99)	19164.40**	(8090.00)
Male household head	1300.53	(954.51)	-104.82	(685.05)	3816.87***	(1138.02)	10503.39**	(4969.12)
Female share of family labor supply	30.88**	(13.08)	-0.97	(7.57)	15.4	(10.65)	59.23	(36.86)
Family size	-47.58	(179.47)	26.82	(117.13)	-457.38**	(207.80)	-1434.82**	(599.81)
Years household settled in village	-11.35	(15.74)	12.09	(10.10)	-43.20**	(18.58)	65.78	(74.58)
Household members' participation in groups								
- Coffee producers' group	-3321.16***	(1122.59)	-1241.38	(758.89)	718.34	(895.43)	-2010.23	(3596.49)
- Labor-sharing group	1617.08***	(575.47)	221.45	(450.18)	-658.94	(722.23)	-2679.77	(1955.88)
Distance to output market (km)	-178.03***	(59.82)	25.89	(33.46)	132.20**	(54.43)	248.97	(168.28)
Access to formal credit	332.38	(434.51)	-173.93	(255.23)	-38.98	(421.69)	2240.61*	(1230.68)
Access to technical assistance								
- ICRAF	1744.11	(1095.70)	488.15	(818.33)	-3363.34***	(1224.57)	-11065.80**	(4594.97)
- Forest Department	690.66	(446.41)	97.97	(251.99)	699.73	(611.86)	6946.44***	(2136.70)
- Agriculture Department	206.05	(783.10)	-252.97	(477.54)	1903.41**	(745.44)	4100.39	(3659.50)
Number of observations	607		607		607		607	
Left censored observations	390		307		428		357	
Uncensored observations	217		300		179		250	
Joint significance of village-level 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	

[1] Coefficients and standard errors adjusted for probability weights and stratification of sample, and standard errors computed using White's robust estimator. Village-level fixed effects not estimated in timber trees regression because of lack of convergence. Intercepts (fixed effects) not reported to save space. Tobit regressions with village-level fixed effects.

ICRAF = World Agroforestry Centre.

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

Other factors we found to have significant impacts on planting of some types of trees include the means of plot acquisition; the initial stock of trees on the plot; household endowments of physical assets, human capital, and social capital; access to technical assistance, markets, and roads; and plot quality characteristics. We do not discuss the impacts of these other factors in detail here or in subsequent discussions of econometric results, because this study focused on the impacts of the HKm program.

The econometric results demonstrate that many factors beside land tenure security and access to the HKm program influenced tree planting decisions. Although we controlled for the influences of such factors using econometric methods, the validity of those methods are dependent on the parametric assumptions that underlie them, particularly the assumed linear relationship and the assumed normality of the error term in equation (2). One method of addressing the weaknesses of econometric regression analysis is to use propensity score matching (PSM). The next subsection describes how we used PSM to investigate differences in tree planting on plots of various tenure and HKm statuses.

Assessment of Tree-Planting Impacts Using Propensity Score Matching[14]

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 the two groups can be attributed as much as possible to differences in the treatment of interest. The intent of PSM is to mimic an experimental approach by selecting observations having similar observable characteristics. This is not equivalent to experimental random assignment, which ensures that the groups are similar in terms of unobservable as well as observable characteristics, but is similar to standard regression analysis in assuming that the 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 in an IV model, which can control for biases resulting from selection on unobservables if valid and relevant instrumental variables are available), failure of this conditional independence assumption can cause the results of PSM to be biased. Unfortunately, this assumption is not directly testable (Heckman et al. 1998). However, because our test of exogeneity of the HKm status variables in the econometric analysis described in the previous subsection supports the assumption of exogeneity, this strengthens our confidence in using PSM to compare across various HKm and land tenure groups.

The advantage of PSM over econometric regression analysis is that it seeks to compare only comparable observations and does not 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 incomparable observations can be much larger than the bias resulting from selection on unobservables, which is the more usual concern.

For comparing binary "treatment versus control" outcomes, PSM is implemented by first running a binary response model (usually a probit or logit model) to predict whether observations are in the treatment or control samples (the probabilities predicted by this model are referred to as propensity scores). Then matching control observations are selected for comparison to the treatment observations, based on being similar to the treatment observations in terms of their propensity scores. The rationale for doing this is that matching on propensity scores removes bias associated with pretreatment differences in observable variables, and it is much easier to match observations on scalar propensity scores than on a multidimensional set of variables, as required by approaches involving matching on the covariates (Rosenbaum and Rubin 1983). The matching sets of observations are selected to have "common support," meaning that both treatment and control observations are taken from ranges of the values of the propensity scores for which both types of observations are observed.

Various methods may be used to select the matching observations, including one-to-one matching (e.g., selecting the nearest neighbor, or nearest neighbor within some tolerance [called caliper matching in the literature]), selecting a set of nearest neighbors among the control observations (e.g., all neighbors

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[14] Some useful references on propensity score matching include Heckman et al. (1998), Smith and Todd (2001), and Imbens (2004). The seminal paper on the method is Rosenbaum and Rubin (1983).

within a given radius of the treatment propensity score are selected with radius matching), comparing the treatment to the average of the nearest neighbors, or more generally using a weighted average of the control observations for comparison. The main advantage of using multiple control observations to compute the comparison mean is that it reduces the variance of the estimator (Smith and Todd 2001). Methods used to select the weights of control observations in the comparison group include kernel functions (such as the normal density function), which are unimodal symmetric functions that generate declining weights for observations with propensity scores further in absolute value from the treatment observation, local linear matching (which is a generalization of kernel matching), and other approaches (Smith and Todd 2001).

