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Land tenure and farm management efficiency: the case of paddy and cinnamon production in customary land areas of Sumatra

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This study attempts to identify the impacts of land tenure institutions on the efficiency of farm management based on a case study of lowland paddy (rice) and upland cinnamon production in customary land areas of Sumatra. While the traditional joint-family ownership system is found to exist in paddy land, more individualised ownership systems are widely observed in upland areas. Yet, we found no statistical evidence that residual profit per unit of land is affected by land tenure institutions in either the lowlands or uplands, indicating that the prevailing land tenure institutions are equally conducive to efficient farm management.

1. Introduction

While usufruct rights usually are well established under customary land tenure regimes, individual rights to transfer and inherit are limited and controlled by community and lineage leaders (Bassett 1993; Shepherd 1991). Such customary land tenure institutions, however, have evolved towards individualised tenure in response to population pressure and agricultural commercialisation in many parts of Asia and Africa (e.g. Ault and Rutman 1979; Bruce and Migot-Adholla 1993; Otsuka *et al.* 2001; Place and Otsuka 2000; Place and Otsuka 2001; Quisumbing *et al.* 2001).[1] Yet it is not well known whether and to what extent individual land rights are established under newly emerging tenure institutions. If individual rights are insecure, incentives to invest in land improvement will be thwarted (Besley 1995). Truly individualised and secure tenure institutions, however, may develop in customary land areas through induced institutional change, as envisaged by the evolutionary view of farming systems proposed by Boserup (1965), the

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[1] We believe there are more similarities than dissimilarities in land tenure rules between Sumatra and customary land areas of Sub-Saharan Africa.

theory of property rights formulated by Demsetz (1967) and Alchian and Demsetz (1973), and the theory of induced institutional innovation postulated by Hayami and Ruttan (1985) and Hayami (1997).

The quantitative literature on customary land tenure institutions so far has focused on the impact of different institutions on crop yields (e.g. Place and Hazell 1993) and on the incidence of commercial tree planting (e.g. Besley 1995; Otsuka *et al.* 2001). Crop yields and the incidence of tree planting, however, do not necessarily reflect the efficiency of farm management. In order to obtain more clear-cut implications of land tenure institutions for efficiency, we propose in this study to assess their impacts on the profitability of farm management by estimating the short-run profit functions and the internal rate of return to long-term investment in the establishment of commercial trees.

Specifically, we explore the effects of newly-emerging land tenure institutions on the efficiency of farm management based on a case study of paddy (rice) and cinnamon production in the Kerinci valley in West Sumatra.[2] In our study sites, the matrilineal system of inheritance in which land is bequeathed from a mother to her sisters, daughters, or nieces in accordance with the decision of lineage leaders, has traditionally been practised. This system has been replaced by an undifferentiated system of inheritance for daughters and sons in which land is bequeathed from either mother or father to both daughters and sons, whether jointly or individually. Furthermore, both paddy lands and upland fields are often sold to and purchased by community members. Such transactions are witnessed by village leaders and family members of both sellers and buyers to ensure proper protection of the transacted property. In this way, private property rights on land have been established. Reflecting the establishment of clear private land rights, tenancy contracts are widely observed. If factor markets, including land rental and labour markets, are perfect, household endowments of land and labour should not affect factor proportions across farms, since households will rent land or hire labour so as to equalise them. As a result, we expect that production cost, revenue, and profit per unit of area are independent from household factor endowments. In this study, we estimate the revenue, cost, and profit functions of paddy and cinnamon production, which include a variety of land tenure dummies and endowments of land and family labour among the explanatory variables. We also estimate the internal rate of return to investment in tree planting under different land tenure institutions based on the results of the estimated profit function.

[2] See Aumeeruddy (1994), who describes the ecological, cultural, and historical characteristics of the Kerinci Valley, with special reference to the development of cinnamon-based agroforestry.

The organisation of this article is as follows. We explain the selection of sites and sampling procedures of farm households and examine the prevailing land tenure institutions by land use type. We then assess the revenue, production cost, residual profit, and labour use in paddy and cinnamon production. After estimating the revenue, cost, and profit functions, we estimate the internal rates of return to investment in cinnamon trees. Finally, we conclude this article with the discussion of policy implications.

2. Sampling procedures

Our previous study on land tenure institutions in 60 communities located over wide areas of West Sumatra and Jambi Provinces discovered that the traditional matrilineal inheritance system has undergone substantial transformation (Otsuka *et al.* 2001). Table 1 shows the types of land tenure institutions that prevailed in our site. Traditionally land, particularly paddy fields, was owned collectively by a lineage or a group of kin members typically consisting of a grandmother, her husband, children, and grandchildren. Land is bequeathed to sisters, nieces, and daughters of deceased women, in accordance with the decision of a lineage head, who is selected from the male members of the second generation. The basic principle of land allocation is to maintain equity among lineage members, and individual land rights, other than usufruct rights, are highly restricted.

This system of lineage ownership, however, has disappeared in many areas. Joint-family ownership by daughters and sons, in which children jointly inherit the land, is common for paddy fields at present. The use of land is often rotated among siblings, rather than dividing it into smaller

Table 1 Land tenure categories and their major characteristics

Ownership categories	Owners	Inheritance to	Joint ownership
Lineage	Lineage members	Sisters, nieces, and daughters	Yes
Joint family I	Daughters	Daughters	Yes
Joint family II	Daughters and sons	Daughters and sons	Yes
Single family I	Daughters	Daughters	No
Single family II	Daughters and sons	Daughters and sons	No
Single family III	Sons	Son	No
Private	Single person or family	Daughters, or daughters and sons	No

plots, in order to prevent excessive fragmentation. Furthermore, single-family ownership by daughters and sons, in which both daughters and sons inherit the land individually, has become common for paddy land. For upland cinnamon tree fields, single-family ownership is widespread, and there are cases in which only sons inherit the land. In addition, 'private' ownership has been widely created; unlike family ownership acquired by inheritance, private ownership is acquired by purchase of land and clearance of communally-owned primary forests, particularly for upland fields.[3] Moreover, tenancy contracts are often employed, which indicates that rights to rent out are well established in customary areas.

