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The contribution of agroforestry systems to reducing farmers' dependence on the resources of adjacent national parks: a case study from Sumatra, Indonesia

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Abstract

There is much debate about the way conservation and development are best integrated to reduce the encroachment pressures of poor rural communities on the biodiversity resources of protected areas in the tropics. One frequently recommended instrument is to intensify farming systems in the adjacent areas, so as to decrease the need to harvest resources from national parks. This study examined this issue by analyzing the effects of different household land uses in villages near a national park on their propensity to harvest resources from the park. In the northern part of the Kerinci Seblat National Park (Sumatra Island, Indonesia) the park buffer zone is comprised largely of community or village forests and human settlements. The village forests were formerly managed as production forests and provided significant cash income to the village. They were converted into farmland, particularly to mixed-tree gardens or agroforests. Natural forest coverage has now declined to 10% of the former area within village forest land. We analyzed the characteristics of the mixed gardens and village forests, and their practical contribution to reducing farmers' dependence on the adjacent national park resources. Households with farms that were more diversified were found to have much less dependency on the national park resources. Households that farmed only wetland rice fields registered the highest value of forest products obtained from inside the park. Households that farmed only mixed gardens had an intermediate level of park resource extraction, while those that had farms composed of both components (i.e. wetland rice fields and mixed gardens) had a dramatically lower level of economic dependency on park resources than households in either of the other two categories.

Introduction

The classical method of preserving a natural area has always been to declare it off-limits and to enforce exclusion by local people (Wells and Brandon, 1992). Recently, an alternative approach has been receiving much attention: Linking enforcement to some form of compensation to the communities that are directly affected by the presence of the natural area. This enables them to recover some benefits from foregoing their use of the protected area's resources. Conservation would be ensured by reconciling the management of protected areas with the social and economic needs of local people. These projects have come to be known as integrated conservation-development projects (ICDPs).

Management plans for parks and multiple-use

areas around the world frequently refer to buffer zones (Garrity et al., 1996; MacKinnon et al., 1986; Wind and Prins, 1989). Buffer zone management is now generally considered a key priority for ICDPs. So far, however, there is a large gap between planning and successful realization. The problem is that there are few examples of buffer zones that function with sufficient effectiveness to provide clear, positive guidance to practitioners.

Compensation to communities in terms of development activities may take a number of forms. Most projects attempt to encourage improved natural resource management practices in the areas outside the reserve. The objective is to increase people's incomes, and to intensify production systems away from the more extensive, environmentally-degrading systems that may currently be practiced. There is growing interest in the development of more intensive land use systems on the margins of protected forests. Agroforestry systems are emphasized in many of these projects. Where there has been a history of tree crop cultivation in the vicinity of a protected area, the environment outside the boundary develops ecologically favorable characteristics for protection, and even extension, of the biological diversity of the park itself (Garrity, 1997). One case exemplifying this is the '*damar*' agroforest systems found on the boundaries of the Barisan National Park in Lampung, Sumatra, Indonesia (de Foresta and Michon, 1994, 1997). Another example is the 'jungle rubber' system wisely practiced (more than 2.5 million hectares) in Sumatra and Kalimantan, Indonesia (Penot, 1995)

Research will play an increasingly important role in providing options and insights for ICDP development. The Sustainable Agriculture and Natural Resources Management (SANREM) Collaborative Research Support Program is a major global program that takes a landscape approach with a highly participatory bias. At the SANREM research location in the Manupali Watershed in Mindanao, Philippines, the biodiversity consortium's focus is on the elements of a buffer zone management plan for the Kitanglad National Park (Garrity et al., 2000). The research is developing the elements of a practical social contract for buffer zone management, developing improved agroforestry systems for the buffer zone, and assembling a natural resource management system.

Kerinci Seblat National Park (KSNP) in Sumatra, Indonesia was gazetted as a national park in 1982. The land is part of the Bukit Barisan mountain range. It occupies nearly 1.5 million ha in four provinces on the island of Sumatra, namely Jambi (40% of the park area), West Sumatra (25%), Bengkulu (21%) and South Sumatra Province (14%) (*Tim Penelitian Daerah Penyangga Taman Nasional Kerinci Seblat*, 1992). Linkages have traditionally occurred between KSNP and communities that live around it. Communities extract many resources from the Park to fulfill their basic livelihood, such as fruits, fuelwood, timber, medicines and wild animals. These traditional linkages were not destructive when the population density around the park was low. As population density increased, livelihood pressures on the park have intensified, leading the traditional people-park linkages toward greater natural resource exploitation. This now threatens the integrity of the park. The gathering of forest products from the national park takes place on a continuous or an occasional basis, depending upon the products obtained. Timber and fuelwood are gathered continuously. Products such as rattan, incense, palm fibers, and game animals are obtained on an occasional basis.

Indonesia, with the support of international partner institutions, is attempting to apply the ICDP approach to these problems (Alikodra and Soekmadi, 1991; WWF, 1992). One of the directions of the effort is to increase land productivity in the park buffer zone to deflect settlement pressure. Agroforestry systems have been viewed as one of the most promising ways of intensifying land use in buffer zone areas (Garrity, 1995; de Foresta and Michon, 1997).

The objectives of this research project were to study the effects of farm diversification within the buffer zone on the levels of park forest resource extraction, and to determine the contribution of mixed garden farm and community forest to alleviate farmers' use of KSNP resources. There are three general farm types in the villages adjacent to the park: farms with only wetland rice fields, farms with only mixed-perennial gardens, and farms composed of both wetland rice fields and mixed gardens. We hypothesized that the

nature of the farming systems outside the protected forest boundaries have a strong influence on the levels of extraction from the park, and that the type of farming system practiced by a family has a definitive effect on the degree to which it is dependent upon gathering resources from within the park boundaries. Specifically, we expected that farms containing mixed perennial gardens would be less dependent on park resources than rice farms, since products harvested in the garden may be substituted for those gathered in the park. If so, then there may be useful implications as to the ways in which outside stakeholders may assist villagers in the evolution of their farming systems in ways that would impact positively on park protection. This study examined these issues.