In our application, we used kernel matching with the normal kernel function for weighting the control observations. We used PSM to make binary comparisons between tree planting for three pairs of comparisons on PF land with various HKm statuses: (1) plots with HKm permits versus plots with HKm applications pending, (2) plots with HKm permits versus plots without HKm permits or applications, and (3) plots with HKm applications versus plots without HKm applications. PSM was not feasible for other possible comparisons involving non-PF land (e.g., plots with HKm permits or applications versus NP land or private land) because of a lack of sufficient numbers of observations with common support for those comparisons. The first stage of each analysis involved a probit regression for the plots included in the binary comparison (e.g., plots with HKm permits versus those with applications pending). 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, because HKm status was determined in all cases in the Sumberjaya watershed before initiation of the GNRHL program in 2003 (so access to GNRHL could not be considered a determinant of HKm status). We also excluded the village-level fixed effects in this model, because 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 7. We found that plots where past evictions occurred are more likely to have obtained HKm permits than those having either HKm applications pending or no applications by the time of our survey. However, plots where trees were uprooted are less likely to have HKm permits than either of those alternatives. It is not surprising that a past eviction increases the likelihood of a group pursuing an HKm permit but surprising that uprooting trees in an eviction reduces the likelihood. Perhaps people have become more distrustful of the government in areas where trees were uprooted and less likely to apply for HKm permits as a result.

Several household characteristics are associated with differences in access to the HKm program. Households with more coffee land are, not surprisingly, more likely to be part of a group that applied for an HKm permit, whereas those with more paddy land are less likely to have applied, probably because they are less concerned about coffee production on PF land. Javanese households are more likely to be part of a group that applied or obtained an HKm permit than Sumendo households, whereas Sundanese households are 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 are also more likely to have already obtained a permit. Larger households are less likely to have either applied for or obtained a permit. Households closer to an output market are more likely to have obtained a permit. Households with access to technical assistance from the Forest Department are more likely to have obtained a permit. This finding is consistent with the results of our community survey showing that a group with an HKm permit is more likely to have staff of the Forest Department or friends of Forest Department staff living in the village (Kerr et al. 2006). These findings are generally consistent with the descriptive statistics presented in Table 1 and suggest that social and human capital and access to markets and technical assistance are important determinants of participation in the HKm program.

Table 7. 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***	-0.65	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	-0.16
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*	-0.28
- Brown	-0.604**	-0.281	-0.248	-0.306	-0.214	-0.25
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)	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	-0.02	-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
- Multipurpose	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**	-0.55
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

Table 7. Continued

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
Household characteristics in 2000						
Value of assets (millions of 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	-0.05
- Livestock	-0.31	-0.356	0.287	-0.537	0.217	-0.329
- 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**	-0.32	0.494	-0.351	-0.029	-0.251
Age of the household head	0.030**	-0.012	0.011	-0.011	-0.005	-0.01
Dependency ratio	2.167***	-0.76	1.248*	-0.752	-1.049	-0.68
Years of education of males	0.137***	-0.044	0.086*	-0.047	-0.054	-0.038
Years of education of females	0.035	-0.04	0.025	-0.046	0.054	-0.037
Occupation nonagricultural	-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	-0.01	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*	-0.56
Distance to output market (km)	-0.154***	-0.044	-0.061	-0.05	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*	-2.03	6.054***	-1.6
Number of observations	300		281		290	

ICRAF = World Agroforestry Centre; PF = Protection Forest.

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

We also found some differences in plot quality characteristics between PF plots of different HKm status. Plots with HKm permits are at higher altitudes than either plots with HKm applications pending or plots without HKm applications, while plots with applications pending tend to be at lower altitudes than PF plots without HKm applications. HKm permit plots are less likely to have brown soil than HKm application plots. HKm plots had greater stocks of multipurpose trees in 2000 than did non-HKm plots, and both plots with HKm permits and those with HKm applications were more likely to have been cleared than were plots without HKm applications by 2000. HKm permit plots are closer to the nearest road than are PF plots with or without HKm applications. These results suggest that farmers are more apt to pursue HKm permits for plots with prior investments and good road access.

In Table 8, we present the mean pairwise differences among PF plots having different HKm statuses, using PSM to match plots that have similar propensity scores using the results of the probit regressions presented in Table 7. We found statistically insignificant differences in tree planting between plots with HKm permits and those with applications pending, that planting of both timber and multipurpose trees is greater on HKm permit plots than on plots without an HKm application, and that multipurpose tree planting is (weakly significantly) greater on plots with HKm applications in process than on plots without an HKm application. These results are qualitatively similar to the econometric regression results presented in Table 6, which show that planting of both timber and multipurpose trees is greatest on plots with HKm permits or with HKm applications pending. Unlike in the regression results, we were unable to compare tree planting on HKm plots to planting on 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 Table 6 comparing HKm plots to the other types of tenure are based on comparing noncomparable 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 multipurpose trees. Because we did not find comparable evidence that the program contributed to increased planting of nonprescribed types of trees, it appears that these impacts are more likely the result of the tree planting requirements of the program than of increased tenure security.

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

Table 8. Comparison of tree planting between PF plots of varying HKm status using PSM[1]

Comparison	Timber			Multipurpose			Shade			Coffee		
	Mean	Std. error[2]	*N*[3]	Mean	Std. error[2]	*N*[3]	Mean	Std. error[2]	*N*[3]	Mean	Std. error[2]	*N*[3]
HKm permit – HKm application in process	201.1	556.0	300	431.6	521.2	300	-773.4	535.4	300	634.3	1250.8	300
HKm permit – PF land without HKm	326.5**	166.7	281	472.8**	234.6	281	-41.3	261.1	281	178.8	1924.0	281
HKm application in process – PF land without HKm	151.5	237.2	290	204.4*	109.4	290	37.0	904.0	290	-79.2	2093.1	290

[1] Matching procedure: kernel matching with replacement, using the normal kernel.