In order to explore how far individualised land rights have been established under the joint- and single-family ownership by daughters and sons *vis-à-vis* private ownership and other tenure institutions, this study selected two typical cinnamon-growing villages in Kerinci District in Jambi Province (see figure 1). Almost all inhabitants belong to the Kerinci ethnic group, which traditionally has practised matrilineal descent.[4] We conducted a random sample survey of 50 households in each of the two contiguous villages with similar topographical, ecological, and socio-economic environments. Three rounds of the household survey were conducted in August/September 1996, February/March 1997, and August 1997.

As shown in table 2, we found 695 fields cultivated under joint-family ownership, other ownership systems, or tenancy or borrowing arrangements. Out of 695, 239 were lowland paddy fields. Note that a rotation system of cultivation is common under the joint-family ownership system, in which only qualified households cultivate the land in a particular year. Actually, 99 paddy fields, which were jointly owned, were cultivated by members of joint families other than selected sample households during the 1996/97 wet season. Therefore, we focus on 140 paddy fields actually cultivated by our sample households in this study. Among these, 82 per cent were irrigated by traditional simple gravity systems using streams flowing from nearby mountains, while the rest were rainfed. The average size of paddy field was

[3] As in Sub-Saharan Africa, private ownership is established by clearing natural forest because the labour effort required is viewed as creating a legitimate claim on land. This recognition of land clearing effort is a common feature of customary land tenure systems (Shepherd 1991). Individualised property rights on cleared forest land in Sumatra, however, may be subject to erosion over time unless it is planted to trees (Aumeeruddy 1994; Angelsen 1995; Otsuka *et al.* 2001).

[4] The traditional land inheritance rules followed in our study area in the Kerinci Valley are the same as the matrilineal system of the Minangkabau, the dominant ethnic group in the West Sumatra, which is described by Errington (1984), Kahn (1980), and many others.

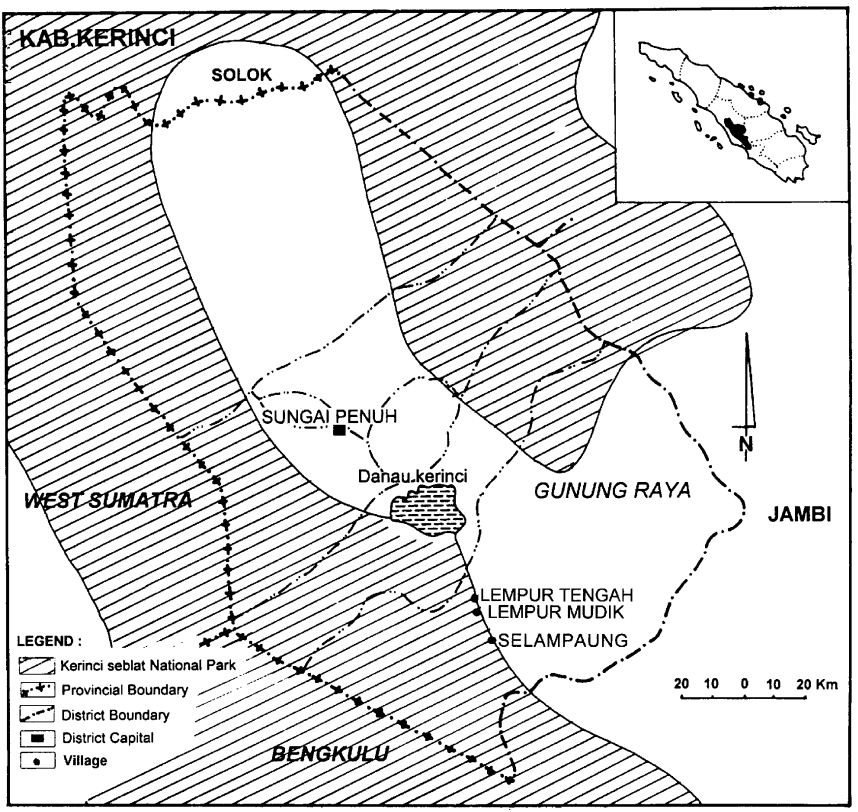

Figure 1 Location of study site

Table 2 Distribution and average size of owned/cultivated and sample plots by land use in selected villages in Sumatra

	Owned/cultivated plots [a]		Sample plots		
	No.	Average size (ha)	No.	Average size (ha)	No. of households
Total	695	0.96	378	0.75	100
Lowland rice fields	239	0.48	140	0.47	88
Young cinnamon fields [b]	155	1.20	63 [d]	0.70	46
Productive cinnamon fields [c]	264	1.18	175 [d]	0.99	79
Bush-fallow	37	1.60	0	–	33

Notes:
[a] Owned under joint-family ownership, owner-cultivated under other ownership systems, and cultivated under tenancy and borrowing arrangements.
[b] Young cinnamon fields refer to those with trees of age one to three.
[c] Productive cinnamon fields refer to those with trees of age four and above.
[d] Excluding those cinnamon fields intercropped with coffee.

less than a half-hectare and a typical household owned two to three plots, including jointly-owned plots.

Upland fields were divided into 155 young cinnamon fields with trees one to three years of age, 264 productive cinnamon fields with trees of age four to thirteen, and 37 bush-fallow fields. A considerable number of cinnamon fields were intercropped with coffee, even though cinnamon trees predominate. To simplify the analysis of profitability, we chose 63 young and 175 productive fields entirely planted to cinnamon for the detailed survey of production, input use, and cost.[5]

Indonesian cinnamon (*Cinnamomum burmanii*) — also called 'cassiavera' — accounts for roughly two-thirds of world supply of this species, which is ground from the bark. It is a different species from that in South Asia (*Cinnamomum verum)*. The bark of the South Asian species can be removed without cutting down the living trees. In the main harvest of Indonesian cinnamon, however, trees are felled before the bark is removed.

