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Village Economic Opportunity, Forest Dependence, and Rural Livelihoods in East Kalimantan, Indonesia

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Summary. — The changing role of forests in people's livelihoods in frontier areas is important from the perspective of poverty alleviation and forest conservation. This study explores the link between expanding economic opportunities, forest dependence, and welfare in 73 villages. Village economic options, forest cover, and land suitability for agriculture and forestry are determining factors of people's well-being. Increased accessibility to markets and deforestation are strongly associated with economic diversity at the village level. Increased economic diversity, larger areas of forests, more intensive land use, higher endowments of agricultural land and forest, and higher village population are related to increased well-being.

Key words — Asia, Indonesia, spatial analysis, geographical targeting, income portfolio, rural nonfarm employment

1. INTRODUCTION

Increasing interest in rural poverty alleviation has resulted in a new focus on the "forest-dependent poor" and on the actual and potential contributions of forests to livelihoods (Angelsen & Wunder, 2003; Arnold, 2001; Dove, 1993; World Bank, 2001; Wunder, 2001). Forest-rich areas are frequently associated with rural poverty. Remote locations, rugged terrain, low population densities, limited communications and transportation infrastructure, infertile soils, and difficult climates act as constraints that limit forest harvesting and the conversion of forests to agricultural land. The same factors limit the economic opportunities of people living in the area (Ashley & Maxell, 2002; Wunder, 2001). Development in frontier areas in the form of resource extraction projects, infrastructure development, or industrial development, for example, rapidly changes both the physical and the economic landscapes and the corresponding opportunities for local people (Brookfield, Potter, & Byron, 1995; Padoch & Peluso, 1996). Analysis of the relationship between such developments and rural livelihoods is needed to better understand their impact and to target interventions aimed at improving livelihoods in forest areas.

Some argue that forest resources can be put to work to help improve the livelihoods of the poor (Scherr, White, & Kaimowitz, 2002), while others believe that forests have a limited potential to contribute to poverty reduction (Wunder, 2001). Part of the discrepancy between these views originates in different assumptions about the scope for creating new opportunities for rural people to take advantage of forest resources. Typically, the poor

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residents of forest-rich areas have not had a voice in deciding how to use forests and have lacked opportunities to transform forest resources into wealth for themselves. They tend to lack ownership and control over the resources, and do not have access to the markets or the skills and contacts needed to take advantage of opportunities. And, while there is a global trend toward devolving natural resource management rights and responsibilities to local communities, this is usually in degraded forest areas and in many cases has resulted in increased state control (Edmunds & Wollenberg, 2003). Governments are reluctant to give up control over valuable revenue sources. There is a tendency to assign rights to well-connected investors as in Sarawak (Cooke, 2002), Kalimantan (Dove, 1993, 1996; Dove & Kammen, 2001), and Thailand (Vandergeest & Peluso, 1995). Decisions about forest use and investments in forest areas are often determined by outsiders interested in short-term extraction of forest resources, with little concern about the long-term economic impact on local people. Large-scale resource extraction, forest conversion, and other development projects in forest areas tend to provide little direct benefit to forest-dependent communities, and more commonly have a negative impact as local peoples' access to resources is curtailed and the physical resource base is degraded (Brookfield *et al.*, 1995; Potter & Lee, 1998).

On the other hand, development in forested areas might be expected to create new opportunities for generating employment, income, and wealth. The World Bank (2002) identifies limited land and market opportunities as a major constraint to poverty reduction. Road building, for example, increases people's access to facilities and resources and also reduces transport costs. Several studies in rural Latin America found that factors outside the agricultural sector raised demand for nonfarm goods and services and resulted in increased local incomes and the accumulation of capital for investment. Investment further increases rural nonfarm wages and self-employment through production and expenditure linkages ("economic transformation") to reduce the incidence of poverty (Reardon, Berdegué, & Escobar, 2001). Benefits arise in the form of improved transportation facilities, better market access, new markets for agricultural products, opportunities for petty trading, and some employment, at least in the short term (Brookfield *et al.*, 1995).

Efforts to encourage equitable and durable improvements in human well-being need to take account of the direct and indirect livelihood impacts of resource-extraction projects, and the impacts of broader development efforts. In this paper, we examine these issues as they have been played out in East Kalimantan, a forest-rich and fast-changing part of Borneo. Agriculture is the mainstay in the area, based primarily on a shifting cultivation system in which regenerating forest is used to replenish soils and control weeds, and the secondary forest is managed for a variety of economic products (Lahjie, 1996; Sardjono & Samsoedin, 2001). Forests are very important in local livelihoods. Many valuable products are harvested from the forest and rivers for direct consumption and for sale. We use the term "agroforestry" throughout the paper to define this integrated system, in which households rely on agriculture and forestry both simultaneously and sequentially for their livelihoods.