[2] Standard errors computed using bootstrapping.

[3] Number of matched observations based on a requirement of common support of the treatment and control observation by dropping any treatment observation with a propensity score higher than the maximum or less than the minimum propensity score of the controls.

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

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 percent of plots between 2000 and 2005), followed by land clearing and terraces (each about 6 percent of plots; Table 9). Soil fertility management practices include application of inorganic fertilizer (47 percent of plots) and compost (14 percent of plots). Investment in sediment pits is most common on private plots, followed by plots where evictions occurred in the past with HKm permits or pending HKm applications. Investment in land clearing is most common on plots with HKm applications pending, with or without past evictions, and on plots with HKm permits but no past evictions. Terrace investment is most common on HKm permit plots with past evictions. Use of fertilizer is also most common on HKm permit plots with past evictions, followed by private plots. Use of compost is most common on private and NP plots.

Econometric Model for Land Investments and Land Management Practices

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

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

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 a standard deviation of 1. Maximum likelihood estimation of equation (3) results in a probit model. As in estimating equation (2), we included village-level fixed effects when the model was estimable with fixed effects, and we tested for the significance of the fixed effects. We also tested the exogeneity of the HKm status variables using the method of Smith and Blundell (1986) and failed to reject exogeneity in all cases.

Table 9. Land investments and use of land management practices since 2000 on plots of varying tenures and HKm status

Stratum	*N*	Land Clearing		Sediment Pits		Terraces		Fertilizer		Compost	
		Mean	Std. error	Mean	Std. error	Mean	Std. error	Mean	Std. error	Mean	Std. error
National park	80	0.0500	0.0245	0.0625	0.0272	0.0375	0.0214	0.4625	0.0561	0.1500	0.0402
Private	80	0.0250	0.0176	0.2125	0.0460	0.0750	0.0296	0.5250	0.0562	0.1750	0.0427
HKm permit, with past eviction	80	0.1625	0.0415	0.1625	0.0415	0.1250	0.0372	0.6500	0.0537	0.0625	0.0272
HKm permit, without past eviction	80	0.0625	0.0272	0.0750	0.0296	0.0625	0.0272	0.1750	0.0427	0.0250	0.0176
HKm application pending, with past eviction	80	0.1625	0.0415	0.1125	0.0356	0.0375	0.0214	0.3500	0.0537	0.0500	0.0245
HKm application pending, without past eviction	80	0.1875	0.0439	0.0250	0.0176	0.0000	0.0000	0.3125	0.0521	0.0125	0.0125
PF land without HKm, with past eviction	80	0.0375	0.0214	0.0625	0.0272	0.0500	0.0245	0.4500	0.0560	0.0625	0.0272
PF land without HKm, without past eviction	80	0.0875	0.0318	0.0625	0.0272	0.0125	0.0125	0.2500	0.0487	0.0625	0.0272
All plots	640	0.0600	0.0121	0.1533	0.0270	0.0585	0.0175	0.4720	0.0342	0.1371	0.0255

Source: Plot survey

Econometric Results

The results of the probit models for land investments and land management practices are presented in Table 10. The table does not include regressions for determinants of land clearing or terrace investment because of the small number of positive observations of those variables, causing unreliable results of the probit model. We found that use of compost is less common on PF plots with HKm permits, HKm applications pending, or no HKm applications than on NP or private plots. This finding shows 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, although the coefficient is highly significant only for compost. On plots where GNRHL reforestation efforts have been approved, use of compost is less common. Such reforestation efforts may conflict with the use of organic practices.

Other factors significantly affecting some land management practices include means of plot acquisition, household wealth, ethnicity, human capital, gender composition, social capital, access to technical assistance, land quality, and initial stock of trees on the plot. As for tree planting, we do not discuss the impacts of these other factors in detail.

Table 10. Determinants of land investments and land management practices, 2000–2005 (probit regression results)

Explanatory Variable	Sediment Pits		Fertilizer		Compost	
	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error
Land tenure variables						
Land tenure and HKm status (cf., national park land)						
- Private	0.84	(0.85)	0.141	(0.43)	-0.091	(0.98)
- HKm permit	0.29	(1.09)	-0.352	(0.57)	-2.422***	(0.62)
- HKm application pending	0.32	(0.96)	0.024	(0.41)	-2.900***	(1.68)
- No HKm	0.94	(0.90)	0.281	(0.47)	-2.682***	(0.89)
Past evictions						
- Whether occurred	-0.98*	(0.54)	-0.689*	(0.40)	-10.537***	(0.87)
- Trees uprooted	0.78	(0.74)	0.195	(0.47)	9.147	(1.13)
How plot acquired (cf., encroached)						
- Inherited	0.4	(0.45)	0.277	(0.28)	-0.614	(.)
- Purchased	-0.2	(0.31)	0.414**	(0.21)	1.336***	(0.66)
- Sharecropped	-5.79***	(1.18)	0.495	(0.39)	NE	
- Exchanged	2.73***	(0.83)	-0.034	(0.82)	0.771	(0.51)
Plot characteristics						
Area (ha)	0.04	(0.25)	0.295**	(0.14)	0.397	(0.01)
Soil color (cf., black)						
- Yellow	1.01**	(0.48)	-0.177	(0.28)	-2.140***	(0.72)
- Red	-0.19	(0.40)	-0.157	(0.25)	-4.011***	(0.64)
- Brown	1.50***	(0.47)	-0.666***	(0.25)	-0.984**	(0.46)