The research site

The northern part of the Kerinci Seblat National Park (KSNP) buffer zone is comprised largely of community forest and human settlements. Previously, the forest area in West Sumatra Province consisted of Preservation Forest and Community (*nagari*) Forest (Doerachman, 1957). Preservation forest is managed directly by the national Forestry Department, while community *nagari* forest is managed by each village. *Nagari* forest had formerly been utilized as production forest by local people and provided significant cash income to the village. The *nagari* forest areas have been gradually converted into farmland, i.e. to mixed tree gardens or agroforests.

The research was conducted in three villages located on the boundary of Kerinci-Seblat National Park in Sungai Pagu Sub-district, Solok District, West Sumatra Province. The three villages were Batang Lolo, Sungai Kalu I and Sungai Kalu II (Figures 1). They are located about 130 km southeast of the city of Padang. The capital of Sungai Pagu Subdistrict is Muara Labuh, a small town. Batang Lolo village covers an area of 1089 ha, part of which is flat land with wetland rice fields, and the remainder is sloping upland. Sungai Kalu I and Sungai Kalu II villages have areas of 1404 ha and 2838 ha, respectively, and also have land of these two basic types. Rainfall in Sungai Pagu Subdistrict averages 4108 mm (20 years of data from 1921–1940; Schmidt and Ferguson, 1951), with an average number of 11.9 wet months (rainfall > 100 mm) per year. Based on rainfall observations in the same location during the four years 1990–1933, average annual rainfall declined to 1435 mm, with an average number of wet months of 7.25. Average night temperatures are between 20 and 22 °C, and maximum temperatures are 24 to 26 °C.

The population of the three research villages (Batang Lolo, Sungai Kalu I and Sungai Kalu II) in 1993 was 2630 persons (614 households), 1132 persons (243 households) and 1461 persons (320 households) respectively. Batang Lolo village was established earlier in history then either Sungai Kalu I or Sungai Kalu II. Batang Lolo has existed from the period of Dutch rule, while Sungai Kalu I and Sungai Kalu II were both settled around 1950. The inhabitants of Sungai Kalu I and Sungai Kalu II are migrants from Lembah Gumanti Sub District, about 80 Km to the north-west.

Maps of land use at the study area (Regional Office for National Land Agency, West Sumatra Province, 1991/1992) show five land classes: human settlements, wetland rice, garden/mixed garden, shrubs/underbrush and primary forest. Mixed gardens (agroforest) and primary forests occupy the largest area (Table 1). Figure 2 shows the land use distribution in Sungai Kalu I Village. Seven types of land use are identified: mixed gardens, wetland rice, upland fields, rubber plantations, shrub land, forest, and village settlements. Upland fields and monoculture rubber plantations occupy only a small portion of the area. Upland

Table 1. Land use in the three research villages, Solok District, West Sumatra, Indonesia.

Land Use	Area			
	B. Lolo	S. Kalu I	S. Kalu II	Total
	hectares			
Human settlement	18.0	11.5	25.0	54.5
Wetland rice	160.0	100.0	108.0	368.0
Garden/Mixed Garden	98.5	315.5	465.5	879.5
Shrubs/brush	28.0	12.0	215.5	255.5
Dense Forest	784.0	965.0	2,024.0	3,773.0
Total	1,088.5	1,404.0	2,838.0	5,330.5

fields or *tegalan* usually are planted to monoculture annual crops.

When the boundary of the national park was declared in 1982, a portion of the park had already been occupied by the community. Thus, some mixed gardens, wetland rice, upland fields, and human habitation are located inside the park boundary. Soils in the study area are red-yellow podzolics and andosols. The topography ranges from flat to steeply hilly. The altitude ranges between 440 and 870 m a.s.l.

