A primary objective of Alternatives to Slash and Burn (ASB) research is to identify new combinations of policies, technologies, and institutions capable of simultaneously promoting three fundamental development objectives: poverty reduction, economic growth, and environmental sustainability (Vosti and Reardon 1997; Tomich et al. 1998b; World Bank 2001). To be successful in this effort, we must first understand why the currently predominant land use systems (LUSs) are more attractive to smallholders than existing alternatives. We must then measure the environmental and other consequences of each LUS. Then, if currently predominant LUSs are judged to be unsatisfactory with respect to one or more of the three objectives, alternative LUSs must be identified or developed. Finally, policymakers will need guidance regarding how to promote alternative LUSs: which policy instruments and institutional mechanisms should be used, how much policy action probably will be needed, and for how long this action will be needed to achieve and sustain desired changes.

Research aiming to address these issues must focus on the concerns of resource users, that is, farmers or farm managers charged with allocating scarce resources to best achieve household or firm objectives (Vosti and Witcover 1996; Reardon and Vosti 1997). Therefore, for a subset of the ASB meta-LUS, this chapter shifts the focus from environmental and agronomic issues to economic issues and the incentives and constraints faced by agriculturalists who manage and depend on the LUS for household food security, livelihoods, and profit.

The next section defines farmers’ concerns more precisely and describes how the performance of specific LUSs with respect to farmers’ concerns was
systematically measured across all ASB sites. We then report assessments of LUS performance and labor needs and examine market-related impediments to the adoption of existing and alternative LUSs at ASB benchmark sites in Cameroon, Indonesia, and Brazil. The next section makes cross-site comparisons of LUSs and broader issues that influence LUS choice. The final section forecasts LUS adoption trends for each benchmark site.

METHODS

Defining Land Use Systems

Ranges of Land Use Systems

Deforestation is a primary concern at all benchmark sites, so for analytical purposes natural forest was considered the point of departure for all land uses. Grasslands, short fallow–cultivation systems, and pastures were included as reference points at the opposite ecological extreme. In between, a range of LUSs representative of systems at each site were selected: extraction of forest products; complex multistrata agroforestry; simple tree crop systems, including but not limited to monoculture; fallow–cultivation systems, which include the textbook version of shifting cultivation or slash-and-burn agriculture; continuous annual cropping systems, which may be monocultures or mixed cropping; and cattle production systems. This array of LUSs covers a gradient of meta–land uses often used by biophysical scientists to describe varying levels of disturbance of forest for purposes of agriculture (NRC 1993; Ruthenberg 1980; Angelsen and Kaimowitz 2001).

Spatial Issues

The spatial scale at which LUSs are practiced can vary across systems and, for given systems, over time and across farmers or firms. To deal with this important issue, for each system at each site the observed (or projected) scale of general operation was identified and used in evaluating system performance and resource needs. For example, at one extreme, the short-fallow food cropping system in Cameroon was evaluated at an operational scale of 0.25 ha, whereas community-based managed forestry in Indonesia was evaluated at an operational scale of 35,000 ha. However, to allow for cross-system and cross-site comparisons, all reporting is done on a per hectare basis.

Temporal Issues

Finally, LUSs vary in terms of their active growing periods, the number of times particular components of LUSs can be repeated on a given piece of land, and the necessary
fallow periods. In order to correctly compare the performances and requirements of different _LUSS_, these temporal issues had to be considered explicitly and adjustments made to ensure that performances were measured over the same time horizons. For example, to compare a coffee production system with a 20-year cycle to a swidden agricultural system with a 10-year cycle, the latter’s performance must be measured and appropriately discounted because given the choice between volumetrically identical harvests at two different points in time, farmers will always choose the earlier of the two cycles.

**Measuring Farmers’ Concerns**

A set of three socioeconomic parameters were used to assess _LUSS_ from the smallholders’ perspective: financial profitability, labor needs, and household food security (Tomich et al. 1998a, 1998b; Vosti et al. 2000). The results in this chapter rely heavily on Gockowski et al. (2001), Tomich et al. (2001), and Vosti et al. (2001b).

**Financial Profitability**

Land use systems that generate inadequate profits will not be attractive to farmers. Financial profitability considers all establishment costs, and all cost and benefit streams associated with the production activities of each _LUSS_, over the lifetime of each system. It then discounts these cost and benefit streams to arrive at summary measures (e.g., net present value [NPV], used in this analysis) that can be used to compare _LUSS_ across and especially within benchmark sites. Private prices, those actually faced by farm households, are used in most NPV calculations presented here. Summary measures of financial profitability can be expressed in many ways; we express them in terms of two inputs critical to small-scale agriculturalists: returns to land and labor, reported in 1996 U.S. dollars. Returns to land represent the present discounted value of the net profits from land dedicated to a specific _LUSS_, that is, the per hectare return a farmer would expect to earn from land allocated to a particular _LUSS_, taking into account the stream of costs and benefits over time and valuing family labor used in that system at the market wage. Returns to labor represent the daily wage for family labor input to a system, that is, the average, daily wage that each family member involved in a given _LUSS_ could expect to earn from participating in it if all profits were distributed to family members as wages. Returns to labor that exceed the market wage suggest that an _LUSS_ will be attractive to family members or would justify hiring labor to operate it.

For these ASB sites it is important to point out that the costs and benefits of commercial logging operations that clear forest for agriculture are not included in the calculations of the returns to the _LUSS_ at some sites because the one-time value of timber extracted as a byproduct of land clearing often exceeds the value of the derived land use and would obscure differences in profitability between the derived land uses. Moreover, in most cases smallholders do not reap the full benefits of timber extraction.
Labor Needs

In labor-scarce rural economies or where labor markets are underdeveloped, labor needs are an important determinant of LUS attractiveness. The LUSs that continually entail more labor input than a typical rural household can provide or hire may not be attractive, especially if these systems provide low returns to labor. Of primary concern for ASB was the labor input needed to maintain a given LUS once established, so the adopted measure of LUS labor needs was the time-averaged labor input (measured in person-days) during the operational phase. Moreover, competition for family labor between traditional cropping systems and alternative LUSs can exist; if this competition was likely to be substantial, labor need numbers appearing in the tables in this chapter were set in boldface type. Labor needs for establishing some LUSs can also be very high and therefore reduce system overall attractiveness; data on labor needed for LUS establishment are available but are not presented here.

Household Food Security

Even if an LUS is financially profitable and feasible given household labor constraints and labor market conditions, it may be too risky either in terms of variability in food yields or as a source of income to exchange for food. To identify LUSs for which increased food security risk might be an issue, we adopted an indicator based on Sen’s (1982) concept of risk of food entitlement failure that encompasses trade-based and production-based entitlements to food. A system of indicators identifies the key paths households adopting a particular LUS would use to gain access to food: Is food derived from one’s own production, is food purchased with the proceeds of the production and sale of nonfood commodities or wage labor, or is access to food accomplished via some combination of the two paths? Once paths are identified, cross-LUS comparisons of food access can be made.