Table 10. Continued

Explanatory Variable	Sediment Pits		Fertilizer		Compost	
	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error
Soil texture (cf., loam)						
- Clay	-0.42	(0.33)	0.720***	(0.21)	1.446***	(0.40)
- Sandy	-0.47	(0.43)	-0.074	(0.25)	0.489	(0.67)
Altitude (m)	0.00	0.00	-0.002*	(0.00)	0.005**	(0.00)
Slope (%)	-0.01	(0.01)	-0.010**	(0.01)	-0.006	(0.01)
Soil depth (cm)	0.04*	(0.03)	0	(0.02)	0.061*	(0.03)
Position on slope (cf., bottom)						
- Top	-0.11	(0.43)	0.379	(0.24)	2.356***	(0.56)
- Middle	-0.81**	(0.39)	0.245	(0.22)	2.915***	(0.49)
- Top/middle/bottom	1.49**	(0.69)	0.23	(0.47)	2.688***	
Fallow/shrub in 2000	-0.19	(0.47)	-0.189	(0.29)	-2.249**	(1.05)
Stock of trees in 2000						
- Timber	0	0.00	0	(0.00)	-0.007*	(0.92)
- Multipurpose	0.00**	0.00	0.001	(0.00)	0.005***	(0.00)
- Shade	-0.00*	0.00	0.000***	0.00	0.001***	0.00
- Coffee	0	0.00	0	0.00	-0.000**	0.00
Plot cleared in 2000	-0.33	(1.05)	-0.838	(0.55)	NE	NE
Walking time from residence	0	0.00	0.002	(0.00)	0	(0.75)
Walking time from road	0	(0.01)	0.002	(0.00)	-0.016***	(0.00)
GNRHL	0.55	(0.36)	0.257	(0.25)	-3.318***	(0.28)
Household characteristics						
Value of assets in 2000 (millions of Rupiah)						
- Rice land	-0.04**	(0.02)	-0.005	(0.00)	-0.021*	(0.65)
- Coffee land	-0.01	(0.01)	0.001	(0.00)	0.018***	(0.01)
- Other land	0.02	(0.02)	0.015	(0.02)	0.025	(0.01)
- Livestock	-0.44***	(0.10)	-0.012	(0.06)	0.027	(0.23)
- Farm equipment	0.72***	(0.17)	-0.183	(0.15)	0.687***	(0.02)
- Transport equipment	0	(0.05)	-0.011	(0.02)	-0.116**	(0.13)
- Buildings	-0.01	(0.01)	0.003	(0.00)	0.013**	(0.05)
Ethnicity (cf., Sumendo)						
- Javanese	-0.18	(0.48)	-0.115	(0.26)	0.387	(0.91)
- Sundanese	-1.10**	(0.46)	0.246	(0.27)	-2.418***	(0.60)
Age of household head	0.02	(0.01)	0.004	(0.01)	0.048**	(0.64)
Dependency ratio	1.69*	(0.93)	-0.433	(0.52)	-0.615	(0.02)

Table 10. Continued

Explanatory Variable	Sediment Pits		Fertilizer		Compost	
	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error
Schooling of males	-0.20***	(0.06)	0.013	(0.03)	-0.015	(1.49)
Schooling of females	0.08	(0.06)	0.058*	(0.03)	0.164**	(0.09)
Occupation nonagricultural	0.19	(0.71)	2.228***	(0.61)	0.456	(0.06)
Male head of household			0.457	(0.53)	2.029**	(1.06)
Female share of labor	-0.01	(0.01)	-0.001	(0.01)	0.037**	(0.93)
Family size	-0.1	(0.13)	-0.123	(0.09)	-0.044	(0.02)
Years settled in village	-0.01	(0.01)	-0.015*	(0.01)	-0.076***	(0.21)
Membership in groups						
- Coffee producers' group	-0.71	(0.76)	0.472	(0.46)	-2.055**	(0.02)
- Labor-sharing group	-1.31	(0.81)	0.004	(0.37)	-0.994	(1.01)
Distance to output market	-0.09	(0.06)	0.006	(0.03)	0.021	(0.01)
Access to credit	0.54	(0.37)	0.279	(0.19)	0.045	(0.06)
Access to technical assistance						
- ICRAF	4.14***	(0.93)	-0.035	(0.43)	-2.921	(0.51)
- Forest Department	0.01	(0.33)	-0.418	(0.25)	1.367**	(1.99)
- Agriculture Department	-0.07	(0.46)	-0.619*	(0.33)	-0.088	(0.61)
Intercept	2.86	(2.74)	1.293	(1.59)	-11.168***	(3.20)
N	607		607		607	
Number of plots with practice	62		254		48	
Joint significance of village-level fixed effects	0.000***		0.000***		0.000***	
Smith-Blundell test of exogeneity of HKm status variables (*p* level)	0.2889		0.3764		0.1124	

[1] Coefficients and standard errors adjusted for probability weights and stratification of sample, and standard errors computed using White's robust estimator. Village-level fixed effects not estimated in land clearing and terraces regressions. Fixed effects coefficients not reported to save space.
ICRAF = World Agroforestry Centre.
*, **, *** mean the coefficient is statistically significant at the 10%, 5%, or 1% level, respectively.

Propensity Score Matching Results

We also investigated differences in land investments and management practices among various categories of PF plots using PSM, and the results are presented in Table 11. Consistent with the econometric results, we did not find any statistically significant differences in land investment or management on plots having different HKm statuses.