We developed a transect of Batang Lolo Village

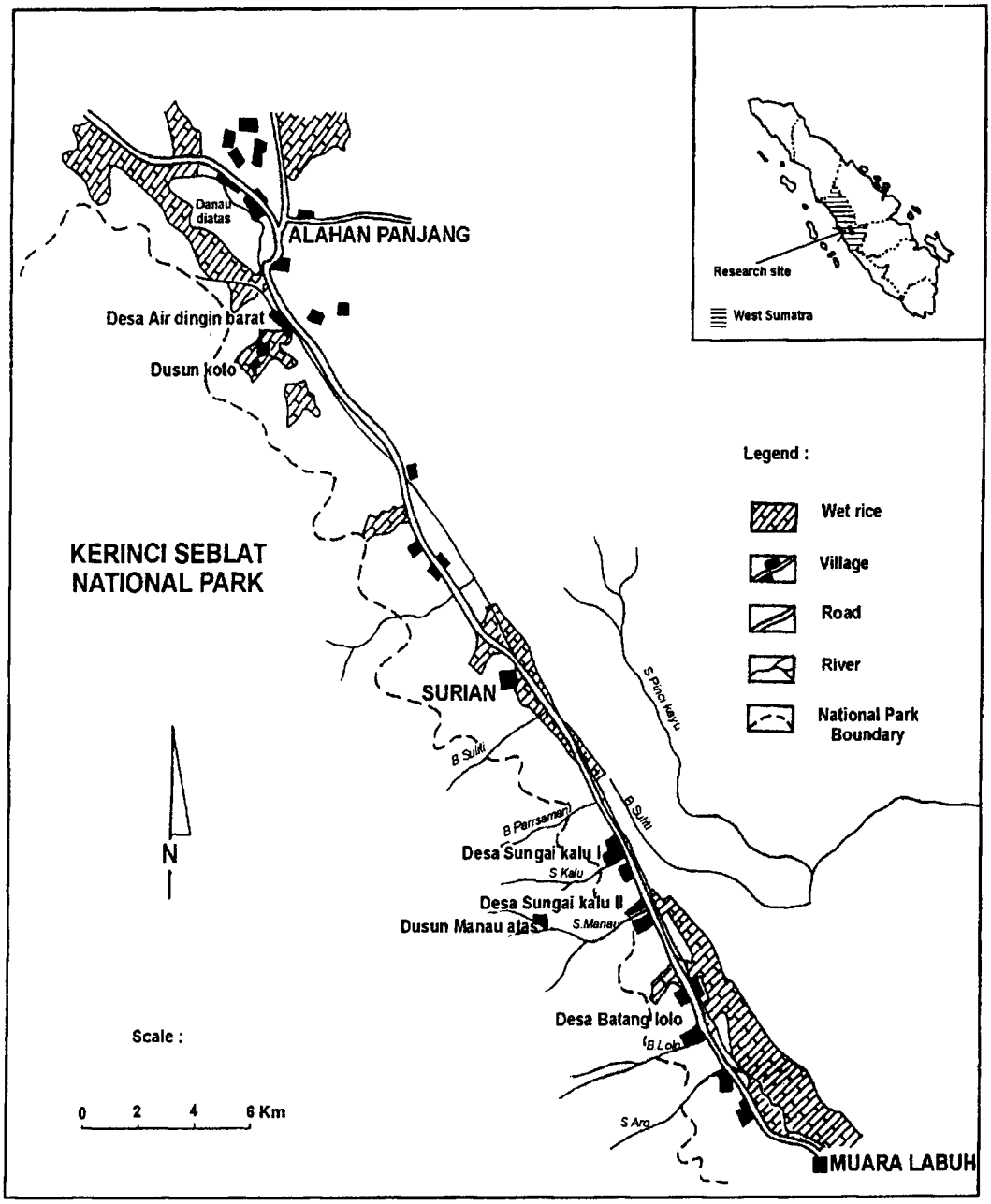

Figure 1. Map of the research site on the boundary of the northeastern part of Kerinci Seblat National Park, Sumatra, Indonesia.

(Figure 3) that shows the various land uses, from the lowest elevation (440 masl) to the highest (≥ 760 masl). Most shrub/underbrush is found on the steeply sloping areas. Since soil fertility was reduced rapidly on the sloping area, farmers did not establish perennial tree crops there after harvesting their annual food and cash crops. As a result, the area reverted to shrub and underbrush