Policy Distortions, Institutional Issues, and Market Imperfections

Although the aforementioned measures of the farmer concerns capture a great deal of the relative attractiveness of the different LUSs, they must be supplemented by assessments of distortions of incentives arising from national policies and assessments of the institutional setting, especially as regards markets for land, labor, capital, and commodities. For all these cases, trade and marketing policies affect prices received and paid by smallholders (often negatively) compared with what they would receive under free trade. These policy distortions of incentives are examined in detail in Gockowski et al. (2001) for Cameroon and Tomich et al. (1998b) for Indonesia. Assessment of
the institutional setting is critical in developing countries for two reasons. First, markets are notoriously imperfect in rural areas and therefore can limit the robustness of standard quantitative assessments; for example, if capital markets routinely fail and credit is needed to establish some LUS, our estimates of returns to land and labor for these LUS may be overstated. Second, because of structural adjustment policies and changing world trade regulations, national policymakers are less able to use blunt trade policies and therefore must rely increasingly on investments in institutions and organizations to promote development objectives (World Bank 2001). Consequently, cash-poor policymakers need guidance in setting institutional or organizational investment priorities, which can include support to fledgling organizations created to compensate for market failures.

As a first step in identifying LUS that were likely to suffer from market imperfections, experts familiar with rural institutions at each benchmark site evaluated LUS in regard to their dependence on input supply, output, labor, and capital markets and the ability of local and regional markets to meet the challenges posed by the potential expansion of given LUS. What emerged was a series of market-specific flags (linked, respectively, to the markets just listed and abbreviated as I, O, LB, and K in tables 7.1 through 7.3) indicating that large problems with particular markets were likely to exist. Less important but still significant market-related problems are identified using lowercase letters.

Cross-LUS Comparisons Using Policy Analysis Matrix

The policy analysis matrix (PAM) technique, originally developed by Monke and Pearson (1989), is the basis for calculating LUS financial profitability and comparing multiyear LUS budgets. We augment the PAM with LUS-specific labor needs, indicators for food security, and institutional concerns. The matrix framework used here to evaluate LUS specifies LUS trajectories, including technology, land area, and time line associated with each system (matrix rows); defines indicators corresponding to different farmer concerns (matrix columns); and presents measurements of how well each selected LUS addressed each of the farmers’ concerns (matrix cells). It should be noted that the matrices for each site take as given the agricultural and other policies in place at the time the analysis was performed and the socioeconomic conditions prevalent at the time and place of analysis (Vosti et al. 2000).

RESULTS FROM ASB BENCHMARK SITES

In this section we present evidence on the financial profitability, labor needs, and market-related obstacles to adoption of selected LUS at the three benchmark sites. For each site, we begin with a brief description of LUS, present research results in PAM form, and discuss the implications of these results.
Cameroon

Land Use Systems

Eight luss were evaluated and compared in the Cameroon benchmark area; two dominant slash-and-burn systems (listed first) involving crop–fallow rotations that together account for approximately 75 percent of all annual and biennial cropland (Gockowski et al. 1998) and six alternative perennial-based systems practiced at different levels of intensity and frequency and are described more thoroughly in chapter 14.

- Intercropped food field planted after a short (4-year) Chromolaena odorata (L.) R.M. King and H. Robinson fallow (abbreviated as “SF–annual food crop”). This semicommercial system is the most common lus in the forest zone of Cameroon, is agronomically and commercially managed by women, and provides the bulk of the food consumed by households practicing it.
- Intercropped food field planted in a long fallow (“LF–forest crop field”). This lus, comprising melonseed (Cucumeropsis mannii Naudin), plantain (Musa spp.), maize (Zea mays L.), and cocoyam (Xanthosoma sagittifolium Schott), all cultivated in a 15-year fallow field, became a major commercial alternative for cocoa farmers when cocoa prices collapsed in 1989.
- Intensive cocoa with mixed fruit tree shade canopy planted after a short (4-year) Chromolaena fallow (“SF–intensive cacao w/fruit”). This cacao-based system includes avocado (Persea americana Miller), mango (Mangifera indica L.), African plum (Dacryodes edulis [G. Don] H.J. Lam), and mandarin orange (Citrus reticulata Blanco), all of which can provide significant secondary revenues when location permits access to urban markets (Duguma et al. 2001).
- Intensive cocoa with shade canopy planted after a short (4-year) Chromolaena fallow (“SF–intensive cocoa w/o fruit”). This is essentially the same lus as the short-fallow intensive cacao with fruit, except that fruit trees are not a commercial component because of limited market access.
- Extensive cocoa with mixed fruit tree shade canopy planted to forest land or long fallow (“FOR–extensive cocoa w/fruit”). This system represents the extensive cocoa production systems more characteristic of the less populated areas of the benchmark site that enjoy good market access.
- Extensive cocoa with shade canopy planted to forest land or long fallow (“FOR–extensive cocoa w/o fruit”). This is essentially the same lus as extensive cocoa with fruit except that fruit trees are not a commercial component.
- Improved Tenera hybrid oil palm (Elaeis guineensis Jacq.) system planted after a short (4-year) Chromolaena fallow (“SF–oil palm”). In this lus, oil palm is established in a 4-year Chromolaena odorata fallow with intercropped groundnuts, maize, leafy vegetables, and cocoyams during the first year; after the food crops are harvested a monoculture oil palm of the hybrid Tenera remains.
• Improved Tenera hybrid oil palm system planted to forested land or long fallow (“FOR–oil palm”). As in the case of short-fallow –oil palm, hybrid Tenera oil palm is produced in a monoculture. In this case, however, forested land is converted.

Land Use System Evaluation and Performance

Financial Profitability: Returns to Land
The more lucrative perennial crop systems tended to strongly dominate the two slash-and-burn systems (table 17.1, column 3). The NPVs per hectare were $283 and $623 for the traditional long- and short-fallow intercropped food systems, respectively, compared with $1409 and $1471 for the intensive cocoa and mixed fruit tree system and the hybrid oil palm system in forested land, respectively. Among the perennial crop systems, the extensive cocoa system was least profitable at $424 per hectare. Because per hectare profitability is measured on an annual basis and includes the fallow period, annual profitability of the slash-and-burn systems is significantly lower.

Financial Profitability: Returns to Labor
The highest returns to labor were found in the oil palm system planted in forested land ($2.44 per person-day) and in the intensive cocoa system with fruit trees ($2.36 per person-day). (See table 17.1). Returns to labor in intensive cocoa with no fruit ($1.95 per person-day) and in the extensive cocoa with fruit ($2.13 per person-day) were similar to the official minimum wage ($2.17 per person-day for unskilled manual labor). Returns tended to lie below the official minimum wage for the short-fallow annual food crop system ($1.79 per person-day), the long-fallow forest crop field system ($1.70 per person-day), the extensive cocoa system without fruit ($1.63 per person-day), and the short-fallow oil palm system ($1.81 per person-day). Although the absolute differences in labor returns do not seem to be very substantial, the difference between the highest and the lowest return is about 40 percent.

This static view of financial profitability masks price volatility that characterizes agricultural and world commodity markets. For example, in 1997 the average farmgate price per kilogram of cacao in southern Cameroon varied from 600 to 700 Central African francs (CFA), whereas in 1996 producers received 350 to 400 CFA per ton. At 400 CFA per ton of cocoa, the return to labor for the short-fallow intensive cocoa system with fruit fell to $1.58 from $2.36 per person-day.