Table 11. Comparison of land investments and management between PF plots of varying HKm status using PSM[1]

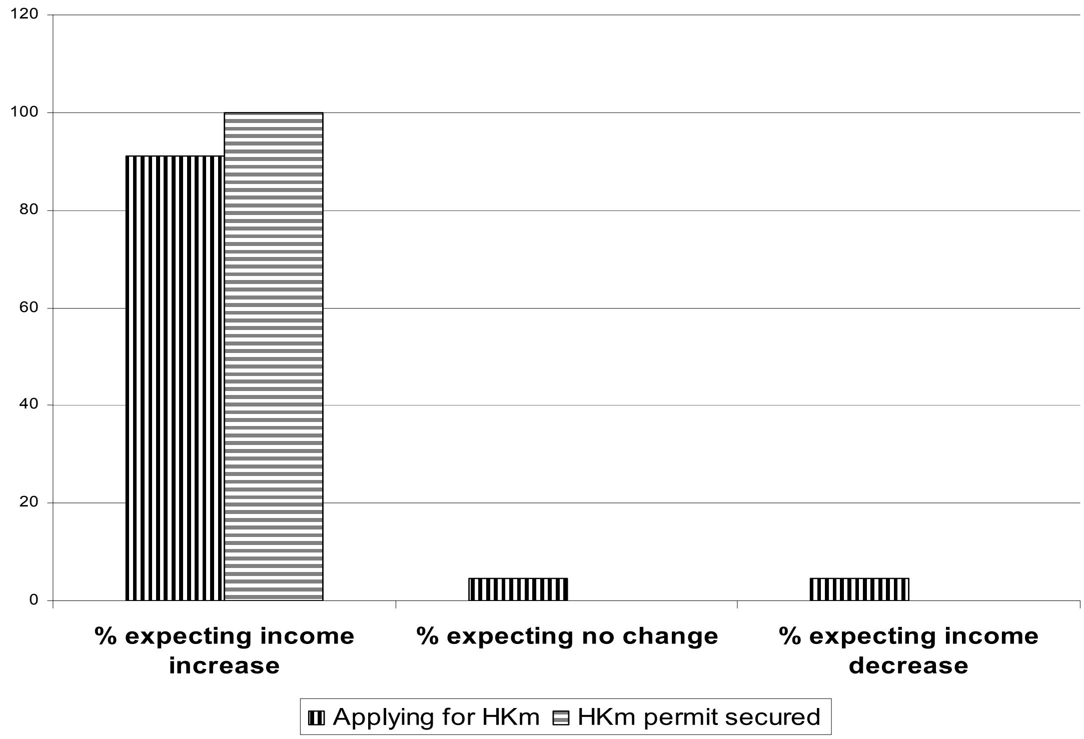
Comparison	Sediment Pits			Fertilizer			Compost		
	Mean	Std. error[2]	N[3]	Mean	Std. error[2]	N[3]	Mean	Std. error[2]	N[3]
HKm permit – HKm application in process	0.084	0.055	300	0.105	0.128	300	0.032	0.029	300
HKm permit – PF land without HKm	0.063	0.057	281	0.095	0.152	281	-0.032	0.089	281
HKm application in process – PF land without HKm	-0.076	0.054	290	-0.017	0.125	290	-0.068	0.057	290

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

Impacts on Profitability of Land Management

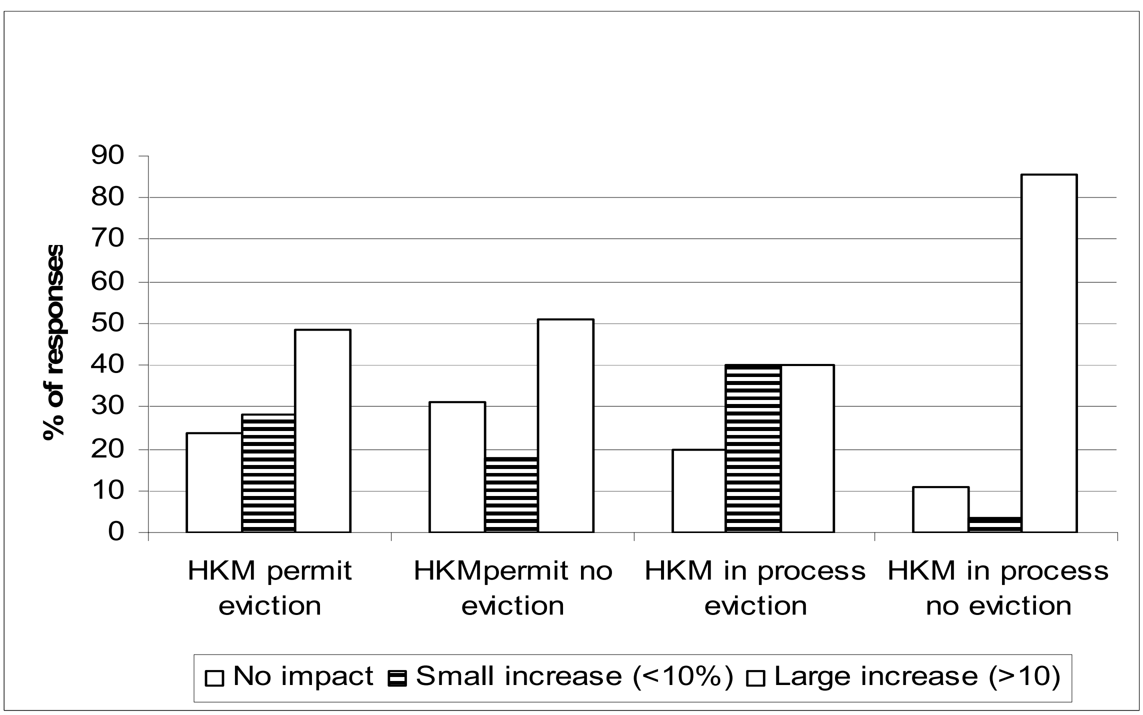
Almost all HKm groups we surveyed in the Sumberjaya watershed said they expected participation in HKm to increase their incomes (Figure 10). This is consistent with the expectations reported in the household survey by individual operators of HKm plots and PF plots with HKm applications pending, most of whom expected their incomes from the plots to increase as a result of the HKm program (Figure 11). A substantial fraction of those operators expected a large increase (more than 10 percent) in plot income. Respondents in the community survey (Kerr et al. 2006) said they expected income to increase with participation in HKm because they would cultivate more intensively and plant more coffee and fruit trees under the program. Some respondents further explained that increased tenure security would make them feel more confident about intensifying their cultivation.