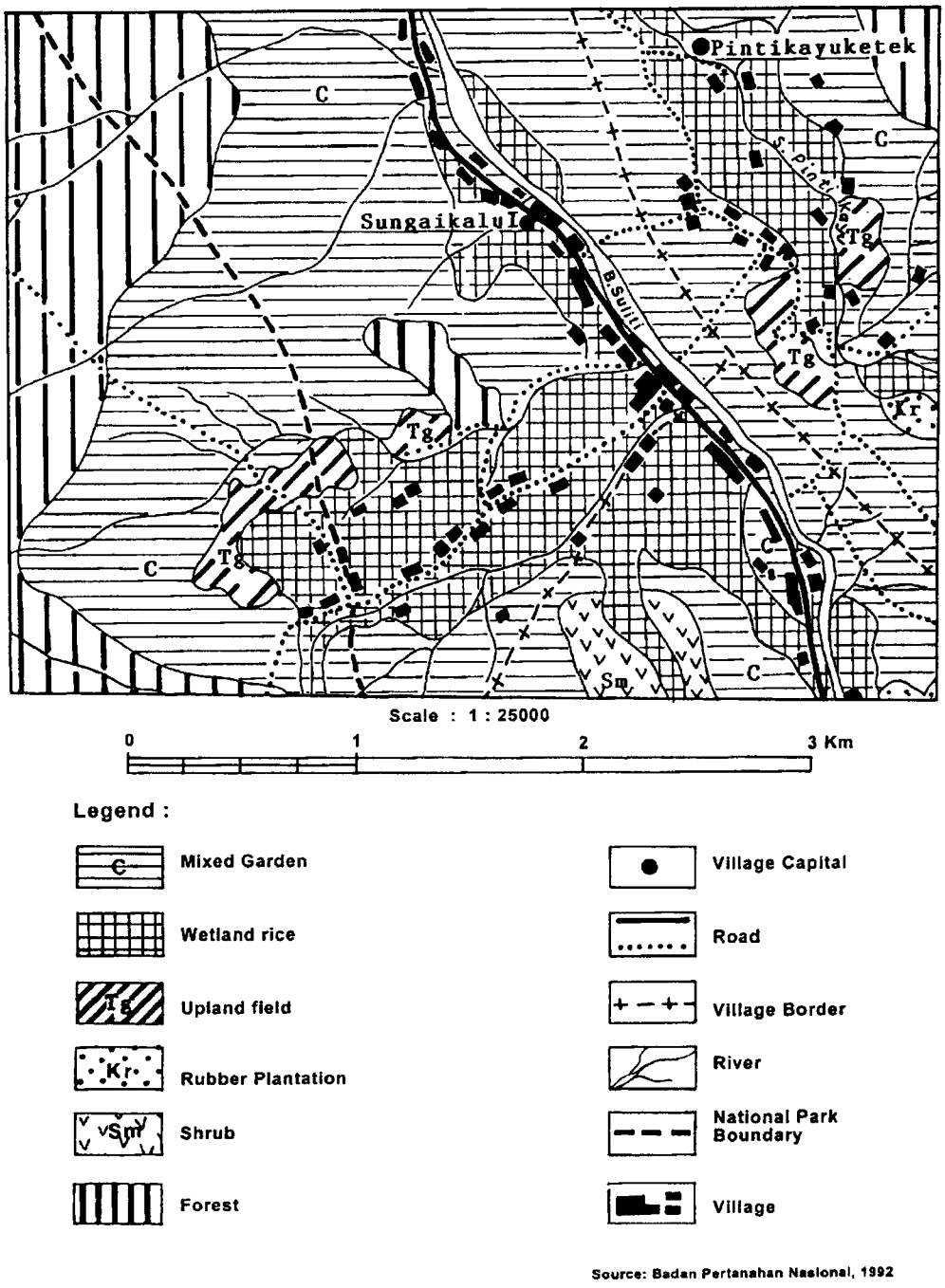

Figure 2. Map of land use in Sungai Kalu village, Sumatra, Indonesia.

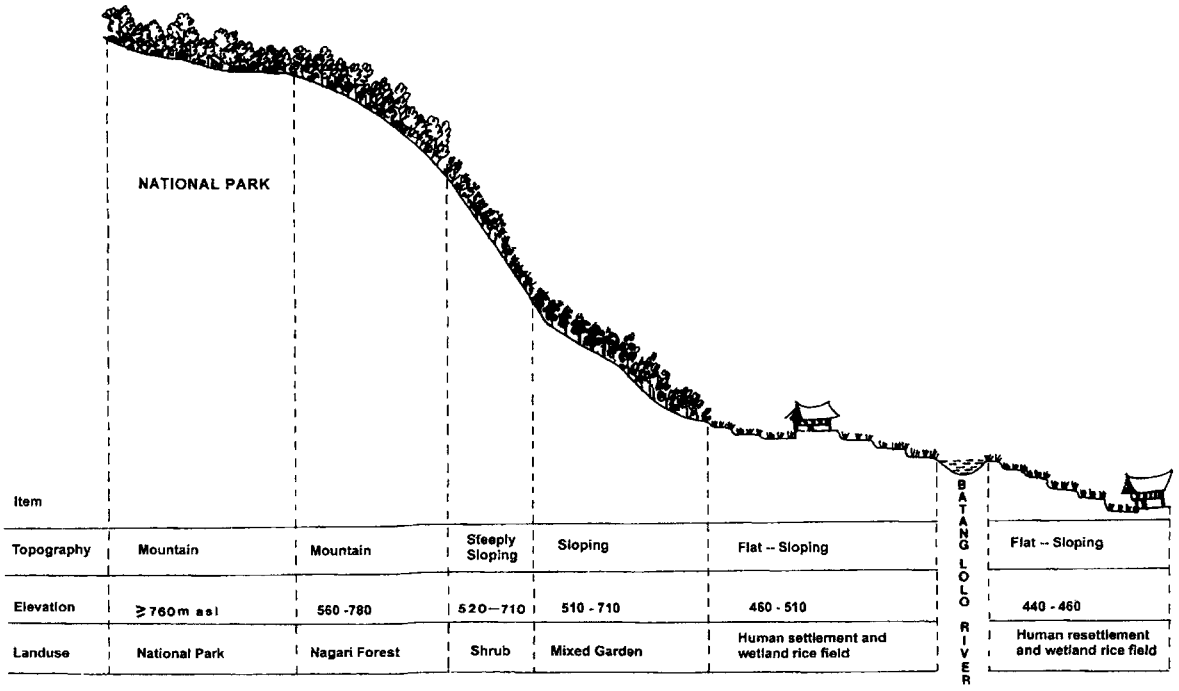

Figure 3. Transect of Batang Lolo Village, Sumatra, Indonesia.

in a fallow situation. Most of the income of villagers in all three communities is from farming, either as a land owner or as a share-cropper. Some villagers also work as hired farm workers and/or forest-product gatherers, obtaining timber, fuelwood, and non-wood forest products from the Kerinci-Seblat National Park Forest.

Research methods

The study focused on the harvesting of forest products from the Kerinci Seblat National Park. The contribution of mixed gardens and community forest to reducing farmers' dependence on park resources was investigated. The research used interview and field observation methods. The sample unit was the farm household with the head of the family as the respondent. The sampling technique was proportionate stratified random sampling, with a sampling intensity of 5% of the households in each village. Stratification was based on the nature of farm activities according the following typology of three basic farming systems:

(1) Farms with only wetland rice fields;
(2) Farms with only mixed perennial gardens; and
(3) Farms composed of both of these components (wetland rice fields and mixed gardens).

The procedure for household selection was implemented as follows: All farmers in each village were registered and grouped based on their farm activities. The number of selected households (respondents) was then calculated so as to obtain a sampling intensity of 5% of the households in each group. Finally, sampling households were selected at random within each group. Sixty farmer respondents were interviewed. The sample consisted of 14 households that farmed only wetland rice fields, 10 with only mixed perennial gardens, and 36 households whose farms consisted of both wetland rice fields and mixed perennial gardens.

Interviews focused on the management of the rice lands, mixed gardens, and village (*nagari*) forest, as well as the gathering of forest products from the park. During the interviews we investigated the structure of the mixed-perennial gardens,

and the contributions of products by mixed-perennial gardens in reducing household dependence on harvesting national park resources. Interviews were also conducted with the formal and informal leaders of the village, with leaders at the subdistrict level, and with the personnel of linkage organizations.

Field observations in the mixed gardens and community forest focused on the species of tree crops and natural vegetation, planting patterns, and kinds of forest products harvested routinely or occasionally from the village forest and the park forest. A t-test was used to statistically examine the differences in volume or intensity of KSNP forest product gathering by farmers based on farm typology. Multiple regression analysis was also used to examine whether the differences were caused by farm types, farm size or farmers' income. In the regression, farm types, farm size and farmers' income served as independent variables. The mixed garden farm contribution was calculated based on the difference in value of products gathered from the park by mixed garden farmers compared to rice only farmers.

