Agroforestry Management in Sumatra

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Indonesia is endowed with rich tropical rainforests in its outer islands, including Sumatra, Kalimatan, and Irian Jaya. These are primary forests covering more than 100 million hectares of the nation and representing 10 percent of the world's remaining tropical forest (World Bank 1998). Rapid deforestation, however, has been taking place in this country, which has been the second most conspicuous in the world in terms of lost forest area. FAO (1990) estimates that forest cover of the country had declined from 74 percent to 56 percent during the past 30–40 years. The World Bank (1990) reports that the estimated deforestation rate was 1 million hectares per year in 1990, which is 67 percent higher than in 1981.

Population pressure is considered to be the most important factor underlying the rapid deforestation in Indonesia. Using provincial data, Fraser (1998) finds a strong inverse correlation between population density and forest cover. The population of Indonesia increased dramatically from 77 million in 1950 to almost 195 million in 1995. The majority of the population still relies on agriculture as a source of employment and income. In 1990, 57 percent of the labor force was engaged in agriculture, which contributed to 16.5 percent of the GDP.

Forest conversion for farming purposes by traditional shifting cultivators and spontaneous migrants is an immediate cause of deforestation (Dick 1991). In addition, the establishment of large private estates for the production of timber and commercial tree crops, government-sponsored resettlement schemes (called transmigration), and forest fires have also significantly contributed to deforestation in Indonesia.

The rate of reduction in forest area in Sumatra is the highest in the nation (Dick 1991). The forest cover in Sumatra decreased from 72 percent in 1950 to 48 percent in 1985, whereas it declined from 88 percent to 72 percent for the same period in Kalimatan (Fraser 1998). As a result of rapid population growth, population density increased from 17 people per square kilometer in 1930 to 85

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people per square kilometer in 1995 in Sumatra. How to preserve forest conditions while providing sufficient job opportunities for the growing population is a major development issue in Sumatra.

The major farming system in Sumatra has changed from shifting-cultivation systems to more intensive, tree-based farming systems. The traditional shifting cultivation with a long fallow period has become unsustainable, as the land frontier has gradually closed. In fact, as population pressure increases and land becomes scarce, the fallow periods tend to become too short for sustainable food crop production. Agroforestry systems, which produce such commercial trees as rubber (*Hevea braziliensis*), cinnamon (*Cinnamomum burmannii*), and coffee (*Coffea canephora*), have become common in the study areas where shifting cultivation used to be practiced on sloped areas (de Foresta and Michon 1990). If successful, the development of agroforestry will contribute to the enhancement of incomes in rural population and the prevention of soil erosion and other negative consequences of deforestation.

Establishment of agroforestry requires significant investment in the form of work effort in land preparation, tree planting, weeding, and pruning, for which property right institutions need to provide appropriate incentives. As elsewhere, customary land tenure institutions in Sumatra seem to evolve toward individualization with greater tenure security, which would have a positive influence on the development of agroforestry and the intensity of land use.

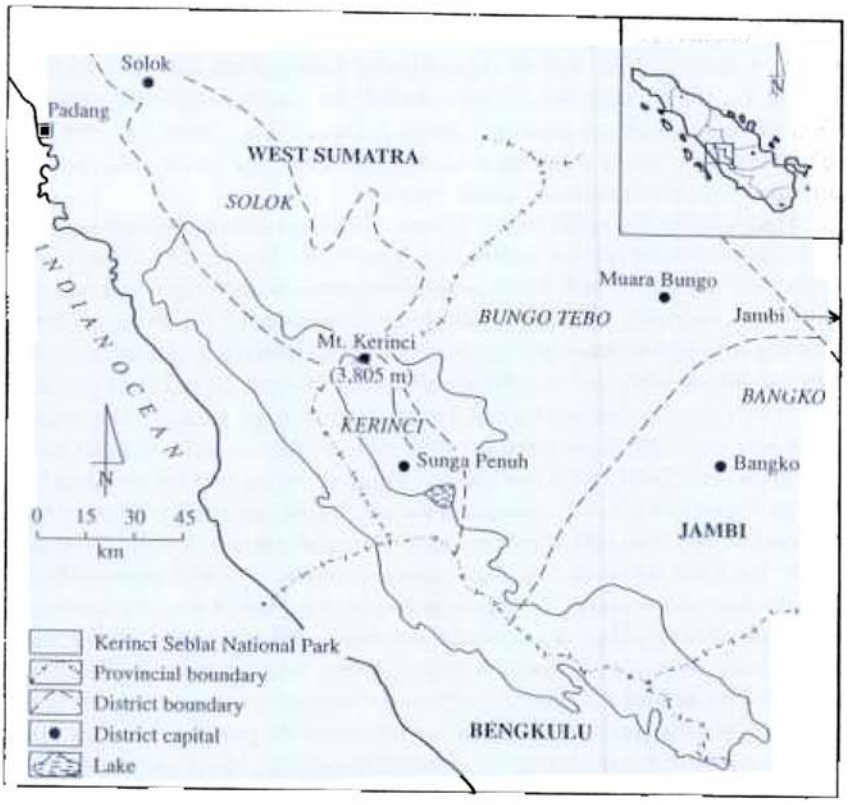
Yet little is known about the evolution of customary land tenure institutions and their consequences on land use and agroforestry management in Sumatra, not to mention appropriate polices the government should adopt to support efficient and equitable evolution of the customary land tenure institutions. The purposes of this study are to identify the causes of the land tenure evolution and to assess its consequences on the efficiency of land and tree resource management.

Organization of this chapter is as follows. Following the introductory section, we present characteristics of land tenure institutions with a special focus on changes from joint family ownership of land to individual ownership that is accompanied by changes from matrilineal to egalitarian or even to patrilineal inheritance systems. After identifying major empirical issues and specifying the testable hypotheses, we carry out econometric analyses to test those hypotheses, separately for extensive and intensive survey studies. We also attempt to analyze the effects of newly emerging land rental and land market transactions on the equity of operational landholdings. The final section discusses policy implications of the findings.

Customary Tenure Systems in Sumatra Sites

In the extensive survey conducted in 1995, we selected 60 villages randomly with probability proportional to village population from four districts in Suma-

FIGURE 4.1 Location of study sites in Sumatra



tra: Solok in West Sumatra Province, Kerinci, Bungo Tebo, and Bangko in Jambi Province along the buffer zone of the Kerinci Seblat National Park (see Figure 4.1). Solok, which we call the high region in this study, is located at the highest elevation, more than 1,000 meters above sea level. The major tree crop is coffee, though the area planted to cinnamon has been increasing. Kerinci is called the middle region, where cinnamon is a major tree crop. Bungo Tebo and Bangko are adjacent districts located in a low-lying area, where rubber is the major tree crop. Since our sites in these two districts are similar in terms of ethnic composition, climate, and topography, we lump them together and call this the low region.[1]

1. For more information on the dominant farming systems in Sumatra, see Angelson (1994, 1995) for shifting cultivation, Aumeeruddy (1994) on cinnamon, and Barlow and Muharminto (1982), Barlow and Jayasuriya (1984), Gouyon, de Foresta, and Levang (1993), and Penot (1997) on rubber.