Most of Indonesia's cinnamon is produced in the Kerinci Valley, where our study sites are located. There, the main cinnamon harvest (when trees are felled) occurs after eight to ten years of growth. Coppices regrow after harvesting and this process can be repeated three times in most cases. Because of the declining rate of regrowth, trees are usually replanted after four harvests. Minor output is 'produced' when certain branches are pruned beginning with four years after planting or regrowth. Among the young cinnamon fields in our sample, 16 per cent were converted from bush-fallow land after clearance, 22 per cent were established after clearing old cinnamon fields and replanting, and 62 per cent were derived from regrowth after the main harvest. Young fields were intercropped with annual crops, mostly with chili; in our sample, 62 per cent were intercropped in the first year, 21 per cent in the second year, and 5 per cent in the third year. Intercropping intensity declines primarily because of the increasing competition for sunlight with growing trees.

Bush-fallow fields, which accounted for a small proportion of area, were generally located in areas far from village centres and were planted to food crops in the distant past. Only one-third of our sample households owned such land, which reflects the near exhaustion of easily accessible cultivable land in the Kerinci valley. At present, some of them are secondary forests.[6] Farmers sell standing cinnamon trees to local traders, who offer prices to

[5] Intercropping with coffee was practised to reduce the revenue risk of cinnamon monoculture. Insofar as coffee is a minor crop, the choice between cinnamon alone and cinnamon intercropped with coffee seems to be of secondary importance.

[6] The choice between growing cinnamon trees and maintaining bush-fallow fields is not explicitly analysed in this study because of the minor importance of the latter.

farmers based on their own assessment of the value of cinnamon in the field. Taking advantage of this practice, we employed traders in our survey and requested them to assess the value of standing cinnamon trees in all productive sample fields. We define the sum of the estimated value of trees and actual sale value of minor output as 'potential value of output' and the potential value net of total non-land cost as 'potential profit'. We used both of these variables in our statistical analysis. In our survey, we also measured the altitude and slope of plots to obtain information on land quality. Land quality may be affected not only by its physical characteristics but also by soil fertility, which is considered to be critically affected by the previous land cover (i.e., forest, cinnamon field, or bush fallow). Thus, we also investigated the previous land cover of our sample plots. It is expected that soil fertility is higher on land that has just been cleared from natural forests.

Our study of the impact of tenure on efficiency of production of cinnamon — and perennials more generally — under customary land tenure in Sumatra is complicated by the fact that planting trees influences informal tenure security just as expected tenure security influences the farmers' decision to plant. Thus, there is unavoidable simultaneity between tree planting and tenure in land (and trees). This problem does not exist for annuals, like paddy. Although there already is a substantial literature on relationships between tenure and production efficiency for paddy, it nevertheless is valuable to include both commodities in this study.

3. Land use and land tenure institutions

The prevailing land tenure institutions differ somewhat between lowland paddy fields and upland cinnamon fields. Table 3 shows the land tenure

Table 3 Land tenure distribution of sample plots by land use type (%)

Land tenure categories	Lowland rice	Young cinnamon	Productive cinnamon
Number of plots	239	155	264
Joint family:	24	0	0
Daughters	3	0	0
Daughters and sons	21	0	0
Single family:	28	37	43
Daughters	2	3	3
Daughters and sons	22	27	38
Sons	4	6	1
Borrowing	8	18	14
Private — purchase	10	18	24
Private — forest clearance	1	14	9
Share tenancy	19	14	10
Fixed-rent tenancy	11	0	0

distribution of all sample plots by land use type. There were varieties of land tenure institutions in lowland paddy fields, ranging from joint-family ownership to private tenure and to share and fixed-rent tenancy. It is remarkable that the traditional matrilineal inheritance system (joint family tenure, with inheritance by daughters) has almost completely given way to inheritance by daughters and sons alike, in both joint-family and single-family ownership systems. Because of the predominant importance of this inheritance system, we combined sub-categories in each family ownership system and used aggregated categories of joint family and single family ownership systems in our statistical analysis.

In order to assess the strength of property rights under different land tenure institutions, we asked sample farmers whether the cultivating household possess rights to rent out under share tenancy, rent out under fixed-rent leasehold tenancy, pawn, and sell with and without approval of family leaders for the various tenure categories. The right to rent out under share tenancy is the weakest right followed closely by the right to rent out under leasehold tenancy, whereas the strongest right rests in the right to sell without approval. There are stronger incentives to mine the soil under leasehold tenancy than share tenancy, because the whole marginal product accrues to leasehold tenants, unlike share tenants who receive only a portion of output (Hayami and Otsuka, 1993). Pawning is problem-ridden, because if a pawner cannot repay the loan, the land may eventually be confiscated by a pawnee. Farmers' answers were either 'yes without approval' or 'yes with approval', for all categories. Therefore, we characterised the strength of individual land rights in terms of the number of rights without requiring approval (see table 4). It is unreasonable to assume equal importance of each right and, hence, the number of rights should be understood as ordinal but not cardinal numbers.[7]

In the case of joint-family ownership of wet rice fields, a household that has the right to cultivate in a particular year also has rights to rent out under both share and fixed-rent tenancy without permission of other members of the 'joint family' (i.e., members of the extended family descended from a common grandmother). However, only around two-thirds of households in this category have the right to pawn without permission of other joint-family members. In the case of single-family ownership, respondents indicated that the cultivator possesses rights to rent out under share and fixed-rent tenancy and pawn without exception. The difference in land rights between joint- and single-family ownership systems lies in the extent to which pawning is

[7] Besley (1995) constructs a similar variable and treats it as a continuous variable for the regression analysis. This procedure, however, is highly problematic.

Table 4 Average number of land property rights under different land tenure [a]

	Joint family ownership	Single family ownership	Private ownership (purchased and cleared)
Paddy field	2.64	3.06	4.00
Upland fields [b]	n.a.	3.08	4.00

Notes:
[a] Four rights are considered; rights to rent out under share tenancy, rent out under leasehold tenancy, pawn, and to sell. Numbers refer to average number of rights without obtaining approval of the family.
[b] Upland field refers to both agroforestry plots and bush-fallow.

allowed. On the other hand, in the case of private ownership, perfect rights are granted including the right to sell without anybody's permission, even though land cannot be used as collateral for credit from formal financial institutions. Since our sample includes only one case of private ownership of a paddy field acquired by conversion from primary forest, we combined the private ownership acquired by both purchase and forest clearance in the statistical analysis. The common arrangement under share tenancy was output sharing between tenant and landowner in the ratio 2:1 without cost sharing, as is sometimes observed elsewhere in Asia (Hayami and Otsuka 1993; Otsuka *et al.* 1992).