Figure 10. Expected impacts of HKm on income



Source: HKm groups survey.

Figure 11. Expected impact of HKm on income from plot



Source: Household survey.

Descriptive statistics on the mean profits per hectare from plots of various tenure and HKm statuses are somewhat, but not fully, consistent with those perceptions (Table 12). Mean profits from private plots are higher than those from other plots, followed by NP plots, plots with HKm applications pending, plots with HKm permits, and PF plots without HKm permits. Next we tested for differences between profits on plots of different tenures and HKm statuses, controlling for other factors, using econometrics.

Table 12. Profits on plots of varying tenures and HKm status in 2005 (thousands of Rupiah/ha).

Land Tenure/HKm Category	Mean	Standard Error
National park	1,019.6	114.7
Private	1,968.8	201.4
HKm permit	767.6	145.0
HKm application pending	991.9	110.7
PF land without HKm	405.0	89.3

Econometric Model for Profits per Hectare

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

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

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 in equation (4) we used values of assets and other time-varying explanatory variables in 2005, rather than 2000. Two additional variables are included in the vector of plot-level variables (X_{pt}) that were not included in earlier specifications (because they were unavailable for the earlier period): 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 expected both variables to have a positive impact on the profitability of coffee and other tree crop production.

We estimated 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 village-level fixed effects (IV–no FE). We estimated the median regression with fixed effects because of concerns about outliers of the dependent variable (e.g., a substantial proportion of negative values) that might undermine the robustness of the results of OLS estimation. We estimated the IV model because of concerns about possible endogeneity of the HKm status variables, and we used this model to test the exogeneity of those variables. As in earlier IV regressions, the IV model was not estimable with fixed effects because the excluded instrumental variables used for identification are village-level variables.

Econometric Results

The results of the econometric models for determinants of profits per hectare are reported in Table 13. 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. In general, land tenure variables have limited direct impacts on profitability in these regressions.

Although land tenure and HKm status have limited direct impacts on profitability, those 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 found that the stock of multipurpose trees has a positive impact on profits. Because we found earlier that HKm contributes to planting of multipurpose trees, this provides evidence of indirect positive impacts of HKm on profitability. According to the PSM results in Table 8, an HKm permit results in households planting an estimated 473 more multipurpose trees per hectare than on comparable plots without HKm permits. Based on the OLS coefficient estimates shown in Table 13, the additional trees increase profits by an estimated 1,270 Rupiah per additional tree (1,120 Rupiah per tree in the median regression), so the estimated additional profit resulting from additional multipurpose trees as a result of an HKm permit is about 600,000 Rupiah per hectare (530,000 Rupiah per hectare using the median regression results). This represents a significant increase in farmers' incomes resulting from an HKm permit.

Because the HKm program also promotes increased planting of timber trees, and those trees were found to have a negative impact on profit in the OLS regression (–1,320 Rupiah per timber tree), the negative impacts may offset the positive profit impact of HKm through its effects on multipurpose 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 because this coefficient is statistically insignificant in the median regression.

Other factors that have robust effects on profits in both the OLS and median regressions include the value of farm equipment (+), buildings (+ but quantitatively very small), age of household head (–), membership in a coffee producers' group (+), membership in a labor-sharing group (–), and access to formal credit (+). Other factors having statistically significant (at the 5 percent level) impacts in at least one of the regressions include altitude of the plot (– in OLS regression), the share of organic carbon in the topsoil (+ in OLS), whether the plot was fallow in 2005 (– in median regression), the value of coffee land owned (+ in OLS), education of males (+ in OLS), the number of years the household had been settled in the village (+ in OLS), and access to technical assistance from the Agriculture Department (+ in OLS). These results indicate that farmers' access to physical, human, and natural capital; participation in coffee producers' organizations; and access to formal credit and technical assistance from the Agriculture Department contribute to higher profitability on coffee-agroforestry plots, while participation in labor-sharing groups is associated with lower profitability. The negative impact of participation in labor-sharing groups may reflect higher opportunity costs of labor for such households, which might limit the labor intensity of their management of coffee-agroforestry plots.

Table 13. Determinants of profits[1] (thousands of Rupiah/ha)

Explanatory Variable	OLS-FE[2]		Median-FE[2]		IV–No FE	
	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error
Land tenure variables						
Land tenure and HKm status (cf., national park 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)
How plot acquired (cf., encroached)						
- Inherited	-316.23	(256.52)	-255.06	(214.80)	168.04	(200.94)
- Purchased	-316.53*	(190.89)	-290.06	(195.75)	95.08	(141.70)
- Sharecropped	-200.59	(253.60)	-276.07	(184.13)	125.88	(220.15)
- Exchanged	1040.48**	(516.22)	562.61	(471.93)	983.17***	(314.14)
Plot characteristics						
Area (ha.)	15.29	(105.36)	28.77	(67.07)	-19.1	(64.15)
Soil color (cf., black)						
- Yellow	-223.58	(200.86)	21.57	(181.90)	8.37	(175.86)
- Red	124.32	(157.27)	-101.06	(149.49)	-26.28	(149.99)
- Brown	-150.1	(189.76)	-3.71	(241.28)	50.34	(130.51)
Soil texture (cf., loam)						
- Clay	250.97	(184.84)	198.37	(136.62)	248.05**	(118.10)
- Sand	437.15*	(224.66)	29.5	(370.76)	-331.11*	(201.09)
Altitude (m)	-2.70**	(1.05)	-0.27	(0.91)	-0.4	(0.56)
Average slope (%)	-2.3	(3.33)	0.94	(3.55)	-1.56	(2.61)
Position on slope (cf., bottom)						
- Top	215.89	(220.41)	34.86	(217.66)	123.91	(170.05)
- Middle	241.47	(187.31)	-161.89	(179.30)	12.56	(140.37)
- Top/middle/bottom	131.11	(339.22)	-29.63	(354.94)	551.93	(346.21)
Topsoil depth (cm)	21.54	(14.89)	-11.82	(9.21)	10.59	(9.16)
Organic carbon in topsoil in 2005 (%)	150.59**	(65.32)	39.08	(59.55)	59.34	(43.83)
Fallow/shrub land in 2005	-237.95	(366.60)	-460.64**	(208.03)	-631.26***	(179.85)
Stock of trees in 2005 (no./ha)						
- Timber	-1.32***	(0.50)	-0.85	(0.68)	-0.06	(0.42)
- Multipurpose	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)