Results

Characteristics of the mixed gardens and village forest

The mixed gardens developed by farmers in the study area almost all have a multi-layered structure. Mixed gardens in West Sumatra tend to be multistoried agroforests, where there is a tight integration between forest trees and crop commodities (Michon, Mary and Bompard, 1986). The upper story of the mixed gardens is typically dominated by jungle rubber (*Hevea brasiliensis*) along with durian (*Durio zibethinus*), jengkol (*Pithecellobium lobatum*), petai (*Parkia speciosa*), and coconut (*Cocos nucifera*), with fewer individuals of a range of other species. The lower canopy layer is dominated by coffee (Coffea sp.), and cinnamon (*Cinamomum burmani*). Allen et al. (1976) noted that the multi-strata canopy composed of several species tends to maximize the response of the system to sunlight inputs.

There are two patterns of mixed garden establishment immediately after an area of village forest land is opened. The first is the establishment of a combination of coffee, annual food or cash crops, and fruit trees. Shade trees (Erythrina sp.) are established universally along the coffee rows in young coffee gardens. The second pattern is the establishment of annual food or cash crops and fruit trees in combination with rubber trees. When the canopy of the trees reaches closure (usually after three years) cinnamon trees are established to replace the annual crops in both mixed garden systems. Coffee may be harvested until the coffee plants are about 15 years old. By this time coffee production has declined to an uneconomic level. The household then establishes a new coffee garden in another plot of village forest land.

Trees grown solely for timber were observed only rarely in the mixed gardens. Surian (Toona spp.) is an indigenous species with high demand for lumber. It was formerly common on village lands and inside the national park. Due to strong exploitation pressure the species is now almost extinct in the vicinity of the villages, at least to a distance of several kilometers inside the park. Management of the mixed gardens is still fairly extensive. Some mixed gardens have reverted back to bush fallow and have a large proportion of natural shrubs. This happens when a low level of maintenance is practiced in the mixed garden. When the gardens are not well tended after planting, the economic trees do not survive and thrive.

Ownership of a piece of land, i.e. a secure traditional land claim, resides with the farmer that originally opens the land for cultivation. Other farmers may borrow this land for their temporary use with the permission of the 'owner', but when doing so they are only allowed to produce annual crops, not perennials. In reality, farmers seldom use land owned by others. They prefer to open a new piece of village forest land, as such land will then be recognized as their own property. This traditional land ownership system tends to result in continued clearing of the village forest lands, and to a limited degree the adjacent national park lands. Although encroachment into the park is not serious at present, there may eventually be intense pressure on the clearance of forest land if more vigilant means of enforcement are not evolved. With this system each farm household controls an area of upland farm area of about two to four

hectares. However, usually only 0.5 to 1.0 hectare of this is cultivated with either annuals or perennials. The farm sizes shown in Table 2 refer only to the area actually cultivated.

Contrary to the situation just described for dry upland areas, wetland rice fields can not be borrowed from owners. If other farmers want to cultivate a piece of wetland, they have to rent it by means of share cropping. This share cropping system for riceland is frequently practiced in the research villages. The tenant receives a third to a half of the yield produced. In principle, the pattern of land tenure in West Sumatra is a matriarchal/matrilineal system. In this system the land is passed from mother to daughter. Therefore, the ownership of land resides predominantly with women.

The total income of respondent households varied by farm type and farm size (Table 2). Households with mixed garden-only farms had the lowest average income (average US$232/year). Households with rice-only farms had an intermediate income (US$286/year) while those with farms composed of both riceland and mixed gardens had an income of US$492. Household income averaged US$320 when farm size was 1 ha or less. Households with a farm size larger than 1 ha had an average income of US$502. Total annual household income for all respondents ranged from US$36 to US$1,043.

Farm income and on-farm work consisted of the value of farm produce and income from labor on neighboring farms. Other income included such enterprises as small shops and the trading of agriculture products and livestock. Enterprises income as a proportion of farm income varied by farm type and size. On-farm income for rice-only farms was only 30% (US$86) of total income, and for mixed garden-only farms it was about 37% (US$86) of total income. Farms with both mixed gardens and rice obtained 67% of their total income from the farm (US$328).

Forest product gathering in the park forest

Results of the interviews with the 60 respondents indicated that the gathering of forest products inside the park is conducted either on a frequent or continuous basis, or on an infrequent or occasional basis. This depends upon the specific product. Products that are frequently and continuously gathered include timber for lumber and beams, and fuelwood (especially for cash sales). Rattan, incense, palm fiber, hunted animals (deer and monkeys) and fish were also gathered, but only on an infrequent or occasional basis. The tree species that are logged for timber were '*madang*', (Lauraceae family); '*bayur*' (*Pterospermum javanicum* of the Sterculaceae family); and '*borneo*' (*Shorea platyclados* of the Dipterocarpaceae family). Species that are commonly harvested for fuelwood included 'paniang-paniang' (Quercus

Table 2. Farm area and annual income from different enterprises (May, 1993 to May, 1994) among a sample of households with three basic farming systems across three villages on the boundary of Kerinci Seblat National Park, Solok District, West Sumatra, Indonesia.