The land tenure institutions of cinnamon fields were much more individualised (table 3). First of all, there was no joint-family ownership in this type of land. Individual land rights on upland fields were strong because the effort to plant and grow trees traditionally has been rewarded by strong individual land rights in Sumatra (Marsden 1811). As in the case of paddy fields, the rights to rent out under leasehold and share contract, pawn, and sell without permission of any family members existed only under private ownership (table 4). In the case of the single-family ownership system, right to sell without permission is generally not granted. Whether the difference in land rights between single-family ownership and private ownership leads to significantly different management efficiency of cinnamon fields is an important issue to be analysed statistically.

Renting under share tenancy contracts has also been observed, in which revenue from cinnamon was shared equally between landowner and tenant if planting or replanting is carried out by the tenant, and shared between them in the ratio 2:1, if trees were established prior to the tenancy. For annual crops intercropped with cinnamon seedlings, harvests were shared equally if current inputs were provided by the landowner or wholly given to the tenant if the tenant provided inputs. Share tenants and borrowers have cultivated the presently occupied land for 4.0 and 5.6 years, respectively, on average. The distribution of land tenure institutions was essentially no different between young and productive cinnamon fields.

Table 5 shows land use by land tenure before the current cohort of cinnamon trees was established. These data show that 13 per cent of both young and productive cinnamon fields under single-family ownership previously were bush fallow and 87 per cent were cinnamon fields. In the latter case, cinnamon was either replanted or coppiced after the previous cinnamon harvest. Significant numbers of cinnamon fields have been purchased and many others are operated under borrowing arrangements and share tenancy contracts, indicating that land market institutions are functioning. In the case of privately-owned plots acquired by clearing natural forest, 44 to 47 per cent had been used as cinnamon fields before current trees were established, 20 to 33 per cent previously were bush-fallow land, and less than one-third of the plots were converted directly from primary forest.

4. Revenue, cost and profit

In order to analyse how the prevailing land tenure institutions affect the profitability of cinnamon and paddy production, we estimated the residual profit, defined as gross revenue minus both actual and imputed costs of hired and family labour, and current and capital inputs. The residual profit thus defined is intended to measure the contribution of land, management inputs, and the intensity of labour effort, which cannot be directly measured. Moreover, because tenure security determines incentives to manage fields for future benefits (Besley 1995), it is reasonable to assume that after controlling for land quality, the differences in the residual profit can be attributed to the differences in tenure security. We therefore regressed the estimated residual profit on the land tenure variables and variables representing land quality, among other things.

Labour, particularly family labour, is the major cost item in the production of paddy and cinnamon. In order to estimate the total cost of production, we imputed the cost of family labour by activity and gender by using the relevant, prevailing wage rates of hired labourers. Wages of both male and female workers in the same activity under the same contractual arrangement (i.e., daily wage or piece rate contract) were quite uniform across our sample observations, suggesting that a standard wage existed in each activity in our sites. It is also found that both daily wages and piece rate contracts coexisted in many activities in both paddy and cinnamon production and that daily wages were substantially lower than daily earnings under piece rate contracts. Such uniform differences between daily wages and daily earnings under piece rate contracts are widely observed in rice-growing areas of Asia, which may be attributed to incentive-enhancing and self-selection effects of the latter contract (David and Otsuka 1994).

Daily wages and daily earnings used for the imputation of family labour

Table 5 Previous land use of current cinnamon fields by land tenure type

	Young cinnamon				Productive cinnamon			
		Previous land use (%)				Previous land use (%)		
	No. of plots	Bush-fallow	Cinnamon	Forest	No. of plots	Bush-fallow	Cinnamon	Forest
Single family	57	13	87	0	114	13	87	0
Borrowing	28	9	91	0	37	33	67	0
Private — purchase	28	0	100	0	63	21	79	0
Private — clearance	22	33	44	22	24	20	47	33
Share tenancy	20	11	89	0	20	22	78	0

Table 6 Average wage per day by crop and activity in Sumatra (rupiah/day) [a]

	Men	Women
Lowland rice fields		
Daily wage for land preparation [b]	5 036	3 787
	(184)	(28)
Daily earnings for weeding	4 644	3 683
	(6)	(80)
Daily earnings for harvesting and threshing	5 547	3 891
	(81)	(39)
Daily earnings for hauling	4 917	n.a.
	(6)	
Upland cinnamon fields		
Daily wage in annual crop production [c]	4 500	3 417
	(17)	(23)
Daily earnings for care of cinnamon	6 487	4 169
	(53)	(23)
Daily earnings for cinnamon harvesting	5 849	3 757 [c]
	(45)	(0)

Notes:
[a] Daily wage includes imputed value of food provided to hired labourers, whereas daily earnings refers to earnings per day under piece rate or output-sharing contracts. The numbers in parentheses indicate the number of observations used to take average values.
[b] The average wage for seedbed preparation, land preparation, and transplanting.
[c] The average wage of land preparation, planting both annual crops and seedlings of cinnamon, crop care, and harvesting of annual crops.

costs are shown in table 6. Wage income per day ranged from 4 500 to 6 500 rupiah (US$1.88 to US$2.71) for men and from 3 400 to 3 900 rupiah (US$1.42 to US$1.63) for women.[8] Since family labour is expected to work more intensively than daily wage workers, we used daily earnings under piece-rate contracts for the imputation whenever such contracts prevailed.[9] For this imputation for paddy production, we used the daily earnings, except for hauling in which only daily wage contracts were adopted. In the case of cinnamon fields, we used the average daily wage for annual crop production, and daily earnings for care of cinnamon (mostly weeding) and cinnamon harvesting.[10]

[8] The prevailing exchange rate of approximately US$1.00: 2 400 rupiah in 1996/97 was applied for the conversion from Indonesian rupiah to US dollars.