Labor Needs
Person-days of labor needed to operate a hectare of each selected lus, once they are established, are presented in table 17.1. The systems using the least labor are the extensive cocoa without fruit (43 person-days/ha/yr) and the long-fallow forest crop field (44 person-days/ha/yr). The labor needs of the crop–fallow system are averaged over the entire rotation and therefore are artificially low in table 17.1. If one were to consider only the cropping phase, it would take 731 person-days of labor per hectare.
Table 17.1 Land Use System Performance and Resource Inputs at the Cameroon Site

<table>
<thead>
<tr>
<th>Land Use System</th>
<th>Scale of Operation (ha)</th>
<th>Financial Profitabilitya</th>
<th>Labor Needs</th>
<th>Household Food Security</th>
<th>Institutional Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Returns to Land (US$/ha)</td>
<td>Returns to Labor (wage setting NPV = 0) (US$/person-day)</td>
<td>Operational Phase (person-day/ha/yr)</td>
<td>Food Entitlement Pathsb</td>
<td>Market Imperfectionsc</td>
</tr>
<tr>
<td>SF–annual food crop</td>
<td>0.25</td>
<td>623</td>
<td>1.79</td>
<td>115</td>
<td>op, ex</td>
</tr>
<tr>
<td>LF–forest crop field</td>
<td>0.25</td>
<td>283</td>
<td>1.70</td>
<td>44</td>
<td>op, ex</td>
</tr>
<tr>
<td>SF–intensive cocoa w/fruit</td>
<td>1.30</td>
<td>1409</td>
<td>2.36</td>
<td>97</td>
<td>op, ex</td>
</tr>
<tr>
<td>SF–intensive cocoa w/o fruit</td>
<td>1.30</td>
<td>889</td>
<td>1.95</td>
<td>95</td>
<td>op, ex</td>
</tr>
<tr>
<td>FOR–extensive cocoa w/fruit</td>
<td>1.30</td>
<td>943</td>
<td>2.13</td>
<td>46</td>
<td>op, ex</td>
</tr>
<tr>
<td>FOR–extensive cocoa w/o fruit</td>
<td>1.30</td>
<td>424</td>
<td>1.63</td>
<td>43</td>
<td>ex only</td>
</tr>
<tr>
<td>SF–oil palm</td>
<td>1.00</td>
<td>736</td>
<td>1.81</td>
<td>71</td>
<td>op, ex</td>
</tr>
<tr>
<td>FOR–oil palm</td>
<td>1.00</td>
<td>1471</td>
<td>2.44</td>
<td>73</td>
<td>op, ex</td>
</tr>
</tbody>
</table>

aA discount rate of 10% was used, and the opportunity cost of household labor was set at $1.21 per day. The local currency unit (FCFA) was converted at rate of 1 US$ = 577 FCFA. Each proposed system’s socioeconomic indicators are based on optimistic yield parameters. Sensitivity analyses to establish lower ranges of profitability figures and to check robustness of results to observed swings in relative output prices and a range of discount rates are ongoing.

bFor food security, “own production (op)” and “exchange (ex)” reflect whether the system generates food for own consumption or income that could be used to buy food; combined food entitlement paths are common.

cFor institutional issues, letters indicate market imperfections judged to constrain US adoption (with uppercase indicating a serious problem and lowercase indicating a more minor difficulty), as follows: i, input markets; o, output markets; lb, labor markets; k, capital markets.

Source: Data derived from Gockowski et al. (2001).
to cultivate the long-fallow field crop, which helps to explain the small size (2500 m²) of the cultivated plots. The short-fallow annual food crop system and the intensive cocoa with fruit made the most intensive use of labor (115, which includes the 6 years of fallow, and 97 person-days/ha/yr, respectively). The extensive cocoa systems were the least labor demanding, at roughly half the labor needs of the intensive systems, and the oil palm systems were intermediate between the two types of cocoa-based lus.

**Household Food and Health Security**

In many areas of the Congo basin, rural food markets either do not exist or, if they do, are often periodic, and access is limited by transportation costs. As a consequence, most households at this site rely on own production to meet food needs. Household food security usually is not a major concern because of stable rainfall patterns and the safety net provided by extended kinship groups. In essence, the short-fallow annual food crop lus provides the bulk of food consumed in the household and usually is planted with subsistence objectives paramount and commercial objectives only secondary (Gockowski and Ndoumbé 1999). The same subsistence objective is largely true of the long-fallow forest crop field. With one exception, that of extensive cocoa without fruit, all lus at the Cameroon benchmark site contributed directly (via own production) and indirectly (via production sales) to meeting food needs.

**Institutional Issues: Market Imperfections**

The performance of input, output, labor, and credit markets exhibit wide geographic variation within the benchmark site, and lus vary in terms of purchased input intensity. That said, some consistent patterns regarding institutional obstacles to adoption emerged (table 17.1). The intensive cocoa systems are the most dependent on the reliable supply of agrochemicals. Intensive cocoa systems with fruit trees presume good access to urban fruit markets. In areas where access to market is difficult, the profitability of these systems will consequently decline. Labor market imperfections affected all intensive cropping systems.

Of note is that the oil palm systems face several market-related obstacles to broad adoption. First, the performance of these lus depends on the multiplication and distribution of hybrid palm varieties. Current capacity in Cameroon for producing pregerminated hybrid oil palm seed is low and in the hands of only a few suppliers, so prices are high ($0.42 per seed). By the time the seedling has spent a year in the nursery, farmers can expect to spend up to $400/ha on planting material alone. Second, three levels of postharvest processing technologies are commonly used: artisanal methods requiring almost no capital investment, small-scale manual and motorized turnscREW presses with some capital investment, and large-scale industrial processing with high capital investment. As operational scale increases, market development and market access become more critical. Third, export restrictions on palm oil during the dry season period drive down producer prices.

An additional constraint is that poorly maintained rural road networks in Central Africa contribute to high marketing margins that can lower farmgate prices in areas
distant from markets (e.g., low-value, bulky fruits from cocoa agroforests) to the point
that these enterprises are no longer commercially viable. The high costs of marketing
in Central Africa reduce its competitiveness in world markets, with negative implica-
tions for consumer and producer welfare and the adoption of agroforest-based LUSS.

INDONESIA

Land Use Systems Evaluated

The eight Sumatran land use systems examined in this section are presented here.
For an overview of LUSS, the driving forces that promote and sustain them, and their
environmental consequences, see van Noordwijk et al. (1995), Tomich et al. (1998b),
and Tomich et al. (2001).

- Natural forest. These forests, though generally not pristine, have been undisturbed
  for at least 100 years and are not currently used for economic purposes. They
  serve as the reference point for assessing alternative LUSS, although they no longer are
  common in the benchmark sites in Sumatra.

- Community-based forest management. This LUSS is practiced on 10,000- to
  35,000-ha blocks of common forest land managed by indigenous smallholders.

- Commercial logging. Concessions of 35,000 ha or more are logged for timber
  using a system based on a 20- to 25-year cycle that is generally practiced but probably
  does not meet sustainable logging criteria.

- Rubber agroforests. This is the dominant smallholder LUSS and is an integral
  part of an indigenous landscape mosaic. One- to five-hectare plots of forest or existing
  rubber (Hevea brasiliensis) agroforest are cleared, and the land is planted to upland rice
  (Oryza sativa L.) and unselected rubber seedlings, with natural regeneration of forest
  species.