We collected information about the prevailing land tenure institutions and land rights through a group interview of village leaders and farmers. In addition, we conducted a brief interview of five farmers in each location to inquire into the manner and the date of acquisition of land and the incidence of tree planting. For the intensive survey, we selected two cinnamon-growing villages in Kerinci and two rubber-growing villages in Bungo Tebo. Since the results of the two intensive survey studies (cinnamon and rubber) are very similar, we report only the case of cinnamon in this chapter.[2]

Traditionally, the major ethnic groups—Minangkabau in the high region, Kerinci in the middle region, and Melayu Jambi in the low region—have relied on wet rice cultivation, and, hence, areas along streams and rivers are predominantly used for paddy fields. Paddy fields are surrounded by agroforestry plots, including both mature trees and newly planted trees intercropped with annuals, and bush-fallow plots under shifting cultivation. Natural forests are typically located in the mountainous terrain farther from village centers. The bush-fallow area originally was converted from primary forests and is planted with food crops periodically for a few seasons followed by another fallow period.

As shown in Table 4.1, villages in the high region are endowed with large paddy areas, whereas paddy fields account for a small portion of land in the low region. The bush-fallow area is smallest in the middle region in terms of both absolute area and relative proportion in the total exploited area. In contrast, large tracts of bush-fallow remain in the low region. Unfortunately, official statistics do not distinguish between secondary forest, which is a part of the bush-fallow system, and primary forest, and farmers' estimates of primary forest area are subject to substantial errors. Thus, we estimated the primary forest area by subtracting the total exploited area estimated by a group of farmers from the total village area reported by official statistics. According to the results shown in Table 4.1, primary forests still account for the lion's share of village land. This may be explained partly by the fact that a relatively well-protected national park accounts for about 58 percent of the area in the high region and 74 percent in the middle region, according to farmers' estimates, and partly by steep slopes of mountainous areas unsuitable for cultivation. Although we cannot provide concrete evidence, we have an impression that our estimation procedure resulted in overestimation of primary forest areas.

While all primary forestland in Indonesia is officially owned by the state, native people in our sites believe that forestland belongs to their community and is controlled by village chief, with the possible exception of forests in Kerinci Seblat National Park, which was established in 1985. Farmers, however, continue to encroach on the park, and boundary disputes have often occurred between local farmers and park officials. Usually farmers obtain permission to clear forestland from the village chief before carrying out clearance. Once the forestland is cleared, strong land rights are granted to farmers.

2. See Suyanto, Tomich, and Otsuka (2001b) for the case study of rubber.

TABLE 4.1 Land use patterns and population size in selected villages in Sumatra

	Sample Size	Exploited Area in 1995[a]			Total Village Area[b]	Primary Forest Area[c] (ha)	Population in 1993[b]	Population Density in 1993[d]
		Paddy Fields	Agroforestry Plots	Bush-Fallow				
		(hectares)						(persons/ square kilometer)
High region	24	259 (31)	377 (45)	204 (24)	5,143	4,303	,764	34
Middle region	19	151 (19)	526 (66)	125 (16)	3,173	2,371	,340	42
Low region	17	102 (9)	594 (55)	385 (36)	6,735	5,654	772	11

SOURCE: Extensive survey.

[a]Numbers in parentheses are proportions in exploited area in percentage terms.

[b]Based on Agricultural Census (Bureau of Statistics).

[c]Estimated by subtracting total exploited area from total village area.

[d]Population divided by village area.

Population density is highest in the middle region and lowest in the low region. None of the selected villages is newly settled, and more than 90 percent of them were established before the Dutch period ended in 1942. Low population density in the low region may be explained partly by the paucity of paddy fields in this area, whereas the rich endowment of flat fertile area suitable for rice cultivation and the high profitability of cinnamon would explain the highest population density in the middle region.

The three major ethnic groups all follow matrilineal inheritance and matrilocal residence systems, even though the inheritance system has undergone substantial transformation over time (Kahn 1980; Errington 1984). Traditionally lineage land, particularly that for paddy fields, has been owned collectively by a group of kin members, and this group usually consisted of a grandmother, her husband, children, and grandchildren. Land is bequeathed to sisters, nieces, and daughters of a woman who passed away, in accordance with the decision of a lineage head. The head is selected from among uncles, that is, a male member of the second generation, who exercises strong authority regarding land inheritance. The basic principle of land allocation is to maintain equity among lineage members.

According to our interviews with farmers, it is primarily husbands who make farm management decisions under this version of the matrilineal system, even though they have no customary land rights. Traditionally no single member of a lineage had complete ownership rights, and land transactions were strictly prohibited. Although formal approval by a lineage or community head is required for clearing community-owned forests, such approval is easily granted. Women are the custodians of lineage and family land and are expected to oppose the transfer of land to nonfamily members. Nowadays lineage land occupies only small areas in our sample villages.

Land under joint family ownership, which is inherited and owned jointly by daughters, is much more common than lineage ownership. The major difference from lineage tenure is that land is owned by a smaller number of family members. A system of rotating land use among sisters' families is often practiced for the cultivation of wet rice fields to prevent excessive fragmentation. All types of decisions regarding land use, inheritance, renting, and mortgaging are made jointly by sisters and their husbands without the intervention of other lineage members.

Joint family land tenure has developed along two paths. In the first form, lineage members agree to divide lineage land into joint family land, usually at the time of inheritance. In the second, daughters jointly inherit private land, which was acquired either by opening forestland or by purchasing already exploited bush-fallow land. Although the sale of lineage and family land traditionally has been prohibited, such land actually can be sold with the consent of the family members. In fact, the sale of land ownership rights is the most common method of land transfer among village population in recent years in our in-

tensive study sites, as is shown later in this chapter. This would reflect the increasing scarcity of cultivable forestland. 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 firmly established.

Single family ownership is also emerging. Like joint family ownership, daughters inherit land under single family ownership, but ownership rights are more individualized. Another form of the single family ownership system has appeared in which sons are permitted to inherit some land, even though daughters inherit shares greater than or at least equal to those of sons. In some areas, the patrilineal system, in which only sons individually inherit the land, has also emerged. As in the case of Ghana, tree planting is usually a prerequisite for transforming jointly owned family land to a single family land at the time of inheritance. Compensation payments from those who have acquired single family land after tree planting to those who used to have joint ownership rights are sometimes made. Single family ownership could also have evolved from inheritance of private lands.

In these ways, the traditional matrilineal inheritance system in Sumatra has eroded considerably and given way to more individualized systems.

Major Issue and Hypotheses

If tree planting rights do not exist, incentives to tree planting are suppressed. Similarly, if rights to rent out, bequeath to desired heirs, and sell do not exist, expected returns to investment for those who plant and grow trees will be reduced (Besley 1995). As population pressure increases, the comparative advantage of agroforestry over shifting cultivation tends to increase, because net revenue from shifting cultivation decreases owing to declining fallow period and its negative impact on soil fertility.[3] The critical question is whether more secure land tenure institutions are induced to develop in order to capture larger benefits from investment in tree planting. It must be also pointed out that there may be security rewards from efforts to invest in land improvement in general, rather than investment in tree planting alone. Based on the theoretical framework developed in Chapter 1, we postulate the following hypotheses:

Hypothesis 1: More secure individualized land tenure institutions will develop in response to increasing scarcity of land relative to labor in order to reap benefits from investing in the establishment of agroforestry. In other words, this hypothesis suggests that increasing scarcity of land induces the development of an institutional rule stipulating that tree planting increases land rights.

3. Our study of rubber-growing villages (Suyanto, Tomich, and Otsuka 2001b) finds that shifting cultivation of upland rice is no longer profitable.

The individualization of land tenure institutions, however, is less likely to occur if profitable investment opportunities are limited. This is the case for paddy fields, in which only minor investments in the maintenance of traditional and simple gravity irrigation systems are required. In our empirical study, we compare the difference in land tenure institutions among paddy fields, bush-fallow areas, and tree crop fields, using extensive survey data obtained from the group interviews.