[9] Piece-rate contracts, whenever observed, were the dominant contractual arrangements.

[10] Since no woman was engaged in cinnamon harvesting as a hired labourer, we used the average female wage for other activities (land preparation, planting of annual crops and seedlings of cinnamon, crop care, and harvesting of annual crops) for the imputation of women's family labour cost in cinnamon harvesting.

Table 7 Labour use for rice production by activity and land tenure (person-days/hectare) [a]

	Joint family	Single family	Borrowing	Private	Share tenancy	Fixed-rent tenancy
Land preparation [c]	110	101	97	106	98	99
Transplanting	4	10	12	7	13	11
Crop care	67	56	69	62	61	55
Harvesting and threshing	38	39	45	36	48	43
Total	227	216	234	221	221	222
Proportion of female (%)	45	45	45	40	51	49

Notes:
[a] The sum of family and hired labour, including both male and female.
[b] The numbers in parentheses are sample sizes.
[c] Including seedbed preparation.

Labour use per hectare of paddy production by activity and land tenure institution is shown in table 7. Several important observations can be made. First, labour use per hectare, both total and activity-wise, was quite similar across different tenure systems, which suggests that tenure effects on labour allocation were relatively small. Although unreported, the average rice yields were also similar and clustered around 2.1 tons per hectare. Second, labour use was very high in absolute terms, despite the fact that the traditional, six-month varieties were grown. In fact, it is generally greater than that observed in well-irrigated paddy fields growing modern, high-yielding rice varieties in other parts of Asia, which are considered to be quite labour-intensive (David and Otsuka 1994). The high labour intensity suggests that paddy area was scarce relative to labour in our sites. Third, the proportion of female labour was about one-half, implying that both men and women worked more or less equally in paddy fields. There was, however, specialisation of work by gender, women worked primarily in weeding and harvesting, whereas men were engaged mostly in land preparation. The proportion of hired labour was approximately two-thirds, which indicates that the labour market is well developed in this area.

Table 8 shows labour use per hectare in cinnamon fields by gender and age of trees. Since farmers sell standing cinnamon trees to traders for the main harvest (when trees are felled), harvesting labour other than that for minor harvesting associated with pruning is not included. It is clear that in cinnamon fields, too, men and women worked more or less equally. Labour use per hectare was particularly high in the first year due to heavy labour requirements for land preparation, and planting of both cinnamon and annual crops. From the second year, labour requirements tended to decline as the proportion of fields planted to food crops and weeding requirements

Table 8 Labour use in cinnamon fields by gender and age of trees (person-days/hectare) [a]

Age of trees	No. of sample plots	Men	Women	Total
1	21	57.3 (85)	51.9 (78)	109.2 (82)
2	21	18.1 (80)	29.8 (31)	47.9 (49)
3	21	20.6 (67)	25.4 (58)	46.0 (62)
4	25	21.5 (20)	22.5 (9)	44.0 (14)
5	29	15.1 (58)	5.5 (85)	20.7 (65)
6	28	17.5 (32)	3.6 (36)	21.1 (33)
7	30	17.6 (27)	17.4 (9)	35.0?? (18)
8	23	11.5 (33)	8.7 (0)	20.2 (19)
9	6	14.0 (75)	12.5 (0)	26.5 (40)
10	18	7.5 (39)	2.6 (69)	10.1 (47)
11	5	8.3 (13)	0.0 –	8.3 (13)
12	8	15.4 (10)	0.0 –	15.4 (10)
13	3	6.7 (45)	1.7 (100)	8.3 (57)

Note: [a] Numbers in parentheses are proportions of family labour.

declined. Family labour was used mostly in the first three years, whereas hired labour was heavily employed for such simple tasks as weeding in later stages of tree growth. The number of observations declined for fields with trees of age eight and above because most cinnamon trees were harvested at the age of eight to ten years.

Using average wages to impute family labour costs, table 9 shows estimates of revenue, total cost, and the residual profit of rice production by land tenure institution, including the costs of current inputs (such as seeds and chemical fertiliser) and capital services (water buffaloes for land preparation, trucks for hauling, and mechanical threshing). The costs of

Table 9 Gross revenue, production costs, and residual profit of rice production per hectare by land tenure ('000 rupiah/hectare')

	Joint family	Single family	Borrowing	Private	Share tenancy	Fixed-rent tenancy
Gross revenue	2 151	2 130	1 806	2 074	1 940	2 164
Cost of current inputs	51	50	45	44	41	49
Cost of capital inputs [a]	240	226	172	214	212	205
Cost of labour	1 081	1 018	1 151	977	1 059	1 124
(% of hired labour)	(77)	(75)	(72)	(73)	(58)	(78)
Residual profit	779	835	438	839	629	786

Note: [a] Including the cost of water buffalo for land preparation, the payment for hauling output from fields to farmer's house by truck with a driver, and the payment for mechanical threshing.

current inputs and capital accounted for only a small portion of total cost,[11] whereas labour accounted for about 50 per cent. This is not surprising given the high labour intensity of the paddy cultivation system employed in the study area. It is more remarkable to observe that not only gross revenue but also the cost of each item and the residual profit were quite similar among different land tenure institutions. Borrowed land, which exhibits lower values of revenue, total cost, and profit, is an exception to this pattern. These observations suggest that, despite differences among the prevailing tenure institutions, these institutional differences do not have a significant influence on the efficiency of paddy production. This may be explained partly by the fact that while the lack of tenure security may affect long-term investment incentives, rice is an annual crop and the simple gravity irrigation system requires little investment to establish or maintain. It may also be the case that practices that would degrade land, which in principle would arise under the rotation system of jointly-owned plots, were effectively prevented by mutual enforcement mechanisms operating in the joint ownership arrangements within extended families.

Also, note that the proportion of hired labour is quite high: even under share tenancy more than 50 per cent of the labour cost was accounted for by wage payments to hired labour. Some of the hired labourers were small-scale farmers in the villages and others were seasonal migrants from other areas. This high incidence of hired labour suggests that the labour market worked effectively in our sites.