- Rubber agroforests with improved planting material. This is an experimental
  LUSS based on traditional rubber agroforests but with the introduction of rubber clones
  with higher yield potential. One- to five-hectare plots were planted to upland rice and
  rubber clones, with regeneration of natural forest species.

- Oil palm monoculture. Practiced on estates of 35,000 ha or more, plantation
  oil palm is grown with substantial use of purchased inputs and wage labor, in close
  association with processing plants.

- Upland rice–bush fallow rotation. This shifting cultivation LUSS was once prac-
ticed by most smallholders on 1- to 2-ha plots on community land as part of an indig-
enous landscape mosaic but is now almost nonexistent. The version of this LUSS exam-
in here consists of 1 year of upland rice followed by a short bush fallow of 5 years.

- Continuous cassava degrading to Imperata grasslands. Aside from irrigated rice
  production, continuous annual cropping is rare in Sumatra except in transmigration
  settlement sites. Estimates for continuous cassava (Manihot esculenta Crantz) mono-
culture degrading to *Imperata cylindrica* L. are reported here for comparison with other asb sites. Smallholders cultivated 1- to 2-ha plots of monocrop cassava with little use of purchased inputs.

### Land Use System Evaluation and Performance

**Financial Profitability: Returns to Land and Labor**

For the food crop systems, the upland rice and bush fallow rotation stands out as being unprofitable (negative US$62/ha), which helps explain its disappearance in most of Sumatra’s peneplains. Cassava, on the other hand, may be among the most profitable of the technically feasible continuous food crop alternatives for the peneplains (US$60/ha), but its longer-run sustainability warrants further study (van Noordwijk et al. 1997b; chapter 6, this volume).

Returns to labor are highest for community-based forest management (extraction of nontimber forest products (NTFPs; US$4.77/d), but these high returns depend on the ability of existing local communities to regulate access and exclude outsiders. The low returns to land, US$5/ha, suggest that NTFP extraction is not a feasible alternative for large numbers of people because there is not enough land for everyone to practice this extensive livelihood strategy. These results should be interpreted with care because not all extractive activities were accounted for, which may bias profitability estimates downward. In particular, timber extraction (currently illegal and hence not reported) is likely to be significant, and tenure insecurity on State Land might have biased reported offtake of NTFPs. On the other hand, long-run profitability may be overstated because of unsustainable harvesting.

Several profitability estimates for commercial logging can be calculated, depending on the degree of compliance with government regulations. However, companies circumvent regulations on timber extraction, and most typically are vertically integrated firms producing products such as plywood for the export market. Therefore, the best profitability estimate for commercial logging is $1080/ha, valued at social prices that reflect world prices of forestry products.

Oil palm is widely viewed as the most profitable alternative for Sumatra’s peneplains, and Indonesia’s oil palm producers have the lowest unit costs in the world. Thus, it is no surprise that large-scale oil palm monoculture is among the most profitable alternatives in terms of returns to land and returns to labor, both of which are indicators of firm-level profitability, because the official wages for plantation workers are well below our estimates of returns to labor.

The two contrasting rubber agroforest systems produce a wide range of results. It is encouraging that returns to labor are almost identical to the market wage ($1.67 per person-day) for rubber agroforests planted with seedlings. Although these smallholders are the lowest-cost producers of natural rubber in the world (Barlow et al. 1994), returns to land at private prices are not much higher than for upland rice with a long bush fallow rotation and are well below those of oil palm monoculture.
Perhaps the most striking result in table 17.2 is the returns to land for rubber agroforests planted with PB 260 clones, which exceed those of large-scale oil palm monoculture (US$878 vs. US$114/ha). This system also produces attractive returns to labor. These are based on projections from farmer-managed trials and therefore should be interpreted with caution. However, these results support the idea that potential profitability of rubber agroforests planted with clonal material (and other smallholder agroforests planted with appropriate, higher-yielding germplasm) may be comparable to large-scale oil palm plantation monoculture.

**Labor Requirements**
For the rubber and oil palm systems evaluated, total time-averaged labor needs are similar, ranging between 108 and 150 person-days/ha/yr. Harvesting labor is the biggest component in these systems. Because of lack of pronounced seasonality in much of Sumatra, harvesting of rubber and oil palm can go on roughly 10 months a year. The two extractive activities—community-based forest management and commercial logging—fall at the opposite extreme, with less than 1 person-day per hectare per year. Neither of these extractive activities nor the upland rice–bush fallow rotations, using 31 person-days/ha/yr, can provide many employment opportunities.

**Household Food Security**
A wide range of household food entitlement paths were identified for Sumatra, from complete dependence on wage labor (commercial logging) to complete self-sufficiency in food production (upland rice production). The norm for Sumatran smallholders falls between these extremes, with some production for household food consumption supplementing income earned from sale of export commodities such as rubber.

**Institutional Issues: Market Imperfections**

**Input Supply Markets**
Markets for planting material are the greatest barrier to adoption of profitable alternatives by smallholders, as indicated by $i$ in the final column of table 17.2 for clonal rubber and oil palm. For example, the Treecrops Advisory Service, almost the sole provider of rubber budwood, has focused its efforts on supplying planting materials to settlement project participants in the past and has largely ignored the much larger number of nonparticipants (Tomich 1991). The private nursery industry has only begun to develop in a few areas of Sumatra. For public and private sources alike, there are serious problems of reliability of quality of planting material, which is difficult to assess until several years after planting. Current delivery pathways for improved planting material and the information needed to use it seem inadequate, but direct government intervention to supply germplasm may be neither feasible nor desirable.
Table 17.2 Land Use System Performance and Resource Inputs at the Sumatra Site

<table>
<thead>
<tr>
<th>Land Use System</th>
<th>Scale of Operation (ha)</th>
<th>Profitability*</th>
<th>Labor Requirements</th>
<th>Household Food Security</th>
<th>Institutional Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Returns to Land (US $/ha, at private prices)</td>
<td>Returns to Labor (US $/d, at private prices)</td>
<td>Time-Averaged Labor Input (person-day/ha/yr)</td>
<td>Food Entitlement Pathsb</td>
</tr>
<tr>
<td>Natural forest</td>
<td>25-ha fragment</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>NA</td>
</tr>
<tr>
<td>Community-based forest management</td>
<td>35,000-ha common forest</td>
<td>5</td>
<td>4.77</td>
<td>0.2–0.4</td>
<td>op, ex</td>
</tr>
<tr>
<td>Commercial logging</td>
<td>35,000-ha concession</td>
<td>1080</td>
<td>0.78</td>
<td>31</td>
<td>Wages</td>
</tr>
<tr>
<td>Rubber agroforest</td>
<td>1- to 5-ha plots</td>
<td>0.70</td>
<td>1.67</td>
<td>111</td>
<td>ex</td>
</tr>
<tr>
<td>Rubber agroforest w/ clonal planting material</td>
<td>1- to 5-ha plots</td>
<td>878</td>
<td>2.25</td>
<td>150</td>
<td>ex</td>
</tr>
<tr>
<td>Oil palm monoculture</td>
<td>35,000-ha estate</td>
<td>114</td>
<td>4.74</td>
<td>108</td>
<td>ex</td>
</tr>
<tr>
<td>Upland rice–long bush fallow rotation</td>
<td>1- to 2-ha plots</td>
<td>(62)</td>
<td>1.47</td>
<td>15–25</td>
<td>op</td>
</tr>
<tr>
<td>Continuous cassava degrading to <em>Imperata</em></td>
<td>1- to 2-ha plots within settlement project/1 ha</td>
<td>60</td>
<td>1.78</td>
<td>98–104</td>
<td>op, ex</td>
</tr>
</tbody>
</table>

NA, not applicable.