We are interested in exploring the causes of deforestation and the determinants of the development of agroforests. For this analysis, we use household data on the manner of land acquisition collected from five households in each of 60 randomly selected communities. Since inheritance is determined by the parent generation, it is assumed that inherited land area is given for (that is, not a choice of) individual households.

Hypothesis 2: Population pressure, manifested in both reduction of inherited land area per household and an increase in households size, increases the land area acquired by the clearance of forest.

In our observation, primary forest areas are largely open access, at least for community members, even though the village chief is supposed to be a custodian of communally held primary forest areas. As a result, forests have been cleared on a first-come basis, which has led to the rapid exhaustion of forestland and its conversion to cropland including agroforest areas in many locations. Since we expect that forests were more abundant in earlier years, older household heads are more likely to have had better access to forestland in their youth, and, hence, their acquired forest areas would be larger.

Hypothesis 3: Age of household head positively affects the amount of land acquired through forest clearance.

It is considered that the development of profitable agroforesty systems will help prevent deforestation (Tomich and van Noordwijk 1996). An implicit assumption of this argument is that the development of agroforest increases the demand for labor, which otherwise might have been allocated to the clearance of forest. In addition, the increased wealth due to the development of agroforest may reduce the supply of labor for such hard work as clearance of forests. Angelsen (1995, 1999) does not concur, arguing that the pace of deforestation would depend on the profitability of land use, so that the opportunity to grow profitable perennial crops will accelerate the speed of deforestation. In our view, the arguments of Angelson are valid if labor markets are well developed. Therefore, even where labor demand for agroforestry management increases, if labor markets are developed and agroforestry is profitable, labor can be hired to clear the forest. Thus, whether the development of agroforest deters or promotes deforestation is an empirical question (Kaimowitz and Angelsen 1998).

4. See the model of Anderson and Hill (1990), which describes how rapidly unused open-access land will be exploited when the property rights are conferred to those who have opened the land.

We examine this issue by assessing the effect of inherited agroforestry land on the area of cleared forestland.

Tree planting has played a catalytic role in the establishment of individual rights, because, as in the case of Ghana, tree planting confers stronger individual rights (see regression models specified in Chapter 1). Therefore, incentives to plant trees and carry out subsequent management activities are embedded in customary land tenure rules. As a null hypothesis, we would like to postulate the following:

Hypothesis 4: Given the expected increase in tenure security after tree planting, tree planting and the management efficiency of agroforestry are independent from initial tenure security levels under different land tenure institutions.

We test this hypothesis by estimating tree-planting function using extensive survey data and profit function using intensive household survey data. 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.

Reflecting the establishment of clear private land rights, tenancy contracts are widely observed. If factor markets, including land rental and labor markets, are perfect, household endowments of land and labor should not affect factor proportions across farms, since households will rent land or hire labor so as to equalize them. As a result, we expect that production cost, revenue, and profit per unit of area are independent from household factor endowments.

Hypothesis 5: Household factor endowments do not affect production efficiency because of resource reallocation effects of efficient factor markets.

We expect that factor markets are induced to work more efficiently when land becomes scarce and, hence, valuable, because the economic cost of inefficient resource allocation becomes higher.

It is widely believed that the individualization of land rights results in inequitable distribution of land. Considering that customary land tenure institutions are designed to achieve equitable distribution of land among community members, the conventional view has some force. Yet the degree to which the individualization of land rights leads to inequitable distribution of land is not known. As in the study of Ghana in Chapter 3, we examine this issue by performing the analysis of decomposition of Gini ratios by land tenure category.

Extensive Study

Property Rights and Land Use

Through group interviews, we obtained estimates of the proportions of land under different land tenure institutions by type of land use. Since measurement of areas under different land tenure at the village level has never been done, such data are necessarily crude and subject to errors. Thus, we combine similar land tenure categories, such as single family ownership by daughters and by daugh-

ters and sons in order to reduce measurement errors associated with the finer classification of land tenure categories. Nonetheless, as is demonstrated in Table 4.2, some clear tendencies can be observed. First, lineage land is observed mostly in bush-fallow areas and in limited areas of paddy land. Second, joint ownership is dominant for paddy fields in the middle and low regions but accounts for only 3.1 to 19.4 percent of bush-fallow and smaller portions of tree crop plots in all regions. Third, single family ownership is more important than joint ownership except for paddy fields. Fourth, private ownership tends to be predominant in tree crop plots and accounts for a sizable portion of bush-fallow.

The fact that area under joint family and lineage ownership is generally small in all the regions indicates erosion of the traditional matrilineal inheritance system. A major exception is bush-fallow area, in which lineage land remains observed in relatively large areas. In our Sumatra sites, private ownership rights acquired by clearing forest are strong while the acquired land is cultivated, but they become weaker once it is left fallow and subject to traditional inheritance rules unless trees are planted.[5] This explains why joint family ownership is more prevalent for bush-fallow than for tree fields.

In order to assess the strength of property rights under different land tenure institutions, we asked a group of farmers in each village whether the cultivating household possesses rights to rent out under share tenancy, rent out under fixed-rent leasehold tenancy, pawn, and sell with and without approval of family or lineage leaders, or both, for the various tenure categories. Theoretically, the right to rent out under share tenancy is the weakest right followed closely by the right to rent out under leasehold tenancy,[6] whereas the strongest right rests in the right to sell without approval. Pawning is problem-ridden, because if a pawner cannot repay the loan, the land may eventually be confiscated by a pawnee. Except for the case of lineage-owned paddy fields, in which there is no individual right to sell at all, farmers' answers were either "yes without approval" or "yes with approval," for all categories. Therefore, we characterized the strength of individual land rights in terms of the number of rights without requiring approval (see Table 4.3).[7] Since there is no difference in land rights

5. The role of trees in establishing land claims was noted by one of the earliest Europeans to publish on Sumatra. Marsden (1811:69), drawing on his experience living in Sumatra in the late sixteenth century, long before rubber and coffee were introduced, wrote that "property in land depends on occupancy, unless where fruit-bearing trees have been planted." For a more recent analysis, see Angelson (1995).

6. This could be because there is stronger incentive 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 incremental output. See Otsuka, Chuma, and Hayami (1992) for a survey of the literature on the land tenancy contracts in agrarian economies.

7. Besley (1995) constructs a similar variable and treats it as a continuous variable for the regression analyses. This procedure is problematic: unless the differences in land rights between all contiguous land tenure categories are equal, the land right index should be treated as an ordinal rather than a cardinal variable.

TABLE 4.2 Distribution of area under different land tenure institutions by land use type

	Lineage Ownership	Joint Family Ownership	Single Family Ownership	Private Ownership I (Purchase)	Private Ownership II (Clearance)
			(percentage)		
Paddy field					
High region	2.2	9.0	75.7	7.9	4.1
Middle region	10.4	63.9	6.3	5.5	7.8
Low region	0.0	64.6	29.2	6.1	0.1
Tree plots					
High region	3.1	5.2	41.8	10.4	37.1
Middle region	4.7	1.5	61.7	13.5	18.5
Low region	0.0	3.0	45.6	12.4	38.7
Bush-fallow area					
High region	15.5	8.5	36.3	5.2	32.6
Middle region	10.3	19.4	43.1	14.3	12.5
Low region	22.5	3.1	41.7	5.7	27.0

SOURCE: Extensive survey.

NOTE: Numbers in some rows do not add up to 100 percent because of the small area of land under state ownership.