The main drivers of land use change in the area are forest concessions, timber and estate crop plantations, mining, road building by projects and public investment, and migration (both government sponsored "transmigration" and independent migration) (Brookfield *et al.*, 1995; Padoch & Peluso, 1996). We investigate the impact of forest-based and infrastructure developments on economic opportunities and welfare in the study area. We focus on the relationships between village-level income diversity (as an indicator of economic opportunity) and village welfare. We look at the relationship of those characteristics to the location of industrial resource extraction projects, roads, and other economic features like forest cover, land-use suitability, and political and economic centers. This allows an empirical test of the role of these various factors in determining welfare. We use the village as the unit of analysis for two reasons: First, communities in the area tend to be small (mean = 150 households, but many have fewer than 100) and relatively homogeneous, and the main drivers of change operate at a scale larger than a single community. The main differences in income opportunities, welfare, and other factors of interest are found across communities rather than within them. Second, for an analysis of spatial patterns, we need to cover an area large enough to capture a range of stimuli. This approach is consistent with the geographic targeting of small administrative regions advocated by Bigman and Fofack (2000). We supplement the village-scale analysis with household level data and case studies to explore how different degrees of forest dependence at the household level are reflected at the community level.

2. STUDY AREA

The study area includes the contiguous *Kabupatens* (districts) of Paser and Kutai Barat in the Indonesian province of East Kalimantan, covering 1,111,107 ha (Figure 1). The area is undergoing a rapid change. Previously heavily forested, it has been deforested by large-scale resource extraction, small-scale agricultural expansion, and two episodes of large-scale forest fire, one in 1982 and the other after the study period, in 1997–98. Marked improvement in transportation and communication infrastructure in recent years, in-migration from other areas of Indonesia, and new markets for agricultural and forest products and for labor have led to important socioeconomic changes. There are clear gradients from villages that have been strongly affected by development to villages that remain remote and less affected by modernization.

The most important activities driving change in the study area are logging (forest concessions), [1] timber plantations, [2] coal mining [3], oil-palm plantations, [4] smallholder rubber plantations [5], and transmigration projects, [6] as well as road building [7] (Figure 1). All except smallholder rubber planting and roads compete directly with local people for resources by limiting access and/or by depleting or degrading the resource base. Some employment is generated by these activities, but there has been a tendency to hire from outside the local area. Local people do not tend to have the skills and experience or, according to some employers, the work ethic, to compete for anything but low-paid jobs. There are projects to also develop roads, improve market access, and create new markets for locally produced supplies, and some services. Some companies are required by law to support community development in their surrounding areas, although there are few demonstrable impacts. Table 1 summarizes information about each project in the study area.

The boundary of the study area was defined based on data availability. Cloud cover in satellite images is a key limiting factor in this high-rainfall area; no "cloud-free" images were available. Projects located outside the boundaries of the study area were included as influences in the analysis. These include a gold mine, a coal mine, an oil-palm plantation, a rubber plantation, some transmigration sites in West Kutai, and oil-palm plantations in the Paser district.

3. DATA

(a) *Spatial data*

Geo-referenced data were collected from a variety of sources, including (i) topographic and infrastructure maps produced by the National Coordinating Agency for Surveys and Mapping in 1991; (ii) Land Systems and Suitability maps (Regional Physical Planning Program for Transmigration—RePPProt, 1982); and (iii) maps of company locations produced by the Ministries of Forestry and Transmigration in 1997. Land-cover maps were produced using unsupervised classification of Landsat TM images for 1992 and 1996, with three classes: (i) mature forest; (ii) young secondary forest; (iii) nonforest land. This classification scheme allows an accurate and clear classification because each of the three classes has a distinctive signature, and it fits well with our definition of deforestation. We calculated the deforestation rate as the area of mature forest and young secondary forest in period 1 that changed to nonforest in period 2, divided by total forest in period 1 per village area. Smallholder deforestation patches were distinguished from others by using spatial characteristics including size and location. In shifting cultivation systems, the length of the fallow period is commonly used as an indicator of land use intensity (Inoue, 2000). In this study, a higher proportion of new agricultural plots created from young secondary forest (i.e., land that had been cultivated too recently to permit mature forest to regenerate) was taken as an indicator of higher land use intensity. An index of land use intensity was calculated as the proportion of agricultural plots cleared from young secondary forest relative to total smallholder deforestation patches.