Table 13. Continued

Explanatory Variable	OLS-FE²		Median-FE²		IV–No FE	
	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error
- 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)
Walking time from residence	-2.29	(1.72)	0.81	(2.48)	2.93	(1.92)
Walking time from home	-2.19	(1.71)	-1.91	(2.01)	-3.80**	(1.52)
GNRHL	13.32	(224.86)	2.49	(221.01)	-137.37	(151.47)
Household characteristics						
Value of assets in 2005 (millions of Rupiah)						
- Rice land	4.33	(2.67)	8.50*	(4.74)	9.53***	(2.23)
- Coffee land	7.25***	(2.66)	1.39	(2.74)	2.86	(2.07)
- Other land	3.16	(6.79)	-3.04	(5.94)	-8.46**	(3.43)
- Livestock	-28.89	(55.24)	-44.28	(52.79)	-44.64**	(20.98)
- Farm equipment	274.32**	(110.87)	178.02*	(104.63)	119.9	(79.15)
- Transportation equipment	-14.89	(14.80)	5.67	(11.46)	3	(9.55)
- Buildings	0.00*	0.00	0.00*	0.00	0	0.00
Ethnicity (cf., Sumendo)						
- Javanese	356.73*	(181.92)	218.65	(152.23)	48.15	(145.35)
- Sundanese	-354.93	(219.76)	85.29	(174.55)	26.7	(146.28)
Age of household head	-26.21***	(7.70)	-14.26**	(7.16)	-2.45	(5.49)
Dependency ratio	-243.83	(344.99)	206.39	(318.46)	79.79	(315.32)
Schooling of males	87.43***	(29.02)	38.04	(27.11)	76.97***	(20.95)
Schooling of females	46.24	(33.66)	15.77	(29.45)	32.52	(20.92)
Occupation nonagricultural	-296.67	(443.37)	497.26	(807.67)	345.28	(318.52)
Male head of household	515.41	(407.98)	-358.08	(780.19)	-343.84	(444.86)
Female share of labor	-1.32	(4.15)	0.85	(3.33)	1.37	(3.45)
Family size	-4.3	(52.06)	-49.41	(55.58)	-69.3	(43.66)
Years settled in village	16.54***	(4.79)	-1.17	(5.40)	0.84	(4.24)
Membership in groups						
- Coffee producers' group	1028.90***	(365.05)	913.91*	(536.59)	1550.71**	(611.96)
- Labor-sharing group	-546.91**	(238.49)	-339.89*	(186.53)	-18.78	(202.87)
Distance to output market (km)	-9.24	(17.98)	-10.32	(22.36)	5.53	(18.90)
Access to formal credit	382.25**	(152.49)	312.52**	(127.93)	197.95*	(119.46)
Access to technical assistance						
- ICRAF	469.99	(364.09)	256.83	(302.10)	187.7	(339.78)
- Forest Department	-43.24	(210.66)	-49.03	(187.74)	154.9	(164.32)
- Agriculture Department	642.20**	(284.22)	263.02	(263.18)	-90.75	(226.53)

Table 13. Continued

Explanatory Variable	OLS-FE[2]		Median-FE[2]		IV–No FE	
	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error
Intercept	2440.45*	(1372.55)	3163.28	(2030.20)	-200.06	(981.34)
N	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):					0.000***	
-HKm with permit					0.000***	
-HKm in process						

[1] Coefficients and standard errors adjusted for probability weights and stratification of sample, and standard errors computed using White's robust estimator.
[2] The village-level fixed effects coefficients are not reported to save space.
FE = village-level fixed effects; IV = instrumental variables; OLS = ordinary least squares.
ICRAF = World Agroforestry Centre.
*, **, *** mean the coefficient is statistically significant at the 10%, 5%, or 1% level, respectively.

Propensity Score Matching Results

The results of comparisons of profitability on PF plots with HKm permits, with HKm applications pending, and without HKm applications using PSM are presented in Table 14. We found no significant difference in profitability between HKm permit plots and similar plots with HKm applications pending or PF plots without HKm applications, but we did find significantly higher profits on plots with HKm applications pending than on PF plots without HKm applications.

Table 14. Comparison of profits per hectare between PF plots of varying HKm status using PSM[1].