TABLE 4.3 Index of land property rights under different land tenure institutions

	Lineage Land	Joint Family Ownership	Single Family Ownership I (Daughters)	Single Family Ownership II (Daughters and Sons)	Private Ownership (Purchased and Cleared)
Paddy field					
High region	0.5	0.8	1.6	3.2	3.6
Middle region	0.8	2.2	2.0	2.8	3.9
Low region	n.a.	2.7	2.0	n.a.	3.8
Upland field[a]					
High region	0.0	(0.6)	1.6	2.0	3.1
	(0.6)	(0.6)	(1.9)	(2.0)	(2.0)
Middle region	0.8	0.9	1.9	2.9	3.8
	(0.5)	(0.8)	(2.0)	(2.0)	(2.0)
Low region	0.0	1.0	1.0	2.8	3.8
	(0.5)	(0.5)	(1.7)	(1.7)	(2.0)

SOURCE: Extensive survey.

NOTE: Four rights are considered: rights to rent out under share tenancy, rent out under leasehold tenancy, pawn, and sell. Numbers refer to the average number of rights without obtaining approval of the family or lineage members, or both (maximum = 4.0). For upland fields, rights to plant and replant are also considered, and the average number of rights are shown in parentheses (maximum = 2.0). "n.a." refers to "not applicable."

[a]Upland field refers to both agroforestry plots and bush-fallow.

between bush-fallow and agroforestry plots for the same tenure category, these two types of land are combined under the category of upland fields. Needless to say, less individualized tenure categories are found more widely in bush-fallow plots.

Individual land rights under lineage ownership are very weak, possessing at best the right to rent out under share tenancy. It is interesting to observe that individual land rights for paddy fields under joint family ownership in the middle and low regions are comparatively high, even greater than the land rights under single family ownership by daughters in these two regions. It appears that individual land rights under joint family ownership have been strengthened by the deliberate agreement of the extended family members.

Except for this somewhat anomalous phenomenon, land rights are stronger under single family ownership than joint family ownership, and within single family ownership, the rights are stronger in the case of ownership by both daughters and sons. But even under single family ownership by daughters and sons, there is no right to sell without the approval of family members. The right to sell without approval is granted only to land acquired by clearing forests or by purchasing land. There is practically no difference in land rights between cleared and purchased land at the time of acquisition. Particularly in the middle and low regions, land rights in privately acquired land are close to complete ownership. Even in the high region, where individuals' rights over cleared and purchased land are weaker, it does not seem too difficult to obtain approval from one's family members in order to sell land. The major difference between private ownership in Sumatra and the Western world is the lack of official registration, so that land cannot be used as collateral for loans from banks. It is important to note that land rights acquired by clearing forests tend to decline over time if the land is planted to food crops and fallowed. How fast this decline occurs, however, is difficult to quantify.

Table 4.3 also compares tree rights on upland field under different land tenure institutions (see numbers in parentheses). Two rights are considered: rights to plant and replant trees. As in the case of land rights, we characterized the strength of individual tree rights in terms of the number of rights without requiring approval. It is clear that tree rights are markedly weaker under the collective ownership (lineage and joint family ownership) than under the individualized ownership (single family ownership and private ownership), which confers almost perfect tree-planting and -replanting rights. In the case of collective ownership, members of the group usually oppose tree planting because those who plant trees tend to demand strong individual ownership or long-term use rights on land.

The data in Tables 4.2 and 4.3 seem consistent with hypothesis 1, that land tenure institutions evolve toward individualized tenure in order to enhance incentives to invest in commercial trees in the face of increasing population pressure on land. On the other hand, investment in traditional irrigation works for

paddy production requires a minimum of effort to maintain and repair these simple, small-scale facilities. Thus, less individualized land tenure for paddy fields is not as much of a problem from the standpoint of required investment incentives. If population pressure is the driving force toward individualization of land tenure institutions, we would expect to observe a predominance of more individualized tenure on tree crop plots in areas where population density and population growth rates are high.

Determinants of Land Tenure Choice

In order to identify the determinants of the choice of land tenure institutions, we estimated functions explaining the proportion of land under lineage, joint and single family ownership, and the two types of private ownership (that is, for purchased and cleared land) separately for paddy fields and tree crop plots. More specifically, we estimated the following functions while using a common set of explanatory variables:

$$Y_{ij} = Y_{ij} \text{ (population density, population growth rate, proportion of paddy area, proportion of ethnic minorities, traveling time to subdistrict town, walking time to forest, regional dummies),}$$

where Y_{ij} shows the proportion of i-th type of land ownership ($i = 1, 2, 3, 4$) on j-th type of land ($j = 1, 2$), and explanatory variables are all village-specific except regional dummies represented by middle and low region dummies. By definition, in principle, $\Sigma_i Y_{ij} = 100$ percent.[8] This equation corresponds to equation (1) in Chapter 2.

Means of explanatory variables by region are exhibited in Table 4.4. Population density in 1983, the earliest census year for which consistent village population statistics are available, was highest in the middle region and lowest in the low region. Annual average population growth rate for 1983–93, however, was low in the middle region, indicating the high population pressure on limited land resources in this region. Annual population growth rates were around 1 percent. Out-migration seems to have taken place, partly because of limited availability of unexploited land suitable for cultivation and partly because of ample job opportunities provided by commendable growth of nonfarm sectors until the recent Asian economic crisis arose. Percentage of paddy area is included to capture the special importance of paddy fields for supplying food. The percentage is computed from data in Table 4.1. In this measure, the high region is located in the most favorable area, with paddy fields covering 5.7 percent of the village land. The percentage of outsiders was highest in the middle region, most of whom were migrants from Java and settled in this region before the 1980s. The Javanese are not matrilineal, and their inflow might have

8. The sum, however, does not add up to 100 percent in some cases because of the small area of land under state ownership.

TABLE 4.4 Means of explanatory variables for village-level regression analysis on land tenure choice

	Population Density in 1983	Annual Average Population Growth Rate, 1983–93	Percentgae of Paddy Field	Percentage of Outsiders	Traveling Time to Subdistrict Capital	Walking Time to Forest
	(person/square kilometer)	(percentage)			(minutes)	(minutes)
High region	37.9	1.1	5.7	1.6	35.3	50.6
Middle region	53.1	1.0	3.7	4.6	20.4	194.8
Low region	11.5	1.0	1.2	1.4	29.7	171.6

SOURCE: Extensive survey and 1983 population census.

affected the traditional land ownership systems in these matrilineal societies. Travel time to the subdistrict capital by motorcycle was included to take into account the impact of access to local markets, whereas walking time to the nearest forest was included to capture the effects of proximity of residential areas to remaining forests. Partly as a result of its well-maintained infrastructure, travel time to the subdistrict capital was shortest in the middle region. Because little forestland is left near villages, walking time to the nearest forest was as long as approximately three hours in both the middle and low regions. Thus, farmers often build cottages and stay there overnight when they work in newly cleared fields. In the high region, walking time is shorter, but villages are often surrounded by the national park, which has been strictly protected in recent years. These observations suggest that the availability of forestland suitable for cultivation has been declining.

We estimated 13 regression functions; the estimation results are shown in Table 4.5, excluding the case of lineage ownership of paddy field and tree plots, which occupied small areas. Since Y_{ij} are truncated below zero, we applied the tobit estimation method.[9]

The validity of hypothesis 1, that population pressure promotes the individualization of land tenure, can be tested by examining whether higher population density and greater population growth rates are associated with greater incidence of private ownership and smaller incidence of family ownership. In order to reduce simultaneous equation bias possibly arising from the endogeneity of the population variables, we used population census figures from the past.[10] Consistent with our hypothesis, population density has a negative and significant effect on the incidence of joint family ownership and positive and significant effects on the incidence of single family ownership and private ownership through purchase in the case of paddy field. Since all forest areas suitable for conversion to paddy cultivation have been exhausted, individualization took the form of replacing collective ownership by single family ownership and inducing market transactions in land. Note that the middle and low region dummies have positive effects on the proportion of joint family ownership and negative effects on the proportion of single family ownership in the paddy field equations. These results are consistent with the observation from Table 4.3 that land rights for joint family tenure in the middle and low regions were similar to or even stronger than land rights of single family ownership. According to the estimation results of the determinants of land tenure in agroforestry plots, higher population density seems to have promoted private ownership by stimulating the clearance of forests at

9. Since tree crop plots under single family ownership existed in all sites, tobit and ordinary least squares (OLS) regressions are identical in this case. According to the OLS estimation, R^2 is 0.39.