* A discount rate of 15% was used, and the opportunity cost of household labor was set at $1.67 per day. The local currency unit (Indonesian rupiah) was converted at rate of 1 US $ = Rp2400 (June 1997). Sensitivity analyses to establish lower ranges of profitability figures and to check robustness of results to observed swings in relative output prices and a range of discount rates are ongoing.

b For food security, “own production (op)” and “exchange (ex)” reflect whether the LUS generates food for own consumption or income that could be used to buy food; combined food entitlement paths are common.

For institutional issues, letters indicate market imperfections judged to constrain LUS adoption (with uppercase indicating a serious problem and lowercase indicating a more minor difficulty), as follows: i, input markets; o, output markets; lb, labor markets; k, capital markets.

Source: Data are derived from Tomich et al. (1998b, 2001).
OUTPUT MARKETS
Government restrictions on marketing and international trade are the greatest barriers to development of smallholder timber-based alternatives and also hinder community-based forest management. Export promotion and job creation were the official rationale for these restrictions, but the main results were rent seeking and inefficiency. In 1998, the Indonesian government agreed to begin deregulation of timber exports, to abolish joint marketing associations that functioned as cartels, and to end export quotas and numerous other restrictive marketing arrangements. As export taxes are gradually reduced, private firms should be free to trade timber, but local restrictions on timber trade continue to be significant barriers.

Previous restrictive marketing practices also damaged most timber companies’ marketing capacity by inhibiting development of marketing networks that could respond to buyers’ needs. The situation is particularly bad for rattan because the export ban on raw rattan destroyed overseas markets and induced importers to seek alternate supplies.

In a largely ineffective quest to stabilize cooking oil prices, oil palm also has been subject to export taxes (set at 60 percent through the end of 1998) and at times to export bans that seriously depressed farmgate prices (Tomich and Mawardi 1995). For oil palm and cassava there also are some concerns about the structure and performance of local markets that are needed to link smallholders with processors. However, competitive market links seem to be emerging.

Local markets for natural rubber have functioned for a century or more. Although there are some imperfections affecting quality (e.g., difficulty of assessing dry rubber content), these markets transmit world price changes to the farmgate rapidly, and marketing margins reflect transport and other costs. Markets for natural rubber have been subject to few distortions from national policy, but at times the international buffer stock has depressed prices.

LABOR MARKETS
Although the complete analysis also included skilled labor, the summary analysis presented here focuses on unskilled labor. Instead of hiring permanent skilled workers, smallholders may be more likely to develop certain technical skills themselves. So the relevant barrier is the acquisition of technical information rather than the market for skilled labor. Although labor markets in Sumatra fall short of the theoretical ideal, recent empirical studies (Suyanto et al. 1998a, 1998b) indicate that labor markets work reasonably well. It is worth noting that casual markets for skilled labor (e.g., chainsaw operators) also are emerging.

CAPITAL MARKETS
Capital market problems are second only to planting material supply as a barrier to adoption resulting from market imperfections. Although no long-term institutional credit is available in rural Sumatra, household savings, which financed investments in existing smallholder agroforestry systems such as rubber agroforests, often are under-
estimated, and farmers are able to receive credit from informal sources (relatives, moneylenders). However, recent economic hardships may be straining these resources. Capital market imperfections may constrain smallholders’ fertilizer purchases for cassava production and use of clonal rubber planting material and certainly are a barrier to the establishment of smallholder oil palm. Whether smallholder timber extraction is constrained by capital market imperfections depends in part on development of contract markets for chainsaw services and log transport.

BRAZIL

Land Use Systems Evaluated

Eight LUs were evaluated at the ASB benchmark site in the western Brazilian Amazon (Souza and Homma 1993; Ávila 1994). Details of the LUs can be found in Vosti et al. (2002), Fujisaka et al. (1996), Lewis et al. (2002), and Witcover et al. (1996b).

• Natural forest. Limited stocks of marketable products and limited smallholder knowledge regarding forest products generally combine to dramatically limit the number of sustainably harvested products extracted by smallholders from forests in this region. Currently, Brazil nut (Bertholletia excelsa Humb. & Bonpl.) extraction is the only major NTFP activity undertaken sustainably in forested areas.

• Managed forestry. This experimental Lu allows low-impact extraction of up to 13 m³ of timber from selected tree species per hectare per year, a rate and method judged by local foresters as conservatively sustainable over a 10-year cycle for a 40-ha tract; a different 4-ha plot is used for extraction each year (chapter 8, this volume). This Lu involves labor for felling, on-farm transport, and sawing of planks, explicitly accounted for here.

• Coffee–bandarra. This is a smallholder coffee (Coffea canephora Pierre ex Fröhner) production system averaging about 2 ha in which native bandarra (Schizolobium amazonica Huber ex Ducke), a quick-growing, native tree valued for its timber, is allowed to emerge, with some thinning to avoid excess shade. This Lu and the following are in initial stages of on-farm experimentation.

• Coffee–rubber. Similar to coffee and bandarra in scale, this Lu contains rubber trees planted among coffee trees; regeneration of native species is suppressed.

• Traditional pasture. Low-productivity, mixed cattle production systems, and the pastures needed to support them are the dominant LUs at the Brazil benchmark site. Traditional cattle breeds and grass-based pastures are most prominent, and the use of purchased inputs generally is limited to those needed to allow the marketing of beef and milk. Scale of operation can vary between 20 and 250 ha for smallholders. Large farm enterprises can practice this Lu on large scales, sometimes exceeding 50,000 ha.
• Improved pasture. Similar in scale to the traditional cattle–pasture system, the improved cattle–pasture land use system comprises more productive breeds of cattle, uses substantial amounts of fencing for pasture management, and makes much more intensive use of purchased inputs for livestock management. Beef and milk offtake increase substantially (Faminow et al. 1997; Vosti et al. 2001a).

• Annual–fallow. This land use system, constructed to provide a cross-site comparison, represents a swidden agriculture system that is rarely found in settlement areas at the benchmark site. Approximately 2 ha of forest is felled and burned, followed by 3 years of crop production (2 years of rice, bean (Phaseolus vulgaris L.), and maize (Zea mays L.) production followed by 1 year of maize and cassava production), after which the land is put to fallow for about 7 years. This cycle is repeated twice to fit into the 20-year time horizon to allow cross-land use system comparisons.

• Improved fallow. This system models that of experimental sites in the region and begins by felling approximately 2 ha of forest, followed by 2 years of annual crop production (rice, bean, and maize) after which land is placed in a legume-based fallow for 2 years. The production cycle is repeated for land use system comparability.