[11] We also imputed the cost of family-owned buffalo and threshing machines, even though they were relatively minor cost items.

Table 10 Potential value, production costs, and potential profit of upland cultivation by age of cinnamon trees ('000 rupiah)

Age	Potential value [a] (1)	Labour cost [b] (2)	Cost of current inputs (3)	Total cost (2) + (3)	Potential profit (1) − (2) − (3)
1 (Plantation)	457	649	126	775	318
1 (Regrowth)	553	328	66	394	158
2 (Plantation)	214	134	2	135	79
2 (Regrowth)	154	282	11	293	−140
3 (Plantation)	38	256	8	264	−226
3 (Regrowth)	82	198	9	206	−124
4	1 071	209	2	211	860
5	1 334	116	0	116	1 218
6	2 441	119	2	121	2 319
7	3 949	127	10	137	3 813
8	4 096	98	0	98	3 995
9	5 616	144	0	144	5 472
10	6 408	64	19	83	6 325
11	7 931	45	0	45	7 886
12	9 271	83	0	83	9 189
13	11 125	44	0	44	11 081

Notes:
[a] Actual revenue from food production for age 1 to 3 years and the value of cinnamon trees estimated by traders for age 4 years and above.
[b] Imputed cost of family labour by the prevailing wages plus cost of hired labour.

The potential value of production, labour costs, current input costs (mostly chemical fertiliser for annual crops), and the potential profit of cinnamon fields are shown by age of trees in table 10. For young cinnamon plots, data are shown by previous land cover (i.e., clearance of a previous cinnamon field, a bush-fallow field, or forest, and coppicing). Clearance of different types of fields was combined because of the limited number of observations and the similarity of costs of clearing among the three cases. The total cost was substantially higher and the value of production was lower in planted fields than in coppiced fields in the first year primarily because of the cost of clearing fields before planting. In the second year, however, the total cost became higher and revenue became smaller in coppiced fields because of the larger labour requirements for weeding. The difference in production cost, as well as the residual profit, became smaller by the third year. For the productive fields with trees aged four years and above, differences between planting and coppicing were negligible. The potential value of production and potential profit increase monotonically as trees age. Note that production and cost data in the very old fields must be interpreted with caution. Since cinnamon trees are generally felled between eight and ten years of age, data for older trees, which represent only a subset of trees planted in the same year, probably are subject to selection bias.

5. Statistical analysis

In this section, we estimate the revenue or potential value, total cost, and actual or potential residual profit functions separately for paddy production and productive cinnamon fields by the ordinary least squares regression method. Dependent variables are expressed as values per hectare. We took logarithms for continuous variables other than ratios. Since the residual profits are negative in about two-thirds of the young cinnamon fields, we used a linear specification in the regression analysis unreported in this article.[12] Since no cost was incurred in some cases in the management of productive cinnamon fields, we did not estimate the cost function for productive cinnamon fields. We assume that land tenure institutions are predetermined for each household (see Otsuka *et al.* 2001 for discussion of the evolution of these institutions at the community level). Based on the discussions so far, we intend to test the following hypotheses:

Hypothesis 1: There were no significant differences in farm management efficiency among the prevailing family ownership and private ownership systems.

Hypothesis 2: Factor markets, including both land and labour markets, worked effectively to equalise output, cost, and profit per hectare among fields owned by households endowed with different amounts of land and family labour.

The validity of hypothesis 1 can be tested by examining the significance of dummy variables representing various land tenure institutions. One may question this approach, however, since privately owned land acquired by purchase and forest clearance is endogenously determined and, as a result, estimated coefficients may be biased. To the extent that decisions to purchase upland areas and to clear forests are made by households with a comparative advantage in growing cinnamon, there will be an upward bias in the coefficient of private ownership. *A priori*, we expect private ownership to be at least as efficient as family ownership. Therefore, the potential bias, if it exists, would be unfavorable for hypothesis 1.

The validity of hypothesis 2 can be tested by examining the coefficients of tenancy dummies and those variables representing the endowment of owned land and family labour, which are expressed as total cultivated paddy and cinnamon areas, ratio of paddy areas, the total number of male and female family workers between 16 and 60 years of age, and the ratio of female workers. If none of these is significant in any of the regressions, the

[12] We also estimated similar functions for young cinnamon fields.

Table 11 Means of explanatory variables for plot-level analysis on lowland rice and upland crop production by type of field

	Paddy land	Productive cinnamon
Year of land acquisition	1983	1983
Walking time (minutes)	24.3	86.3
Altitude (m)	n.a. [a]	1 082
Slope (degree)	n.a. [a]	11.66
Total cultivated area (ha) [b]	5.17	6.19
Ratio of paddy	0.23	0.18
No. of family workers [c]	2.44	2.37
Ratio of female workers	0.53	0.55
Age of head	43.3	42.9
Schooling of head (years)	8.0	8.1

Notes:
[a] Not measured.
[b] Including areas under joint-family ownership.
[c] Number of male or female family members between 16 and 60 years of age.

hypothesis of functioning factor markets, which will tend to equalise factor proportions in different fields, is not rejected.

Means of explanatory variables, other than land tenure variables, are shown by type of field in table 11. The majority of sample fields were acquired more than ten years ago. Cinnamon fields were located far from residential areas. Household characteristics represented by ownership of paddy and cinnamon fields, endowment of male and female family workers, and age and schooling of the male household head, were not substantially different across different types of fields.

Estimation results of gross value of output, total cost, and the residual profit functions of paddy production are shown in table 12, in which joint-family ownership is used as the base for comparison of land tenure effects. The fits of the regressions are poor, as reflected in low values of R^2. This can be explained primarily by relatively homogeneous conditions of paddy fields, which tend to reduce variations in output and cost per unit of land area. None of the coefficients of the three land tenure dummies is significant in any of the three functions, implying that resource allocation under joint-family ownership is no different from that under single-family and private ownership systems and borrowing arrangement. These findings support our first hypothesis that the prevailing land tenure institutions do not affect farm management efficiency. These results are consistent with earlier findings by Place and Hazell (1993) that land tenure institutions do not affect crop yields in customary land areas of selected Sub-Saharan countries.