10. Note that the results of our statistical test must be qualified to the extent that population variables are endogenous.

TABLE 4.5 Determinants of proportion of area under different land tenure institutions by land use type at the village level: Tobit regressions

	Paddy Fields				Agroforestry Plots			
	Joint Family	Single Family	Purchased	Cleared	Joint Family	Single Family	Purchased	Cleared
Intercept				5.73			7.44	
				(0.38)			(1.46)	
Population Density				0.13			0.07	
				(0.42)			(0.07)	
Population Growth				4.07			−2.45	
				(1.13)			(−1.74)	
Percentage of paddy area				−7.73*			−0.85	
				(−2.29)			(−1.52)	
Percentage of outsiders				3.45**			0.26	
				(3.03)			(1.08)	
Travel time to town				−0.24			0.15**	
				(−1.41)			(2.50)	
Travel time to forest				−1.10			1.15*	
				(−0.35)			(2.09)	
Middle region				−7.76			−0.77	
				(−0.55)			(−0.15)	
Low region				−35.40			−2.03	
				(−1.85)			(−0.39)	
Log likelihood				−67.40			207.60	
Sample size				55			58	

NOTE: Numbers in parentheses are *t*-statistics.

*.05 level

**.01 level

the expense of single family ownership. The effect of population density on joint family ownership, however, is insignificant presumably because of the small area remaining under this ownership (see Table 4.2). Like population density, higher population growth resulted in lower incidence of single family ownership and higher incidence of private ownership through clearance of forests.

It is interesting to observe that percentage of paddy area tends to have negative effects on the clearance of forest, which is different from the effect of population variables. This is expected, because the larger endowment of paddy fields, which produce more grain per unit of area than upland fields, lessens the population pressure on land. Percentage of outsiders is associated negatively with the incidence of joint family ownership of paddy fields, suggesting that the inflow of outsiders helped undermine the traditional family ownership system of the matrilineal society. There is a possibility of reverse causation that outsiders migrated to villages where land tenure institutions are highly individualized so that they could rent in land. However, outsiders seem to have acquired paddy land in the distant past by clearing the remaining forest areas suitable for paddy cultivation, which is reflected in its positive coefficient in the cleared area regression for paddy fields.

By and large, both travel time to the subdistrict town and walking time to forests have no significant effects on the distribution of land ownership, with the exception of the positive effects of both variables on the incidence of purchased agroforestry plots. The former result indicates that the more remote locations are the only places where people are willing to sell land at a reasonable price. The latter result, which points to the high incidence of purchase of the existing agroforestry plots in areas where there is little forest near the village, is tenable.

To sum up, statistical evidence indicates that population pressure induces the individualization of land ownership, even though we cannot rule out the possibility of simultaneous equation bias. A major question is the relative speed by which primary forest and bush-fallow areas have been converted to commercial tree plots planted to rubber, cinnamon, and coffee under different land tenure institutions. If the major source of tree plots is primary forest, agroforestry development comes at the expense of the natural environment. On the other hand, if tree plots were primarily converted from bush-fallow, this development brings environmental benefits. These are the issues to which we now turn.

Determinants of Deforestation and Land Purchase

In order to obtain more accurate information on the distribution of upland under different land tenure institutions, let us examine the data from a brief individual household survey. Our total sample size consists of 300 households—5 households each in 60 villages. Since we hope to be able to assess the behavior of households regarding deforestation, we focus on 273 households that actually owned upland fields including land acquired through forest clearance. Similarly, we pay particular attention to the 231 households that have ever ac-

quired bush-fallow and forestland for the analysis of the development of agroforestry. The difference, which is 42 households, acquired upland planted to trees from the beginning. In this survey, we failed to obtain reliable data on joint family land areas, as individual respondents could not correctly estimate the areas of land owned by the extended family, particularly when it is "unused" or under fallow. So we focus on inheritance by single family under the matrilineal, newly emerging egalitarian and patrilineal inheritance systems and cleared and privately purchased land.

Table 4.6 demonstrates the manner of acquisition of upland fields. First, we found that the proportion of inherited land is well below 50 percent, suggesting that the importance of inheritance has declined over time. This seems to be a consequence of increasing population pressure on land inherited from the earlier generation. It appears that the proportion of purchased land has increased, even though land transaction has traditionally been prohibited. The proportion of inherited land is highest in the high region, partly because the settlement of villages in this region is earlier.

We also found that the average upland area per household in the low region is higher than in the high and middle regions. This indicates less population pressure on land in the low region compared with the other two regions. It must be also pointed out that the land acquired by forest clearance is quite high in the low region, because of greater availability of forests in this region.[11] Usually, newly cleared forestlands are located in distant areas, whereas purchased lands are commonly located in areas not far from residential areas.

It would be reasonable to assume that acquisition of land through forest clearance and acquisition through purchase are the choices made by an individual household, while the acquisition of inherited land is determined by the parental generation. In the low region, land was first acquired by inheritance, followed by forest clearance and purchase (Table 4.6). In the high and middle regions, although forest was acquired in the earliest years, there is not much difference from the dates of purchase and inheritance. Even though forestlands tend to be acquired earlier, it seems reasonable to assume that young farmers are able to predict relatively accurately how much land they will acquire through inheritance in the near future. This is because in the case of single family ownership qualified heirs can be clearly defined, so that inheritance decisions by parents are public knowledge for their heirs. Although heirs do not know when parents will die, they can temporarily use parents' land until inheritance. If they perceive that land to be received as inheritance will not be sufficient, they will acquire more land by clearing forest or purchasing. Therefore, it is reasonable to assume that the amount of inherited land areas, either actual or expected, influences individual decisions to acquire land. We also

11. The data exhibited in Table 4.6 are largely consistent with the data shown in Table 4.1 We further examine land tenure distribution in the intensive survey sites later in the chapter.

TABLE 4.6 Average upland area per household and average year of land acquisition by manner of land acquisition and site

Land Acquisition	High Region			Middle Region			Low Region		
	(hectares)	(percentage)	(acquisition)	(hectares)	(percentage)	(acquisition)	(hectares)	(percentage)	(acquisition)
Inherited by									
Daughters	0.48	42	1984	0.13	10	1981	0.81	20	1982
Daughters and sons	0.00	3	1982	0.18	14	1982	0.00	0	—
Sons	0.03	0	—	0.07	5	1981	0.41	10	1981
Forest clearance	0.49	42	1981	0.40	31	1980	1.84	42	1988
Purchase	0.15	13	1982	0.51	39	1982	1.06	26	1988
Total	1.17	100	—	1.29	100	—	4.12	100	—

SOURCE: Brief individual household survey in extensive survey villages.

NOTE: Households that have never inherited land have been excluded.

assume that the reduction in inherited land area per household reflects the severity of population pressure, as the population growth must have exceeded the pace of forest clearance over the past few decades. We hypothesize that as the size of inherited land decreases, farmers attempt to clear more forest, even though newly cleared areas may be small, or purchase more land.