Comparison	Mean	Standard Error2	Number of Observations3
HKm permit – HKm application in process	-326.1	382.0	270
HKm permit – PF land without HKm	-124.1	463.9	241
HKm application in process – PF land without HKm	589.5**	292.2	249

[1] Matching procedure: kernel matching with replacement, using the normal kernel. Comparison of HKm permit plots and PF land without HKm resulted in inability to estimate the model in most bootstrap replications, so this comparison was dropped.
[2] Standard errors computed using bootstrapping.
[3] Number of matched observations based on a requirement of common support of the treatment and control observation by dropping any treatment observation with a propensity score higher than the maximum or less than the minimum propensity score of the controls.
*, **, *** mean the coefficient is statistically significant at the 10%, 5%, or 1% level, respectively.

The insignificant differences between plots with HKm permits and other PF plots are consistent with the insignificant direct impacts of HKm status shown in Table 13. However, as noted in the previous subsection, an HKm permit should indirectly increase profitability by promoting planting of multipurpose trees. Because 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 reflect the indirect impact of HKm on profitability by its impact on tree planting after 2000. Our inability to find a significant difference between plots with HKm permits and PF plots without HKm permits in the PSM analysis may have resulted from 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 multipurpose trees may be offset by the impact on planting timber trees. That the process of applying for an HKm permit has a smaller impact on farmers' decisions to plant timber trees than it does on planting multipurpose trees (see Tables 6 and 8) may explain why we found higher profits on plots with HKm applications in process, as shown in Table 14. As with HKm permit plots, more multipurpose trees have been planted on plots with HKm applications in process, contributing to higher profitability, whereas less timber planting has occurred on those plots than on plots with HKm permits, with smaller offsetting negative impacts on profitability.

6. CONCLUSIONS AND IMPLICATIONS

Several key findings have emerged from our analysis of participation in, and impacts of, the HKm program in Sumberjaya:

- Operators of plots with an 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 have not applied for HKm permits and users of NP land. Thus, HKm appears to benefit poorer households because of the nature of the households that use eligible PF land and not because of any targeting in the implementation of the program.
- Households with HKm permits 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 from the Forest Department, ICRAF, or NGOs compared with operators of PF plots who have not applied for permits. Several of these differences (differences in education, membership in groups, and access to technical assistance) were confirmed as statistically significant in the econometric analysis, after controlling for other factors. Thus, human and social capital and access to 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 HKm permits than those that have applied but not yet received permits, suggesting that awareness improves in the process of obtaining the permit or after. 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 substantially increase 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 did 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. However, we did find that HKm permits contribute to increased planting of timber and multipurpose trees. This has mixed impacts on profitability of land use, because multipurpose 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 with comparable PF plots without HKm permits. Planting of multipurpose trees is also higher on plots with HKm applications pending, whereas timber tree planting is less affected by the application process. Possibly as a result, plots with HKm permits have higher profits than do PF plots without HKm permits.

These findings indicate that the HKm program is having positive impacts on planting of noncoffee trees by HKm permit holders and is contributing in a limited way to improving their incomes. Our finding that the holders of HKm permits are poorer on average than holders of private land suggests that 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 certain forms of technical assistance than users of PF land who have not applied for permits. This finding 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.

Other research by ICRAF and others has shown that planting timber and multipurpose trees provides environmental benefits. For example, multistrata coffee farms provide a complex canopy that protects the soil surface from heavy raindrops that cause erosion. The system creates tree litter on the garden floors that also helps weaken the erosion force of water (Hairiah et al. 2005; Van Noordwijk et al. 2004). Our finding that the HKm program has contributed to planting such multistrata agroforestry systems indicates that the program is achieving its objective of promoting provision of such environmental services, at least in the near term.

The findings of this study indicate generally favorable, though not overwhelming, impacts of the HKm program in the Sumberjaya watershed. The program is seen to be pro-poor and to provide some environmental services, suggesting the possibility of both reducing poverty and providing environmental services. This provides empirical support for continuing and expanding the program. At the same time, our findings suggest that implementation of the program could be improved through increased technical assistance to make it more accessible to eligible households that are not yet participating, and to increase awareness and understanding of the nature and requirements of the program. It is also advisable for the Forest Department to consider allowing HKm groups to harvest timber in a sustainable manner (with rotational replanting) from HKm areas, because the negative impact of timber planting on profitability may otherwise undermine compliance with the program as well as its potential to contribute to poverty reduction.

Our study is subject to important limitations that limit our ability to draw more definitive policy recommendations regarding the HKm program. First, this study was conducted in only one watershed. The results in this watershed may not be representative of the impacts occurring in other locations because of differences in ways the program is being implemented, in returns to compliance versus noncompliance, in local community cohesion and social capital, in access to appropriate technical assistance, and in other critical factors across different contexts. Second, we were not able to investigate the spillover effects of the program onto neighboring areas. For example, increased protection of forests in areas where HKm permits are functioning well may cause people to deforest other nearby forest areas. Further research on the impacts of HKm in other contexts is needed to address those issues.

Intertemporal spillovers could also occur. The prospect of receiving future secure-tenure permits to plant coffee in deforested state forestland could encourage people to clear forest in hopes of acquiring such rights. It is also not clear what will happen in the longer term after HKm groups receive longer-term HKm permits. Since this study was completed, several HKm groups in Sumberjaya watershed were granted definitive (25-year) permits. It remains to be seen whether those groups will continue to comply with program requirements. Once they feel assured of their tenure security, they may have less incentive to plant or preserve noncoffee trees in coffee plots unless such trees contribute to income. This problem is particularly likely to be of concern for management of timber trees, unless farmers are allowed to periodically harvest timber trees or tree planting and protection requirements are strictly enforced. Since multipurpose trees appear to be profitable, there will be less need to enforce requirements to maintain those trees after they have been planted. On the more positive side, as HKm groups become more assured of their tenure security, they may be more likely to make other land investments, the value of their land assets will be more likely to increase, and they are likely to be less subject to payment of bribes. Further research in Sumberjaya as well as other contexts, building on this study, would be useful to address such intertemporal issues.

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