The two tenancy variables are not significant either, which is consistent with the general finding that land tenancy contracts do not distort work incentives (Hayami and Otsuka 1993). Moreover, there also is no evidence

Table 12 Estimation results of gross value of output, total cost, and residual profit functions of rice production [a]

	Gross revenue	Total cost	Residual profit
Intercept	7.58	7.67	5.51
	(0.58)	(0.66)	(1.04)
Rainfed dummy	0.04	−0.04	0.26
	(0.09)	(0.10)	(0.16)
Walking time	−0.03	−0.001	−0.08
	(0.03)	(0.04)	(0.06)
Age of head	0.08	−0.06	0.36
	(0.15)	(0.17)	(0.27)
Schooling of head	−0.01	−0.02	−0.001
	(0.06)	(0.06)	(0.10)
Cultivated land area	−0.001	−0.01	0.02
	(0.01)	(0.02)	(0.03)
Ratio of paddy area	−0.34*	−0.47**	−0.20
	(0.16)	(0.19)	(0.30)
No. family workers	0.02	0.02	0.02
	(0.02)	(0.02)	(0.03)
Ratio of female workers	−0.19	−0.25	−0.21
	(0.17)	(0.19)	(0.30)
Single-family	−0.02	−0.02	−0.06
	(0.09)	(0.10)	(0.17)
Private	−0.03	−0.05	−0.13
	(0.13)	(0.15)	(0.23)
Borrowing	−0.07	−0.10	−0.02
	(0.15)	(0.16)	(0.26)
Share tenancy	−0.09	−0.11	−0.17
	(0.11)	(0.12)	(0.19)
Fixed-rent tenancy	−0.04	−0.14	−0.07
	(0.12)	(0.13)	(0.22)
R^2	0.07	0.10	0.10
Number of sample	135	135	135

Notes:
[a] Dependent variables are expressed as values per hectare. Numbers in parentheses are standard errors.
* indicates significance at 5 per cent level.
** indicates significance at 1 per cent level.

that resource endowments of households significantly affect profitability of paddy production, even though the ratio of paddy areas affects gross revenue and total costs. The overall findings are consistent with the second

Table 13 Estimation results of potential value, total cost, and potential profit functions for productive cinnamon fields [a]

	Potential value	Potential profit
Intercept	15.02 (4.17)	17.26 (4.67)
Age 5 dummy	0.14 (0.17)	0.21 (0.19)
Age 6 dummy	0.75** (0.18)	0.98** (0.20)
Age 7 dummy	1.32** (0.17)	1.57** (0.19)
Age 8 dummy	1.29** (0.19)	1.53** (0.21)
Age 9 dummy	1.30** (0.29)	1.51** (0.32)
Age 10 dummy	1.94** (0.20)	2.18** (0.23)
Age 11 dummy	1.75** (0.31)	2.08** (0.35)
Age 12 dummy	2.38** (0.26)	2.63** (0.29)
Age 13 dummy	2.63** (0.38)	2.91** (0.42)
Slope	−0.01 (0.01)	−0.01 (0.01)
Altitude	−1.11* (0.56)	−1.45* (0.62)
Dummy for forest before	0.39 (0.36)	0.41 (0.40)
Dummy for bush-fallow before	0.03 (0.13)	0.02 (0.15)
Age of head	−0.009 (0.21)	−0.06 (0.23)
Schooling of head	−0.10 (0.08)	−0.17 (0.09)
Walking time	−0.03 (0.06)	0.01 (0.06)
Cultivated land area	0.004 (0.03)	0.01 (0.03)
Ratio of paddy area	−0.24 (0.28)	−0.44 (0.32)
No. family workers	0.01 (0.04)	0.009 (0.04)

Table 13 Estimation results of potential value, total cost, and potential profit functions for productive cinnamon fields[a] — *continued*

	Potential value	Potential profit
Ratio of female workers	−0.24	−0.43
	(0.28)	(0.32)
Private — purchase	−0.21	−0.19
	(0.13)	(0.14)
Private — clearance	0.06	0.07
	(0.22)	(0.24)
Share tenancy	0.14	0.17
	(0.17)	(0.19)
Borrowing	0.17	0.19
	(0.16)	(0.18)
R^2	0.64	0.64
Number of sample	170	170

Notes:
[a] Dependent variables are expressed as values per hectare. Numbers in parentheses are standard errors.
* indicates significance at 5 per cent level.
** indicates significance at 1 per cent level.

hypothesis that factor markets, including land rental and hired labour markets, function well.

According to the results unreported here, neither the land and labour endowment variables nor the share tenancy dummies are significant, adding support to hypothesis 2 that factor markets work well.[13] Furthermore, none of the land tenure variables except borrowing is significant, which supports the hypothesis that the customary land tenure institutions provide sufficient tenure security at levels comparable to private ownership.

Table 13 presents results for productive cinnamon fields. We used nine tree age dummies and four variables related to land quality,[14] namely, slope, altitude and two dummy variables representing the previous land cover. Altitude has negative and significant effects on the potential value and profit,

[13] Since residual profits are often negative in the management of young cinnamon fields, we applied linear specifications for the estimation of gross revenue, cost of production, and profit functions.

[14] Considering the possibility of selectivity bias arising from the fact that some cinnamon trees were harvested after the eighth year, we re-estimated all three functions by excluding those fields whose trees were nine years of age and older. Both the magnitude and significance of the remaining variables, however, remain largely unchanged.

which is consistent with the common perception of farmers in this area that trees grow less well and water content of bark tends to be higher at higher altitudes within the Kerinci Valley. Land cleared from forest, however, does not have a significant effect.

It is remarkable to find that neither the factor endowment variables nor private land tenure, share tenancy, and borrowing dummies have significant effects on potential value and potential profit. It may well be that the expected land rights under the single family ownership system are enhanced after tree planting so as to equalise them with those under private ownership systems. These results strongly support our hypotheses that customary land tenure institutions ensure sufficiently strong tenure security and that factor markets work well in customary land areas.