In order to identify the determinants of the choice of upland acquisition, we estimated functions explaining the areas of land acquired by forest clearance and purchase. The explanatory variables in our regressions include the area of inherited land, interaction of inherited land with two inheritance system dummies with the base for comparison being inheritance by daughters, the percentage of trees planted at the time of acquisition of inherited land, age of household head, schooling of head, owned paddy area, and the number of male and female workers between 16 and 60 years of age. Although one may think that owned paddy area is endogenous, actually it is largely inherited (see Table 4.2). We believe that it is legitimate to assume that the inherited land areas are determined by parents and, hence, exogenous for current generations.

The average paddy area was larger in the low region (0.8 hectare) and the high region (0.6 hectare) than in the middle region (0.3 hectare), reflecting the comparatively abundant endowment of paddy land relative to population outside the middle region. There were no appreciable differences in the proportion of trees planted in inherited land among the three regions, which is about 40 percent of the area. There were also no noticeable regional differences in the age and schooling of household head and the number of male and female workers per household. Since there are different inheritance systems, we used interaction terms of inherited land area with two inheritance system dummies in our specification of the regression function.

Because of the nonexistence of certain types of land acquisition in a number of sample households, and because unobservable characteristics of villages may affect land acquisition decisions, we applied the tobit estimation method with village fixed effects. The estimation results are shown in Table 4.7.

The first column shows the determinants of acquired forest areas through forest clearance or deforestation. As we expected, inherited land has a negative and significant effect on deforestation. This is consistent with hypothesis 2, that increasing population pressure on limited land is a major cause for deforestation. Although the tobit beta coefficient is –0.97, the marginal effect of a 1 percent increase in inherited land on forestland is –0.37,[12] which indicates that decreases in inherited land are not well compensated for by increases in forestland. Interaction terms of inherited land with two inheritance dummies, however, were not significant, suggesting that there is no substantive difference in the decision to clear forest among matrilineal, bilateral, and patrilineal inheri-

12. We calculated the marginal effect following the formula proposed by McDonald and Moffitt (1980).

TABLE 4.7 Determinants of land acquisition at the household level: Tobit regression with village fixed effects

	Forest Clearance	Purchase
Intercept		
Inherited upland		
Interaction of inherited upland and dummy for bilateral inheritance		
Interaction of inherited upland and dummy for patrilineal inheritance		
Percentage of area planted to trees in inherited upland		
Age of head		
Schooling of head		
Owned paddy area		
Number of male workers		
Number of female workers		
Log likelihood		

NOTE: Numbers in parentheses are *t*-statistics.

*.05 level

**.01 level

tance systems. From this result we may be able to conclude that the traditional matrilineal inheritance system under single family ownership provides incentives to invest in forest clearance as strong as the more recent bilateral and patrilineal inheritance systems.

Owned paddy area has a positive and significant effect on deforestation, which suggests that wealthier farmers tend to clear more forestland by employing hired laborers. This interpretation is reinforced by the fact that the purpose of forest clearance is to establish agroforest, which also requires labor and capital. The finding that paddy land ownership has a positive effect on forest clearance may seem contradictory to our earlier finding that the proportion of paddy land tends to have negative effects on the proportion of cleared forestland. It must be noted, however, that we applied the village-level fixed effects model in Table 4.7, so that the effects of the availability of paddy and forestland in the village are controlled for. The earlier analysis, in contrast, did not control for such village-specific effects. Thus, it is likely that in villages en-

dowed with relatively large paddy areas the demand for new forestland is smaller, but among farmers it is the rich who can afford to invest in clearance of forests.

The percentage of area planted to trees has a negative effect but is not significant. Therefore, the hypothesis that the development of profitable agroforestry deters deforestation is not supported by our data. The net effect will depend on the labor-using effect of agroforestry and development of labor market, as we discussed earlier.[13] The age of the household head has a positive and significant effect on deforestation. This result is consistent with hypothesis 3, that the older the household head, the greater would have been access to forestland in one's youth. Hence, acquired forestland area would be larger. We also found a significant influence of the increasing number of male workers on deforestation. Since clearance of forest requires hard work by male workers, this result is not surprising.

The second column shows the estimation results of the determinants of purchased land. Owned paddy area has a highly positive effect on the purchase of land, which indicates that wealthier farmers tend to purchase larger areas of upland. We also found that schooling of the household head has a positive and significant effect, suggesting that more educated farmers tend to buy more land. Unexpectedly, inherited land has an insignificant effect on purchased land. Interaction terms of inherited land with the two inheritance dummies are also insignificant. The percentage of area planted to trees has a negative and significant effect. It may well be that the larger demand for labor in agroforestry deterred purchase of additional land.

Determinants of Development of Agroforestry

Under customary law, relatively strong individual rights are granted to those who plant trees not only in Sub-Saharan Africa (for example, Shepherd 1991, chap. 3) but also in Sumatra. Under such an institutional rule, an individual community member who has acquired land through inheritance as well as through other means may have strong incentives to plant trees in order to obtain secure individual land rights. Table 4.8 shows the average acquired forest and bush areas by household and the incidence of tree planting (development of agroforest) by manner of acquisition and region. The percentages of bush-fallow and forest area converted to agroforests are high in all regions. Furthermore, the incidence of tree planting tends to be higher in cleared forest and inherited land than in purchased land, with the exception of the high region. The purchase in the high region, however, was unimportant. These observations indicate that incentives to invest in tree planting are not simply determined by the

13. According to Suyanto, Tomich, and Otsuka (2001b), rubber agroforestry requires substantially more labor than upland rice cultivation under shifting cultivation, which is a major alternative farming system in the low region.

TABLE 4.8 Average areas of acquired forest- and bushland per household and the incidence of tree planting by manner of acquisition and site

Land Acquisition	Acquired Bush and Forest Area	Area Planted to Trees
		(percentage)
High region		
Matrilineal inheritance	0.33	69
Egalitarian inheritance	0.00	n.a.
Patrilineal inheritance	0.00	n.a.
Forest clearance	0.62	79
Purchase	0.08	95
Tenancy	0.03	78
Total/average	1.06	77
Middle region		
Matrilineal inheritance	0.13	95
Egalitarian inheritance	0.12	90
Patrilineal inheritance	0.04	77
Forest clearance	0.48	94
Purchase	0.42	71
Tenancy	0.16	77
Total/average	1.33	84
Low region		
Matrilineal inheritance	0.55	74
Egalitarian inheritance	0.00	n.a.
Patrilineal inheritance	0.12	45
Forest clearance	1.93	71
Purchase	0.35	29
Tenancy	0.01	100
Total/average	2.96	66

SOURCE: Brief individual household survey in extensive survey villages.

NOTE: Tree-planted areas at the time of land acquisition have been excluded. "n.a." refers to "not applicable."

strength of land rights or the level of land tenure security but also by the expected changes in land rights after tree planting.

In order to identify the determinants of the development of agroforests, we estimated a tree-planting function in which area planted to trees is a dependent variable. The explanatory variables included the area of inherited land, interaction terms of inherited land with two inheritance dummies, purchased land, age of household head, owned paddy area, the number of male and female workers 16 to 60 years of age, and outsider dummy. The estimated function corresponds to equation (3) specified in Chapter 2.

Since some households have not planted trees, and because unobservable characteristics of villages may affect the tree-planting decisions, we applied the tobit estimation method with village fixed effects model while using household data. The estimation results, including the estimated marginal effects, are shown in Table 4.9. We found that the estimated marginal effects are almost similar to the estimated tobit beta coefficient, which reflects the high incidence of tree planting.