Farm type	No. of respondents	Farm size (ha)			Annual Household Income (US$) from various sources					
		Wetland rice	Mixed garden	Total	Wetland rice	Mixed garden	Total farm income	On-farm work	Other income	Total household income
Wetland rice farms										
Average	14	0.46	–	0.46	86	–	86	79	121	286
Range	–	0.17–1.0	–	0.17–1.0	15–179	–	15–179	0–347	0–375	36–564
Mixed garden farms										
Average	10	–	0.52	0.52	–	86	86	84	62	232
Range	–		0.2–1.25	0.2–1.25	–	25–196	25–196	0–246	0–193	74–488
Rice + mixed garden										
Average	36	0.44	0.97	1.41	112	216	328	69	95	492
Rage	–	0.1–1.5	0.25–3.0	0.63–3.5	22–390	17–649	85–813	0–252	0–623	134–1043

spp. of the Fagaceae family); 'baliak-baliak angin' (*Mallotus paniculatus* of the Euphorbiaceae family); and 'jambu lelen' (*Bellucia asinanthera* of the Melastomaceae family).

Analysis of the total farm sample population. The *t*-test showed that the value of the products routinely gathered by the village families from inside the national park varied among the three farm types (Table 3). These differences were statistically significant at the 10% error level. The value of products that were gathered on only an occasional basis did not differ significantly among the farm-type groups. The data were pooled and multiple regression analysis was conducted. Table 4 indicates that the household area of mixed gardens and rice fields were both negatively and significantly ($P < 0.05$) related to the value of products extracted from the Park. The area of mixed gardens exerted by largest effect in depressing forest product extraction. Household income level also had a significant effect on the value of forest products extracted. Farm size, on the other hand, did not influence forest product extraction.

Farmers with only wetland rice registered the highest value of forest products obtained routinely from the park. Nine of the fourteen rice-only households surveyed (64%) obtained income from routine harvest of forest products, particularly timber for sale. This income averaged $174 per household ranging from 1/3 to more than three times the amount of income they obtained from all other sources combined. Farmers with only mixed gardens had an intermediate level of dependency on park resources ($126 per household). Their routine harvest from the protected forest had a value 28% lower than that for rice farmers. Their income from all other sources was also less (US$232) than for the rice farmers (US$286). Households with both riceland and mixed gardens, however, had a dramatically lower dependency on park resources (US$11) for products continuously gathered than either of the other two categories. This was 87% less than the rice farmers, and 83% less than those with only mixed gardens. Their income from all other farm and non-farm sources was higher (US$492) than for the other two farm types.

We found a significant negative correlation between the amount of total income that a household derived from the extraction of products from the national park (both continuously and occasionally gathered) and income from other sources. This was true for the sample of households with wetland-rice only farms and mixed-garden only farms. The correlation was not significant for the sample of rice + mixed garden farms, considering that total income from the park for this sample was very low ($31 per year). Thus, it appears that the availability of other substantive sources of income had a strong depressant effect on the propensity of households to extract products from the park.

Analysis of the sample of farms of less than 1 hectare. Average farm size for the sample of rice-only farms (0.46 ha) and for the mixed garden-only farms (0.52) was almost identical. However, the rice-and-mixed-garden farms averaged 1.41 hectares. This raised the issue that differences in farm size may have influenced the results. We tested for such a bias in the regression, and observed no significant effect (Table 4). Correlation analysis was also used to determine

Table 3. Average value per household of forest products gathered from the national park during one year (May 1993–May 1994). Solok District, Sumatra, Indonesia.

Type of farm	Value (US$/year/household)				
	Products continuously gathered		Products gathered occasionally		Total
	Farms ≤ 1.0 ha	All respondents	Farms ≤ 1.0 ha	All respondents	
Rice-only farm	174 a	174 a	8 a	8 a	182
Mixed Garden-only farm	126 b	133 b	15 a	13 a	146
Rice and Mixed Garden farm	11 c	23 c	21 a	8 a	31

Note: In a column different letters signify differences that are significant at $P < 0.10$.

Table 4. Multiple regression analysis of forest product value ($ per household) gathered from the national park during a one year period (May 1993–May 1994). Solok District, West Sumatra, Indonesia.

Predictor	Coef	St. Dev.	*T*-ratio	*P*
Constant	304.51	45.09	6.75	0.00
Rice field	−88.17	42.94	−2.05	0.05
Mixed garden	−131.92	39.26	−3.36	0.01
Farm size	7.71	24.28	0.32	0.75
Income	−0.13092	0.06704	−1.95	0.05

Note: S = 97.99 R-Sq = 37.2% R-Sq (adj) = 32.6%
The regression equation is:

Forest product value = 305 − 88.2 Rice field area − 132 Mixed garden area + 7.7 Farm size − 0.131 Household income.

whether farm size was significantly related to farm income, and to income derived from the national park. Within the entire sample population for mixed-garden only and rice + mixed farms, there was no significant correlation between farm size and farm income from forest products. For the rice-only farms, we did discern a quadratic relationship between the size of farm and income from forest products. In this case, income from forest products declined as farm size increased from 0.2 ha to 0.5 ha, and thereafter tended to increase as farm size further increased to 1.0 ha. This relationship may be an artifact of the small sample size. However, it may also indicate that both poverty and relative wealth are driving park extraction activities at the household level. Forest products income was about the same for the group of smallest farmers (< 0.5 ha) and larger farmers (> 0.5 ha). In this farm population we noted earlier that forest product income was also lowest among farmers with the highest non-forest product income.

In another test to eliminate bias due to differences in average farm size between farm types we discarded the data on all rice + mixed garden farms that were greater than one hectare in size to create a residual population with an average farm size similar to the other two farm types. This analysis showed that the value of forest products gathered by households still differed (at 10% error level) among the farm types compared (Table 3). Farmers with only wetland rice extracted the highest value of forest products obtained frequently from the park. Farmers with mixed-garden-only farms had an intermediate level of dependency on the park's resources. And again the value of forest products harvested by households with rice + mixed gardens was dramatically and significantly lower (94% lower than for rice only; 91% lower than for mixed-garden only). We conclude that farm diversification (i.e. access to both riceland and mixed-garden land) with the same farm size substantially reduced the household's propensity to harvest products from the national park.