6. Estimation of internal rate of return

In order to assess the profitability of investments in cinnamon trees, we computed the internal rate of return by land tenure type under the assumption of an eight-year interval between major cinnamon harvests based on the estimated profit functions shown in table 13. In computing net profits, we assume that bush-fallow land is cleared in the first growth cycle and that cinnamon trees are regrown three times thereafter, which was reported to be the common practice by farmers. We used the average values of variables pertaining to plot and household characteristics and their estimated coefficients, and the coefficients of tree ages and land tenure dummies. Unreported results for linear profit function estimates for young cinnamon trees and linear cost function estimates for productive cinnamon trees were used to derive cash flows from the first year to seventh year. Finally, the profit function result for productive cinnamon was the basis for the estimate of profit from the main harvest in the eighth year.

The estimates of internal rates of return are 40 per cent for single-family ownership, 24 per cent for private ownership through purchase, and 28 per cent for private ownership through clearance of forest (table 14). Note that these estimates are not significantly different, as none of the land tenure

Table 14 Estimates of internal rates of return to investment in cinnamon trees by land tenure (%)

Land tenure	IRR
Single family	40
Purchase	24
Forest clearance	28

dummies was significant in the regression analyses of profits and cost on both young and productive cinnamon fields. The estimated returns are quite high, which indicates that cinnamon is quite profitable. The high profitability of cinnamon production is consistent not only with the expansion of cinnamon areas in Kerinci but also with the transformation of the customary land tenure system towards individualisation, which is conducive to investment in trees (also see Suyanto *et al.* 2001 for similar results for rubber).

These high rates of return on investment may be explained in part by the lack of access to credit because of credit market imperfections, which, in turn, may be explained partly by the absence of collateral value of land due to the lack of land titles, as argued by Feder *et al.* (1988). As we discuss in the concluding section, however, the most likely explanation is restricted access to new land for cinnamon planting. In any event, since these high rates of return are found under private ownership as well as traditional tenure systems, they cannot be attributed to any deficiency of customary land tenure institutions.

7. Policy implications

This study provides support for our hypothesis that traditional land tenure institutions in customary land areas of Sumatra have evolved sufficiently to achieve farm management efficiency comparable to private ownership in both lowland paddy and upland cinnamon production. The efficient management of cinnamon fields under single-family ownership is particularly noteworthy, as this suggests that sufficiently strong incentives to invest in management of agroforestry are provided under this newly emerging ownership system. Furthermore, the estimated internal rates of return to investment in cinnamon trees support the hypothesis that investment in cinnamon trees has high payoffs. This explains why uncultivated bush-fallow land has largely disappeared and has been replaced by more intensive use of land through tree planting in our study sites. It is also likely that the conversion of bush-fallow land to cinnamon fields was facilitated by the individualisation of customary land tenure systems.

We also have obtained evidence that land rental and labour markets effectively allocate resources efficiently among households endowed with different proportions of land and labour. Tenure security established under the prevailing land tenure institutions is likely to have contributed to the formation of smoothly functioning factor markets because security of ownership is a prerequisite for efficient factor market transactions.

In sum, the evolution of customary tenure institutions and factor markets seems effective in achieving a financially efficient allocation of resources in the short run and accumulation of investments in agroforestry trees over

time. At present, property rights in land (and trees) are well recognised and respected among community members, so that there does not seem to be much room for improving investment incentives by strengthening individual rights within these indigenous societies. However, we do not mean to suggest that a land titling program is unnecessary to further enhance management efficiency in the long run. Due to the lack of official titles, land cannot be used as collateral for credit from formal financial institutions. However, as others have recognised for the case of Sub-Saharan Africa (Feder and Noronha 1987; Migot-Adholla *et al.* 1991), there also are important questions about the administrative feasibility and cost effectiveness of formal land titling at this time in Indonesia. Moreover, expansion of formal credit institutions into these relatively remote areas is likely to be a slow process, which further undermines the urgency of efforts to establish formal land titles.

The Kerinci Valley, where our study sites are located, is an enclave surrounded by the Kerinci Seblat National Park, one of the largest parks in Sumatra. The highest plant biodiversity richness measured to date anywhere in the world recently was recorded in areas surrounding this park (A. Gillison, pers. comm.). The high rates of return to investment in cinnamon production in the study area result from efforts by the Forestry Department to restrict conversion of natural forest in the park combined with the significant share of world cinnamon supply produced in the study area.[15] Restriction of expansion of cinnamon production in the Kerinci Valley, which accounts for roughly one-third of world supply of the spice, and growing world demand have increased prices.[16] In turn, higher prices have caused farmers to experiment with planting cinnamon in other parts of Sumatra and Borneo, often at elevations much lower than the Kerinci Valley and sometimes converting forest land that is not as suited to cinnamon production. This raises the possibility, which is yet to be verified, that efforts to save forest land in the Kerinci Seblat National Park may be offset (at least partly), by forest conversion elsewhere in Indonesia.

This study shows that institutional innovation by local communities can establish efficient incentives for production and investment from a private, financial perspective. But it is unrealistic to expect local communities also to supply substitutes for natural forests' many ecological and environmental

[15] The estimated internal rates of return were almost unchanged when we assumed that trees were harvested every ten years.

[16] It is estimated that during the period from 1981 to 1996 the real domestic price of cinnamon increased by 7 per cent per annum. If farmers expect an increasing trend in the cinnamon price, the estimated internal rates of return may still underestimate farmers' expected returns.

services, including abatement of negative environmental externalities of land use change (flooding, siltation, and smoke that impedes aviation and harms public health) and global public goods (carbon sequestration and biodiversity conservation). Our evidence shows that in this case, local farmers' opportunity costs of leaving forests untouched are extremely high. Moreover, no effective mechanism yet exists to compensate these farmers directly for production and investment opportunities foregone in favour of natural forest conservation. The search for workable, incentive-compatible institutional mechanisms that can clarify, monitor, enforce, and compensate for a more socially optimal mix of agricultural production and environmental services deserves high priority. Our hope is that insights from this research on the dynamics of indigenous land and tree tenure institutions can contribute to constructive approaches to address these complex natural resource policy issues.

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