Land Use System Evaluation and Performance

Financial Profitability: Returns to Land
The returns to land range from a low of –$17/ha for the annual crop–fallow system to a high of $2056/ha for the experimental improved fallow system. The least profitable land use systems (forest, –$2/ha and annual–fallow, –$17/ha) no longer exist in isolation from other land use systems. Indeed, the former is practiced only if the opportunity cost of labor is far below the market wage. The most common land use (traditional cattle and pasture) generated only $2/ha, but the more intensive version of this land use system (improved cattle and pasture) boosted returns to land to $710/ha. The small-scale managed forest scheme dramatically increased returns to land over the forest-based alternative (Brazil nut extraction, forest) to $416/ha. The coffee-based land use systems generated impressive returns to land: $1955/ha for coffee–bandarra and $872/ha for coffee–rubber. Finally, the highest returns to land (but not to labor) were found in the improved fallow system.

Returns to Labor
In this labor-scarce environment, returns to labor would outweigh returns to land in farmers’ decision to adopt. Returns to labor estimates: ranged from $1 per person-day in the extractive forest activities to $22 in the improved livestock–pasture system (table 17.3). Systems at or below the average rural daily wage for unskilled labor of approximately $6.25 probably would not attract farmers, although imperfections in the labor market, seasonality of labor demand, and heterogeneity of labor type within a household make this less than a hard-and-fast rule. Indeed, the annual–fallow system that is no longer practiced yields slightly lower returns than working for wages. Traditional pasture–livestock production systems, the most prevalent in the study area,
yield slightly better returns than working for wages; the more labor-intensive systems yielded even more, with the higher of the two coffee-based systems (coffee–bandarra) bringing in about twice the wage and the improved pasture–livestock and managed forestry bringing in nearly three times as much as the traditional livestock system. Farmers more interested in returns to labor than to land would select improved pasture–livestock systems, whereas those more concerned with per hectare asset value (including improvements in the form of established production systems) might prefer systems scoring high on both counts, such as managed forest, improved fallow, and coffee–bandarra.

**Labor Requirements**

An LUS with high returns to labor may simply be out of reach of small farmers in the area, given current labor scarcity and imperfectly functioning labor markets. The coffee–rubber system demands the most labor by far to operate, nearly 60 person-days/ha/yr. At the other end of the spectrum sits the low-level forest extraction systems in Acre, which take only about 1 person-day/ha/yr to manage. The system currently forming the end of the land use trajectory, traditional pasture, uses the least labor of any system other than the forest systems, approximately 11 person-days/ha, but its intensified version (improved pasture) needs just slightly more than this. Clustered at one-and-a-half to just over two times the labor needs of these systems are two other intensified systems (coffee–bandarra and improved fallow) and the annual–fallow LUS.

**Household Food Security**

Forest extraction, small-scale managed forestry, and the two coffee-based systems share the characteristic that once established, they produce no food (table 17.3). To meet food needs, households adopting these LUS will depend on markets for food and on product markets for Brazil nuts, timber, coffee, or rubber. The two cattle-based systems and the two food crop–based systems produce food and provide cash to exchange for food; the proportion of exchange to own production probably will be greater for cattle-based systems.

**Institutional Issues: Market Imperfections**

The market for Brazil nuts has been functioning reasonably well for decades, and collecting nuts takes almost no skill or capital investment, so there are no flags in the market imperfections column for the forest LUS (table 17.3). All other LUSs presented obstacles to adoption linked to market imperfections.

**Output Markets**

Although markets for sawn timber have existed in the region for more than two decades, small-scale agriculturalists generally have not participated in it, either individually or in groups. Therefore, product quality and volume issues loom large for these new market entrants. Coffee markets have also existed for some time and continue to develop thanks to policy-induced expansion of area in coffee, especially in Rondônia (e.g., free
Table 17.3 Land Use System Performance and Resource Inputs at the Brazil Benchmark Site

<table>
<thead>
<tr>
<th>Land Use System</th>
<th>Scale of Operation (ha)</th>
<th>Financial Profitability&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Labor Needs&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Household Food Security&lt;sup&gt;c&lt;/sup&gt;</th>
<th>Institutional Issues&lt;sup&gt;d&lt;/sup&gt;</th>
<th>Market Imperfections</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Returns to Land&lt;sup&gt;e&lt;/sup&gt; (US $/ha)</td>
<td>Returns to Labor&lt;sup&gt;e&lt;/sup&gt; (US $/person-day)</td>
<td>Time-Averaged Labor Input (person-day/ha/yr)</td>
<td>Food Entitlement Path (operational phase)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forest (AC)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>30</td>
<td>–2</td>
<td>1</td>
<td>1</td>
<td>ex</td>
<td>—</td>
</tr>
<tr>
<td>Managed forestry (AC)</td>
<td>40</td>
<td>416</td>
<td>20</td>
<td>1.22</td>
<td>ex</td>
<td>i, lb, k</td>
</tr>
<tr>
<td>Coffee–bandarra (RO)</td>
<td>2</td>
<td>1955</td>
<td>13</td>
<td>27</td>
<td>ex</td>
<td>i, o, lb, k</td>
</tr>
<tr>
<td>Coffee–rubber (RO)</td>
<td>2</td>
<td>872</td>
<td>9</td>
<td>59</td>
<td>ex</td>
<td>i, o, LB, k</td>
</tr>
<tr>
<td>Traditional pasture (AC)</td>
<td>40</td>
<td>2</td>
<td>7</td>
<td>11</td>
<td>ex, op</td>
<td>i, o</td>
</tr>
<tr>
<td>Improved pasture (AC)</td>
<td>40</td>
<td>710</td>
<td>22</td>
<td>13</td>
<td>ex, op</td>
<td>i, lb, k</td>
</tr>
<tr>
<td>Annual–fallow (AC)</td>
<td>2.5</td>
<td>–17</td>
<td>6</td>
<td>23</td>
<td>ex, op</td>
<td>lb</td>
</tr>
<tr>
<td>Improved fallow (AC)</td>
<td>2.5</td>
<td>2056</td>
<td>17</td>
<td>21</td>
<td>ex, op</td>
<td>LB</td>
</tr>
</tbody>
</table>

<sup>a</sup>A discount rate of 9% was used, and the opportunity cost of household labor was set at $6.25 per day. Prices are based on 1996 averages and expressed in December 1996 US$: US$1 = R1.04. Each proposed system’s socioeconomic indicators are based on optimistic yield parameters. Sensitivity analyses to establish lower ranges of profitability figures and to check robustness of results to observed swings in relative output prices and a range of discount rates are ongoing. For example, for managed forestry, a less optimistic offtake of 10 m<sup>3</sup>/ha/yr would mean returns to land and labor of R252/ha and R13.50, respectively, and only slightly less labor (1.2 person-day/ha/yr).

<sup>b</sup>For labor needs, a boldface number indicates competition for labor with other agricultural activities for a typical household.

<sup>c</sup>For food security, “own production (op)” and “exchange (ex)” reflect whether the LUS generates food for own consumption or income that could be used to buy food; combined food entitlement paths are common.

<sup>d</sup>For institutional issues, letters indicate market imperfections judged to constrain LUS adoption (with uppercase indicating a serious problem and lowercase indicating a more minor difficulty), as follows: i, input markets; o, output markets; lb, labor markets; k, capital markets.

<sup>e</sup>“AC” and “RO” refer, respectively, to the Brazilian states of Acre and Rondônia, where measurements on specific LUSs were taken.

Sources: Data derived from Vosti et al. (2001b) and Oliveira (2000b).
technical assistance and subsidized planting materials). Sufficient processing capacity for fluid milk exists in the region, but membership in a dairy cooperative (not available to all) is generally necessary to access this capacity.