Both forestland and inherited land have positive and highly significant effects on tree planting. Purchased land also has a positive but weaker effect, judging from its significantly smaller coefficient than the coefficients of forest- and inherited land. Thus, the incentive to plant trees in purchased land is lower,

TABLE 4.9 Determinants of area planted to commercial trees: Tobit regression with village fixed effects

	Beta coefficients	Marginal effect
Intercept	−0.54	
	(−1.38)	
Forestland area	0.77**	0.73**
	(25.67)	
Inherited land area	0.69**	0.65**
	(8.63)	
Interaction of inherited land area	−0.17	−0.16
and dummy for bilateral inheritance	(−0.74)	
Interaction of inherited land area	0.19	0.18
and dummy for patrilineal inheritance	(0.76)	
Purchased land area	0.38**	0.36**
	(5.43)	
Age of head	0.01	0.01
	(1.00)	
Schooling of head	0.03*	0.03*
	(1.67)	
Owned paddy area	0.19*	0.18*
	(1.73)	
Number of male workers	0.16*	0.15*
	(1.99)	
Number of female workers	−0.14*	−0.13
	(−2.01)	
Outsider dummy	0.12	0.11
	(0.29)	
Log likelihood	−223.97	

NOTE: Numbers in parentheses are *t*-statistics.

*.05 level

**.01 level

even though the strength of purchased land rights is much higher. Because of the secure land right, farmers probably do not have to rush in planting trees. In contrast, if land use is limited to food crops grown under shifting cultivation, individual rights acquired through forest clearance tend to diminish over time. When land is under fallow, other members of the community can claim the right to use this "unused" land (Marry and Michon 1987). Relatively strong individual ownership rights, however, are granted if trees are planted. Under such institutional rules, an individual community member who has cleared forestland would have strong incentives to plant trees in order to establish secure land rights. Similar to this case, if individual household members have not planted trees on bush-fallow land received by inheritance, there is a possibility for other members of the extended family to claim the "unused" land.

The interaction terms of inheritance dummies (egalitarian inheritance by daughters and sons and patrilineal inheritance by sons only) do not have significant coefficients. It appears that the incentives to invest in tree planting are more likely and more strongly affected by expected changes in land rights after tree planting than the level of land rights before tree planting. These findings are consistent with hypothesis 4. Similar phenomena are reported by a case study of cocoa planting in western Ghana (Chapter 3). Our result, however, is quite different from the findings of Besley (1995), who uses the data set from western Ghana to show statistically that stronger land rights lead to a higher incidence of tree planting. We would argue that Besley's methodology of simply counting the number of rights (for example, rights to rent out and sell) to measure the tenure security without considering the relative importance of each right leads to biased estimation.[14] The number of male workers has a positive and significant effect on tree-planted areas, whereas the number of female workers has a negative and significant effect. These results are plausible, since the establishment of agroforest requires primarily male labor (Barlow and Muharminto 1982). Finally, we found that more educated farmers tend to establish agroforest more actively.

Summary for Extensive Study

According to the results of the extensive study, population pressure is positively associated with individualization of land tenure institutions in indigenous societies. The conclusion that population pressure is a causal factor, however, will have to be qualified, to the extent that the population variables are not truly exogenous. The extent of individualization, however, was different for different types of land. Ownership of paddy land is least individualized, which is consistent with the small investment requirement for paddy field. Thus, joint family ownership still prevails in many areas. The ownership of bush-fallow land

14. Moreover, tree planting is expressed by binary variable in Besley's study, which is inadequate where tree-planting areas and densities are significantly different.

is more individualized than paddy fields but less so than agroforestry plots. In fact, joint family–cum–lineage ownership accounts for about one-fourth of bush-fallow but for much less than 10 percent of agroforests. These observations are consistent with our contention that, as in Ghana (Chapter 3), both clearing forests and planting trees enhance individual ownership rights under these indigenous land tenure institutions. These institutional rules seem to reflect the general principle that labor effort for long-term investments is rewarded by stronger individual land rights.

We also obtained evidence that reduction in inherited area results in deforestation in Sumatra and that wealthier farmers clear forests and develop agroforestry more actively. It is found that the development of agroforestry did not exert a strong influence on the pace of deforestation. Therefore, we question the validity of the argument that the development of agroforestry deters deforestation significantly. If it is desirable to preserve primary forest from the social or global viewpoint, measures other than the promotion of profitable agroforestry need to be implemented.

The statistical analysis indicates that the proportion of area planted to trees is higher in formerly forest- and inherited land than in purchased land and that the difference in the strength of land rights between matrilineal and egalitarian inheritance does not have any effect on the pace of tree planting. These results support our hypothesis that the incentive to invest in tree planting is affected not only by strength of individual land rights but also by expected changes in land rights after tree planting. In other words, customary land tenure institutions have built-in incentive mechanisms that ensure active tree planting. In all likelihood, therefore, farmers in customary land areas invest in tree planting if agroforestry is profitable. The establishment of profitable agroforest, in turn, will contribute to the improvement of the well-being of farmers residing in mountainous areas and to the improvement of natural environment, to the extent that it replaces bush-fallow area.

It is observed that inequality between rich and poor farmers may increase in the process of deforestation and the development of agroforestry, as wealthy farmers clear forests and develop agroforests more actively than poor farmers. How to achieve equitable development of agroforestry without sacrificing its profitability is a major challenge we now face.

Intensive Study

Property Rights and Land Use

In order to explore to what degree individualized land rights stimulate the efficient management of agroforests, we conducted an intensive household survey in two typical cinnamon-growing villages in Kerinci District in Jambi Province (see Figure 4.1). Almost all inhabitants belong to the Kerinci ethnic

group, which traditionally has practiced matrilineal descent. We conducted a random sample survey of 50 households in each of the two contiguous villages, which have similar topographical, ecological, and socioeconomic environments. Three rounds of the household survey were conducted in August/September 1996, February/March 1997, and August 1997.

As shown in Table 4.10, we found a total of 695 fields cultivated by our sample households under joint family ownership, other ownership systems, and tenancy and 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. Therefore, we found 99 paddy fields cultivated by members of joint families other than selected sample households during the 1996/97 wet season and focused on the 140 paddy fields actually cultivated by our sample households in this study. Among these, 82 percent 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 less than half a hectare, and a typical household owned two to three paddy plots, including jointly owned plots.

Upland fields were divided into 155 young cinnamon fields with trees 1 to 3 years of age, 264 productive cinnamon fields with trees age 4 to 13, and 37 bush-fallow fields. A considerable number of cinnamon fields were intercropped with coffee, even though cinnamon trees predominated. To simplify

TABLE 4.10 Distribution and average size of owned/cultivated and sample plots by land use

	Owned/ Cultivated Plots[a]		Sample Plots		
	Number	Average Size	Number		Number of households
		(hectares)		(hectares)	
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[c]	0.70	46
Productive cinnamon fields[d]	264	1.18	175[c]	0.99	79
Bush-fallow	37	1.60	0		33

SOURCE: Intensive survey.

[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 aged one to three years.

[c]Excluding those cinnamon fields intercropped with coffee.

[d]Productive cinnamon fields refer to those with trees aged four years and above.

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.[15]

Most of Indonesia's cinnamon is produced in the Kerinci Valley, where our study sites are located.[16] There, the main cinnamon harvest (when trees are felled) occurs after 8 to 10 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 the fourth harvest. 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 percent were converted from bush-fallow land after clearance, 22 percent were established after clearing old cinnamon fields and replanting, and 62 percent were derived from regrowth after the main harvest. Young fields were intercropped with annual crops, mostly with chili; in our sample, 62 percent were intercropped in the first year, 21 percent in the second year, and 5 percent 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 centers and were formerly planted to food crops. 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.[17] Farmers sell standing cinnamon trees to local traders, who offer prices to 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 of output minus total nonland cost as "potential profit." We used both of these variables in our statistical analysis. In our survey we also measured the elevation 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 (that is, forest, cinnamon field, or bush fallow). Thus, we also investigated the previous land cover of our sample plots.