Factors underlying differential propensity to harvest products from the park. Our observations lead to the recognition of three factors that may explain the tendency of those farms consisting of rice-only to have a higher propensity than other farm types to exploit the park's resources. First, households with rice-only have an annual labor distribution that is relatively lumpy, compared to those with mixed gardens. Periods of very intensive labor demand in rice-growing are followed by lengthy periods with little or no field activity. Prospective economic activities to absorb excess labor during the off-season are needed. Forest-product gathering is a convenient sink for excess labor since timber-harvesting in particular is not season-dependent. Second, these households have less access to tree-based products from their own farms, particularly fuelwood, than do either of the other two farm types. Third, farmers harvest either two rice crops per year (Batang Lolo village) or three rice crops in two years (Sungai Kalu 1 and 2). Because their rice area is small (0.5 ha average), only a small surplus is generated beyond family food requirements that can be sold for other basic needs. On farms with a very small area of rice (0.2 to 0.5 ha) this surplus is marginal, or a rice deficit occurs. Other sources of off-farm income are in strong demand by these marginal rice farmers. Forest product gathering is a major ready alternative source of cash.

The tendency for rice-only farmers to earn income from forest products declined as farm size increased from 0.2 to 0.5 hectares. But contrary to the situation with the other farm types, it tended to increase again when rice-only farms were larger than 0.5 ha. This group of families, having relatively larger rice farms (> 0.5 ha), tend to hire

labor to cultivate their rice fields rather than to work the fields themselves. Whereas, in households with smaller farms family members tend to perform all rice-growing operations themselves. For the larger rice farms, the hiring of labor frees them from the drudgery of wetland rice farming. These households tend to invest more of their excess labor and cash in forest-product gathering. This group in particular tends to be engaged in small-scale logging operations in the park. Their total income from forest products, however, was not any higher on average than for the sample of very small farmers. We therefore conclude that household income is the determining factor for propensity to harvest forest products. Those households with the greatest propensity to harvest forest products, regardless of farm size, were those that have the lowest income.

Farms that are composed of both wetland rice and mixed gardens are the most diversified. They usually provide for their basic food needs from the rice land, and their mixed gardens provide products for cash income during the rest of the year. Products for the household and for sale are harvested throughout the year. Family labor is absorbed in managing the mixed farm, with little spare time for other endeavors. Nevertheless, they rarely use hired labor. These households pursue a farming system that dramatically reduces their propensity to obtain products from the national park, compared to the two other farm types.

Farms with mixed gardens alone have less dependency on the park than rice farmers, but the difference is not large. Their constraint is that they have no wetland resources to produce their basic food needs, and therefore are much more dependent on cash income to buy rice than either of the other two types of household. They are unable to fully meet their cash requirements from their mixed gardens, which average only 0.52 hectares in size. They depend exclusively on family labor for farming. They have a more even distribution of annual labor throughout the year than rice farmers. But they are also tempted to engage in harvesting park resources because of the inadequacy of their cash income.

Forest product gathering from village forest land

The village forests, both in their original state and after being converted into mixed gardens, provide resources to satisfy the communities' needs, particularly fuelwood for home consumption, wild vegetables, and medicinal plants. The average annual value of products gathered from the village forests by the communities was US$38 per household for fuelwood, and US$4 for wild vegetables and medicinals. The village forest land thus makes a significant contribution to the annual income of the household. Product gathering from them accounts for about 10% of family income. Fuelwood was by far the dominant income-generating activity. Gathering bamboo shoots and ferns (which are sold commercially) are the 2nd and 3rd most important activities in value. In the past, timber harvesting was important but all commercial timber has now been removed from the village community forest land. Income from the village forest lands is expected to continue to decline in the future. The remaining village forest is gradually being claimed for cultivation and for the establishment of mixed gardens.

Discussion and recommendations

The dominant income-generating activities in the national park are timber harvesting and fuelwood gathering. Sixty-four percent of rice-only households were engaged in this activity, and 70% of the mixed-garden-only households. However, only 14% of the rice + mixed-garden households were involved. A diversified farming system significantly reduced household reliance on national park resources. We translated the difference in value of forest products gathered by rice-only households and rice + mixed garden households into a quantity of timber. When this difference is aggregated across the three villages, we estimate that annually about 700 fewer trees are cut from the national park than would have been the case if all households were rice-only farmers. This estimate is hypothetical, but it indicates the magnitude of importance that a more diversified farm system composed partially of mixed gardens exerts in reducing dependency on the park resources.

This study indicates that the key factors that propelled households to depend on the extraction of protected forest resources were: 1) low farm income and 2) sources of forest products on the farm. This suggests that an integrated conservation-development strategy for this part of the Kerinci-Seblat boundary zone should be focused on increasing the income of the poorest, least diversified farm households.

Farm diversification was found to be strongly related to lower dependency on the park. How might diversification be encouraged in this local context? One major opportunity would be to enable rice-only farmers to gain access to their own mixed-garden land. This is potentially feasible in these villages if such families were given preference in the allocation of village forest land to establish mixed gardens. The local '*adat*' land allocation system might be enjoined to adopt this principle as part of a social contract involving integrated conservation-development. A complication is that much of the undeveloped village forest land is under permanent claim by the families who had once opened it for cultivation in the past. These families hold onto their claim, but often leave the land uncultivated indefinitely. This results in a substantial area of underutilized land resources in villages where there is intense pressure for land by other less well-endowed or landless households.

Less than 10% of the village forest land is still forested. Almost all of this is located on steep slopes and is not suitable for cultivation or for mixed gardens. Some of the cultivable land is not farmed, but yet is claimed by the families that once opened it. Thus, some families, particularly newly married couples, have only rice land because they have no opportunity to find unclaimed land in the village forest to start their own mixed gardens.