**Labor Markets**
Imperfections in the labor market were considered a factor in adoption in all intensified systems, particularly the improved fallow. Seasonal shortages in unskilled labor especially hampered coffee-based production systems, and shortages of skilled labor probably would occur if more intensive LUSS were adopted.

**Input Markets**
All of the more intensive systems also relied more heavily on purchased inputs, especially the improved cattle–pasture system. While markets for these inputs are developing, the private sector continues to focus on medium- and large-scale producers. Most systems needed at least periodic soil nutrient enhancements (e.g., chemical fertilizers); markets for these inputs are just emerging, and suppliers face staggering transportation costs. It is noteworthy that the market prices of purchased inputs generally do not include the costs of training to effectively use them; for example, cattle vaccines are readily available, but many smallholders do not know how and when to use them. Therefore returns to LUSS that depend heavily on such inputs may be overstated.

**Capital Markets and Risk**
All nonforest LUSS entailed greater capital input (with the exception of the improved fallow system) and hence dependence on capital markets. In this frontier area, no informal systems of production credit are locally available; there are no established private banks or money lenders that provide investment capital for agriculture. The only formal sources of credit are the regional and federal banks that provide smallholder credit at subsidized rates, but nonprice rationing (allocation of credit based on something other than the cost of credit, that is, the interest rate paid by farmers) of capital effectively excludes most smallholders from routine borrowing. Moreover, all LUSS entail some production and price risk. To date, there are few institutional mechanisms for managing these risks. Therefore, LUSS that entail large outlays for establishment or purchased inputs for operation (e.g., improved pasture–cattle) may be perceived as more risky to smallholders and therefore less likely to be adopted by them (Vosti et al. 2002; Faminow et al. 1999).

All this said, as in the Cameroon case, market performance in the Brazilian benchmark site varies with distance to main roads and major cities. In hinterland areas transportation costs are high and vary enormously seasonally, so food, information, inputs, and products are much more expensive than in closer-lying areas, especially during the rainy season. More important for market performance, intermediaries capable of reducing overall costs and seasonal swings in costs generally are not in place in remote areas. Finally, small-scale farmers are much more likely to suffer from market imperfections than are their larger-scale counterparts because the latter can invest in private forms of transportation and communication.
CROSS-SITE COMPARISONS OF LAND USE SYSTEMS AND BROADER ISSUES

In this section, we briefly examine the socioeconomic and policy elements of the ASB matrices for Cameroon, Indonesia, and Brazil side by side and then highlight cross-site similarities and differences in a set of broader issues that lie behind the matrices but affect land use choices.

Comparing ASB Matrices

Comparing the LUS evaluation matrices for the three ASB benchmark sites reveals some interesting parallels and some differences. First, at the benchmark sites in Brazil and Cameroon, tapping the forest for anything but timber products generated very low returns to labor. This was not the case in Indonesia, where people involved in the sustainable offtake of NTFPs could expect to earn well above the market wage. The long-term success of this LUS makes it worthy of attention and support, but the sustainability of this LUS requires that extraction not be intensified. Moreover, spatially expanding this LUS within Indonesia is questionable, and the mechanism for replicating this LUS in other sites is unexplored. Second, using the market wage (at each site) as our guide, swidden agriculture is at best marginally profitable and will continue to exist only in areas where food markets fail or the cultural significance surrounding its practice is strong (e.g., Cameroon). Third, certain smallholder tree-based LUS can increase returns to land and labor, but market-related impediments to adoption exist at all sites. Fourth, large agricultural enterprises (in Brazil and Indonesia today, perhaps in Cameroon in the future) may have comparative advantages in some aspects of production or (more likely) processing, but room for smallholder participation in many aspects of production surely exists; policy action should promote, not constrain, this participation.

Broad Socioeconomic Issues

Market Imperfections

There was wide variation in the performance of markets across ASB sites: Indonesian labor and commodity markets and customary land tenure institutions worked well, but capital markets did not; even food markets, usually the first set of markets to develop, failed at certain locations in the Cameroon site, and the Brazil site occupied an intermediate position, with some markets functioning well (e.g., food from southern Brazil was commonly consumed in rural areas of the Amazon) and others (e.g., formal credit markets) performing poorly.

At all benchmark sites, institutions and infrastructure tend to be much better where population densities are higher. In these areas, farmers have better access to
competitive markets system for purchased outputs and inputs, including hired labor. Moreover, traditional land tenure institutions in Cameroon and Indonesia seem to be evolving gradually toward individualistic land ownership, which in Cameroon is characterized by cadastral surveys and an increased incidence of land titling (IITA, unpublished data 1997). This trend can facilitate the development of land markets, which may be fundamental to LUSS change in these areas.

However, several important caveats to this general trend in market development should be noted. First, better functioning capital markets do not generally spontaneously emerge alongside improved markets for products or other agricultural inputs, and informal credit systems that have developed (in Cameroon and Indonesia) often are not able to finance major changes in LUSS. Government action to date has failed to fill this important gap in investment capital; smallholder investments favoring noncapital inputs have been the result. Second, market development is never geographically uniform: Periurban areas generally benefit first, and some outlying areas may never benefit at all. Governments have a role in improving and extending the benefits of market development to all. Finally, the existence of well-performing markets is a necessary but not sufficient condition for market access; some socioeconomic groups clearly have preferential access to certain markets in each of the ASB benchmark sites (e.g., large-scale ranching operations in Brazil). Governments have a clear role in making market access more uniform across socioeconomic groups, too.

Food Markets and Cultural Roles

When food markets fail to develop, smallholder households can become locked into LUSS that generate very low returns to labor (e.g., less than the market wage in Brazil and Cameroon). Policy action such as rice price stabilization in Indonesia reduced risks of specialization in export commodities and permitted households the flexibility to invest in more lucrative LUSS. At the same time, underdeveloped food markets only partially explain the persistence of the subsistence mixed food crop field in southern Cameroon, where gender plays fundamental roles in food security.

Poverty

Poverty continues to persist widely at the Cameroon site but has been substantially reduced at the Brazil and Indonesia sites, in part because of the success of the LUSS that remaining smallholders have chosen to practice and the abandonment of agriculture by those who could not establish such systems. At all sites, however, although some farmers may have risen above abject poverty, many may still be unable to meet high establishment costs associated with some LUSS; that is, although they may have escaped welfare poverty, they still may be investment poor (Reardon and Vosti 1995).
Scope for Policy Action

Dramatic differences were identified across the benchmark sites in the power and responsibilities of policymakers and the policy instruments and resources available to carry out their mandated tasks. For example, at the Brazil benchmark site a complicated patchwork (with gaps and overlaps) of responsibilities for maintaining rural roads has emerged, and no clear system of resource generation and disbursement has developed to match these responsibilities. Consequently, even vital transportation arteries can fall into disrepair. In Cameroon, the downturn in primary commodity markets for coffee, cocoa, cotton, and oil in the late 1980s plunged the country into a deep recession during which per capita incomes declined by more than 50 percent from 1986 to 1993. Accompanying the downturn was a shift in policy objectives and a drastic fall in public investments in vital sectors such as transportation, public health, education, and agricultural research and extension, all of which can influence land use choice at the forest margin. Another factor influencing land use change in Cameroon and most of West Africa has been the rapid urbanization since the 1970s that has increased demand for staple food crops relative to the demand for perennial export crops. This switch has consequent environmental impacts because the associated with the tree-based systems provide many more environmental services than those associated with food crop systems.