15. Insofar as coffee is a minor crop, the choice between cinnamon alone and cinnamon intercropped with coffee seems to be of secondary importance.

16. Indonesian cinnamon (*Cinnamomum burmanii*)—also called "cassiavera"—accounts for roughly two-thirds of the world supply of this species, which is ground from the bark. It is a different species than 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.

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

It is expected that soil fertility is higher on land that has just been cleared from natural forests.

The prevailing land tenure institutions differ somewhat between lowland paddy fields and upland cinnamon fields. Table 4.11 shows the land tenure distribution of all sample plots by land use type. There were a variety 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 predominance of this egalitarian inheritance system, we use the combined subcategories in joint family and single family ownership systems in our statistical analysis. In the case of joint family ownership, 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 and to pawn without permission of other members of the "joint family." Land rights are much weaker in the case of borrowing from relatives, a system with no formally required payments in which the cultivator basically has only usufruct rights. In the case of all other tenure institutions, including single family ownership, respondents indicated that the cultivator possesses perfect rights including the right to sell without anybody's permission, even though land cannot be used as collateral for credit from formal financial institutions. The common arrangement under share tenancy was 2/3:1/3 output sharing for tenant and landowner without cost sharing. Such an output sharing arrangement is sometimes observed elsewhere in Asia (Hayami and Otsuka 1993).

TABLE 4.11 Land tenure distribution of sample plots by land use type

Land Tenure Categories	Lowland Rice	Young Cinnamon	Productive Cinnamon
		(percentage)	
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

SOURCE: Intensive survey

The land tenure institutions of cinnamon fields were much more individualized. First of all, there was no joint family ownership in this type of land. 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 and lineage members existed not only under private ownership but also under single family ownership. 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 was carried out by the tenant, and shared at 2/3:1/3 between them 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 currently 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.

Based on recall data, Figure 4.2 traces out changes in the manner of acquisition of upland fields in terms of ratios of areas.[18] It is clear that as the importance of forest as a source of acquired land declined, the relative importance of single family ownership increased in the 1970s. As forestland became scarcer in the 1980s and 1990s, purchase of land became the predominant mode of land acquisition. It must be noted that the purchase of land became dominant because the right to sell land was bestowed under single family ownership. Figure 4.2 also suggests that the process of the evolution of land tenure institution has been relatively continuous and smooth.

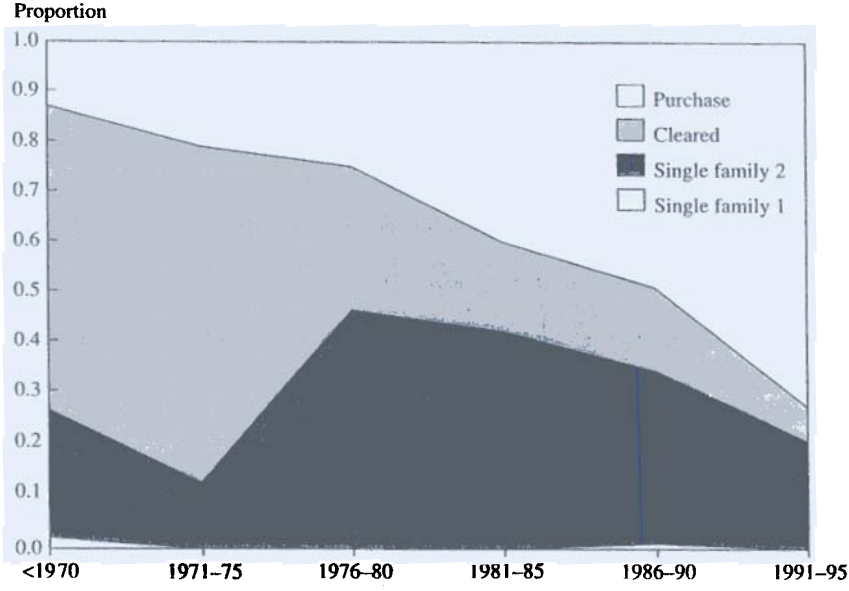
Table 4.12 shows land use by land tenure before the current cohort of cinnamon trees were established. The data show that 13 percent of both young and productive cinnamon fields under single family ownership previously were bush-fallow, and 87 percent were cinnamon fields. In the latter case, either cinnamon was 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 percent had been used as cinnamon fields between the periods after forest clearance and before the establishment of current trees, 20 to 33 percent previously were bush-fallow land, and fewer than one-third of the plots were converted directly from primary forest.

Revenue, Cost, and Profit

In order to analyze how the prevailing land tenure institutions affect the profitability of cinnamon and paddy production, we estimated the residual

18. It must be pointed out that since data are based on recall of current population, in all likelihood, the trend shown in Figure 4.2 understates the importance of the more traditional manners of land acquisition, such as inheritance under joint family ownership, in earlier years.

FIGURE 4.2 Proportion of land acquisition by land tenure in Kerinci



NOTE: "Single family 1" refers to ownership through inheritance by a daughter. "Single family 2" refers to ownership by daughter and son separately.

profit, defined as gross revenue minus both actual and imputed costs of hired and family labor, and current and capital inputs. The residual profit thus defined is intended to measure the contribution of land, management inputs, and the intensity of family labor effort, which cannot be directly measured. Since tenure security determines incentives to manage fields for future benefits, 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.

Labor, particularly family labor, 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 labor by activity and gender by using the relevant prevailing wage rates of hired laborers. Wages of both male and female workers in the same activity under the same contractual arrangement (that is, 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. We also found that both daily wages and piece rate contracts coexisted in many activities in

TABLE 4.12 Previous land use of current cinnamon fields by land tenure type

	Young Cinnamon			Productive Cinnamon		
	Bush-Fallow	Cinnamon	Forest	Bush-Fallow	Cinnamon	Forest
	(percentage)					
Single family	13	87	0	13	87	0
Borrowing	9	91	0	33	67	0
Private—purchase	0	100	0	21	79	0
Private—clearance	33	44	22	20	47	33
Share tenancy	11	89	0	22	78	0

SOURCE: Intensive survey.

both paddy and cinnamon production and that daily wages were substantially lower than daily earnings under piece rate contracts.[19]

Wage income per day used for the imputation of family labor costs ranged from 4,500 to 6,500 rupiah ($1.88 to 2.71) for men and from 3,400 to 3,900 rupiah ($1.42 to 1.63) for women.[20] Since family laborers are expected to work more intensively than daily wage workers, we used daily earnings under piece rate contracts for the imputation whenever such contracts prevailed.[21]

Although unreported in tabular form, several important observations can be made on labor use per hectare of paddy production by activity and land tenure institution. First, labor use per hectare, both total and by activity, was quite similar across different tenure systems, which suggests that tenure effects on labor allocation were relatively small. Second, the average rice yields were also similar and clustered around 2.1 tons per hectare. Third, labor use was very high in absolute terms, amounting to slightly more than 200 days per hectare, even though 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 highly labor intensive (David and Otsuka 1994). The high labor intensity suggests that paddy area was scarce relative to labor in our sites. Fourth, the proportion of female labor was about one-half, implying that both men and women worked more or less equally in paddy fields. There was, however, specialization of work

19. 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).

20. The prevailing exchange rate of approximately US$1.00: 2,400 rupiah in 1996/97 was applied for the conversion from Indonesian rupiah to U.S. dollars.

21. Since no woman was engaged in cinnamon harvesting as a hired laborer, 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 labor cost in cinnamon harvesting.