For the group of mixed garden-only farmers, the opportunities open to them to diversify by obtaining rice land are extremely limited or non-existent, except by means of share-crop tenancy. The extent of wetlands is physically scarce, and all possible rice paddies were fully developed long ago. Therefore the direction for development for these farmers is toward expansion of their mixed gardens, or intensification of their gardens for higher productivity. Expansion will be limited by lack of labor and capital to establish new plots, and in the not-too distant future, by the exhaustion of all village forest land available for new gardens. The adoption of new technology for higher yields is the most feasible route to higher income for these families. This may be accomplished by introducing promising new commodities, better quality cultivars for their current species, and improved management or more farm inputs where these are profitable. One example is the potential for the introduction of high-yielding rubber clones into the mixed garden. Current research estimates that smallholders may double or triple their rubber yields by substituting improved rubber clones for the unselected seedlings that they conventionally use to replant in their rubber gardens (ICRAF, 1995). They may continue to intercrop their rubber with a range of other tree crops. Likewise, better cultivars of fruit trees can be introduced to replace those of local varieties. The productivity of the coffee systems can be improved in a number of ways, including new cultivars and more intensive management of the coffee plants.

Earlier we discussed farmers' concerns that virtually all high-quality timber, such as the dominant species, *Toona sinensis (surian)*, has disappeared from the village and from a radius of some five kilometers into the park. Most farmers interviewed expressed a strong interest in growing *surian* trees in their mixed gardens to insure a future timber supply. One factor encouraging households to consider growing timber is the sheer difficulty of harvesting a tree and dragging it five kilometers out of the park. The economic attractiveness of growing one's own timber is steadily increasing.

Farmers related that *surian* used to be self-reproducing when it was common in the village. Today, however, there are few specimens remaining from which to regenerate seedlings. Farmers noted that it is difficult to establish *surian* from seed unless it is gathered and germinated within a few days after fruiting, as the seed is highly recalcitrant. Simple methods for germination are known, however (A. N. Gintings, pers. Comm. January, 1995) and it appears that there is strong interest in re-establishing *surian* in the area. Farmers are particularly interested to include it as a component of their mixed garden systems.

Intervention focused on *Toona sinensis* regeneration by the forestry extension service should be given attention.

The above examples of interventions were given to indicate the potential areas in which diversification may be encouraged, through practical land allocation mechanisms and technical change. These changes can contribute significantly to solve the encroachment problem but they cannot, in themselves, be viewed as sufficient to do so. Greater sources of off-farm income will be required. An integrated conservation-development program could assist with infrastructure to stimulate private enterprise growth in the region, to absorb a larger share of the rural workforce. Ultimately, attention to these issues may reasonably be expected to increase the acceptability of local villages to cooperate with stricter enforcement of the park boundaries. Enforcement and development will need to be linked. In this area of the Kerinci Seblat National Park boundary, the range of factors impinging upon the situation steep (topography, culture, land tenure, economic development) suggest a reasonable prospect for success.

We have emphasized the need to target ICDP assistance to a particular subset of village households: The poorest and least diversified. Targeting the poorest farmers in development (or research) programs is, however, much more difficult in practice than is often recognized (Ostberg, 1995, pp. 76–77). Chambers (1983) noted six major reasons why development practitioners tend to systemically fail to address the problems of poor rural households, however well-intentioned their efforts. These were: roadside bias, top-down project orientation, elite contacts (male, progressive farmers and leaders), the tendency to make observations only during the dry season, outsiders' avoidance of poor people out of politeness or cowardice, and the professional biases that outsiders bring into the village associated with their particular specialization. Significant progress has been achieved in explicitly addressing these biases by some projects during the past decade. A key element has been the development of Participatory Rural Appraisal methods in general, and the more widespread application of practical techniques for agroecosystems analysis. One such technique particularly relevant to this discussion that has gained wide favor recently is the use of village wealth rankings as a means of defining target groups of households. Silverman (1966) developed the method and it gained limited application within the anthropological research community in the 1970s (Hannerz, 1976; Gerholm, 1977). More recently wealth rankings have been widely used in studies related to development projects (Grandin, 1983, 1987; McCracken et al., 1988; Ostberg, 1995).

We have shown that the type of farm enterprise does influence the degree of dependency of a household on the resources of the adjacent national park. All other things being equal, families with both riceland and mixed gardens depend less on park resources than do rice-only farmers. Farms with only mixed-gardens are intermediate in their dependency on protected forest resources. These results tend to corroborate the view that agroforest systems are a superior land use system for buffer zones. They may be expected to enhance the ecological integrity of a park in several ways. They provide income and products that tend to reduce the need for their harvest inside the park. In addition, they may provide environmental services in the buffer zone itself – soil and water conservation, and the extension of biodiversity habitat out into the agricultural landscape in ways that are conducive to conserving the flora and fauna of the park. Our study did not allow us to seriously examine the proposition that agroforestry systems that are more intensive (i.e. absorb more labor and capital and produce more household income) will have a greater effect in deflecting households away from harvesting in the protected forest than less intensive agroforestry systems. We do observe indirect evidence supporting this hypothesis, since higher household income was associated with less forest product harvest, at least for the mixed-garden only sample.

Even in areas where smallholder agroforestry systems do not yield such striking levels of protection or extension for natural biodiversity, the benefits of increased tree cover on the landscape may nevertheless be very important. Where trees are grown by farm families in reasonable densities for fruit, industrial, or timber uses, even on very small farms of less than one hectare, the tendency for the family to illegally collect fuelwood or timber inside the boundaries of

an adjacent protected area declines quite drastically.

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