As regards the management of forests, in all three benchmark sites management of public forests (e.g., parks, preservation areas, indigenous areas) is extremely difficult, primarily because of the vast areas involved and the lack of resources to do the job and also because local communities surrounding these areas often exploit the natural resources of the forest to invest and to survive. Under these circumstances, curtailing access to forests is expensive and can increase poverty.

Finally, and perhaps most important as regards policy action, at all benchmark sites, most of the fundamental economic factors driving land use adoption were beyond the scope of local, regional, and sometimes even national policymakers. For example, in Cameroon the prices of coffee, cocoa, oil, and timber are of fundamental importance and are set in international markets. A similar situation exists in Indonesia for rubber, timber, and palm oil. In Brazil, farmgate prices of cattle products and food are set thousands of miles from the benchmark site. All these prices, and the incentives and disincentives they pose to the adoption of particular land use systems, are largely beyond the reach of national and subnational policymakers (chapter 7, this volume), so the scope for policy action is narrowed.

Forests and Economic Growth

The relative importance of forests in meeting national growth objectives varied widely across ASB countries. Cameroon’s forest resources, one of the country’s greatest riches,
have played and continue to play a significant role in its economic growth and development. In the 1950s, 1960s, and 1970s conversion of approximately 500,000 ha of moist forests to smallholder coffee and cocoa agroforests resulted in equitable broad-based economic growth averaging 3 to 4 percent. In more recent years, timber exploitation has overtaken coffee and cocoa production as the most important economic activity in the moist forests. Cameroon is now the leading African exporter of tropical timbers, with more than $270 million in annual export sales. It is a poor nation, and at this stage in its economic development Cameroon has little choice but to develop its forest resources. From the standpoint of government policy, the critical question is whether Cameroon’s tropical forests will be converted into sustainable agricultural and forestry production systems or mined into a state of degraded vegetation.

By contrast, Brazil is an industrialized country with a highly diversified economy. It is also in the globally unique situation of having two remaining agricultural frontiers: large savanna areas and huge forest areas. Is converting the Amazon to agriculture necessary to achieve national growth objectives? Probably not. Would converting the Amazon to agriculture contribute to national growth objectives? Probably so, but not without large environmental costs. Perhaps the more relevant question is whether converting the Amazon to agricultural is necessary to meet regional (i.e., Amazonian) growth objectives (Soares 1997). To this question the answer probably is “yes,” although this objective probably would be better achieved by promoting intensive non–forest-based lus in areas with low rainfall and more pronounced and extended dry periods within the Amazon basin.

Indonesia probably occupies an intermediate position on this issue, despite macroeconomic upheaval in the late 1990s. Indonesia had experienced rapid economic growth, poverty reduction, and structural transformation from the early 1970s through the mid-1990s. The financial and monetary crisis of the late 1990s probably will be a temporary setback to absolute declines since the early 1990s in the labor force dependent on agriculture and the resulting decline in pressure on the natural resource base. However, as in Brazil (which crossed this turning point much earlier), there is great regional variation in these patterns, and although agriculture and forestry will play a declining role in the overall economy, they loom large in many regions.

CONCLUSION

Land Use System Trends

Against this backdrop of lus performance and inputs and the institutional and other issues that underlie lus choice and guide policy action, we now look forward at each benchmark site and predict trends in land use.

What will be the likely paths of lus adoption in the three benchmark sites over the next two decades? Although changes in policy and economic factors could alter lus adoption patterns, the following scenarios are likely to play out.
At all ASB sites, traditional swidden agriculture has or will soon disappear because of population pressure and low rates of return to labor. What replaces swidden agriculture varies across sites.

In Cameroon, the slash-and-burn annual cropping short fallow system is likely to increase in area in rough proportion to the increase in rural and urban population. However, in the absence of productivity-enhancing technical change, this system is increasingly unsustainable because of its shortened fallow. In locales with good market access, opportunities for commercial surplus production would be expected to lead to a proportionally greater expansion of these short-fallow systems than in areas with poor market access. Under current and foreseeable market conditions, the cocoa and oil palm perennial crop systems are the most profitable of the systems examined. Currently cocoa is not widely produced in the Congo basin but could be an important lus, especially when the economies of Southeast Asian competitors such as Indonesia and Malaysia resume rapid economic growth and structural transformation. Moreover, input markets, liberalized since 1992, are better developed today. These factors will combine to increase the financial profitability of cocoa and increase the amount of land dedicated to intensive cocoa systems, a large proportion of which probably will come from a shift from extensive to intensive production systems. Whether there will be significant new land conversion to either extensive or intensive cocoa production is difficult to predict. Evidence indicates that West African smallholder producers of perennial export crops are price responsive, suggesting that some expansion in new planting area will occur if currently high world cocoa prices are maintained (Akiyami 1988; Gockowski 1994). If new plantings substitute for short-fallow land uses, net environmental gains are expected. On the other hand, if new planting occurs at the expense of secondary and primary forest, environmental losses will result. Given the choice, the producer normally will choose the latter in an effort to capture forest rents (Ruf 1995).

In Indonesia, large-scale oil palm plantations probably will continue to expand if government development strategies continue to discriminate against the emergence of independent smallholder oil palm producers. These strategies emphasized Nucleus Estate/Smallholder schemes that required marketing of tree products through project channels to repay credit. In addition, in some areas local authorities have attempted to prevent development of free markets in palm oil, which has retarded development of market outlets for independent smallholders.

In Brazil, several trends are likely. First, given labor scarcity, seasonality in production activities, and market imperfections (especially for capital and emerging cultivated tropical products), cattle production will continue to dominate the landscape (Faminow 1998; Faminow and Vosti 1998; chapter 10, this volume). Cattle production systems, especially pasture management, will become more intensive, primarily in response to increasing pressure on soils and market access needs. Technological change in pasture management (e.g., solar-charged, battery-powered electric fences; see Melado 2003) are expected to facilitate this trend. Coffee and other tree-based systems will continue to be adopted and will occupy small amounts of farm land but
large amounts of household labor. With sufficient technical assistance and capital, and with effective and efficient monitoring, small-scale managed forestry could become an important lus (chapter 8, this volume), with very broad environmental impact. Finally, given scale economies in managing some existing luss (e.g., cattle production) and some emerging luss (e.g., managed forestry), it is likely that small-scale agricultural holdings will be consolidated.

Estimates of returns to land and labor presented in this chapter indicate that from a purely private perspective, returns to forest conversion are high at all benchmark sites. If no action is taken to identify workable options either to shift incentives for conversion or restrict access to the remaining natural forests, these rainforests will continue to disappear. Small-scale managed forestry (in Brazil), improved rubber agroforests (in Indonesia), and forest-based cocoa agroforests with fruit (in Cameroon) are all good candidates for increasing the returns to environmentally benign activities at these sites (and perhaps more broadly). But among these, only managed forestry shifts incentives for conversion.

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References


Cross-Site Comparisons and Conclusions


Intensifying small-scale agriculture in the western Brazilian Amazon: Issues, implications  
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