A road map was developed by combining the official national maps, Landsat TM 1992, and maps produced by companies. Access to markets and other features were calculated in terms of travel time. Accessibility was weighted by the quality of roads. Four classes of roads were identified: (i) the trans-Kalimantan highway, which is a surfaced road built and maintained

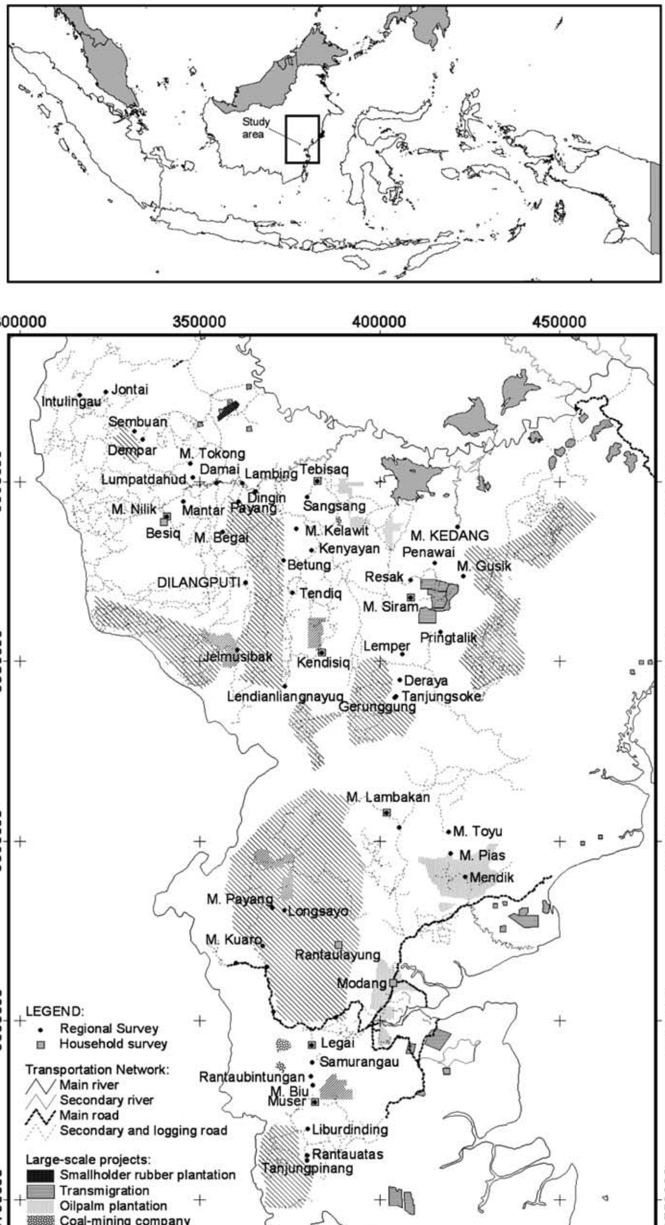

Figure 1. *Map of study area showing villages, transportation network, and large-scale projects.*

by the province to connect district capital cities in Kalimantan; (ii) district roads, which are surfaced roads, some of which were built in conjunction with transmigration projects; (iii) mining roads, built by mining companies, which are unsurfaced roads but usually of a good quality to accommodate heavy equipments; and (iv) logging and plantation roads, which are low-quality roads built by companies, and often not usable during the rainy sea-

Table 1. *Summary of projects within the extent of the study area*

Projects	Area (ha)	District	Established	References
Logging concessions	326,416	Paser and West Kutai	Varies	Integrated Forest Fire Management (IFFM) map
Oil-palm estates	13,141	Paser	Mid-1980s	IFFM map
Timber plantation	29,414	Paser and West Kutai	1992	IFFM map
Coal mine	15,998	Paser	1986	Kompas, August 28, 2001

son. Class (iv) roads have a shorter life, quickly becoming unusable without regular maintenance.

Officially, districts are subdivided into subdistricts based on watershed boundaries. Village boundaries are based on local custom, are not recognized by the state, and are not marked on any available map. We estimated these boundaries by drawing polygons through midpoints between neighboring villages using the Thiessen polygon technique. This roughly approximates the customary method of defining boundaries, [8] and, judging from field observations and interviews, it gave a reasonable estimate. Still, we needed to be cautious in interpreting the results as incorrect boundaries influence several variables.

(b) *Village-level socioeconomic data and household survey information*

Secondary, village-level socioeconomic data were obtained from the Agricultural Census of the Central Board of Statistics: Village Potential, 1993 [9], the latest 10-yearly census data available. These data were used to develop indices of village-level economic diversity and well-being and are described below.

Primary data were collected using structured interviews of household heads in randomly selected households covering between 15% and 50% of households in each of 10 villages in 1997–98 (Figure 1). The villages were selected to represent a range of points along a gradient of distance to projects and other developments, stratified by district. Questionnaires were designed to capture information on demographics, assets, income by source, and land uses. These data give us detailed village case studies to compare with the main analysis based on the Agricultural Census data. The comparability may be compromised by the five-year lag between the Agricultural Census (1993) and the household survey. However, we found a good correspondence between similar data in the two data sets.

4. METHODS

(a) *Indices of economic diversity and well-being at the village level*

We developed two indices of village economic diversity and peoples' well-being at the village level.

(i) *Village economic diversity index (EDI)*

Economic diversity at the village level is defined in terms of heterogeneity of income sources among households in a village. In remote rural locations such as our case study area, where agriculture and forestry are the predominant economic activities and where there are few alternative opportunities, economic diversity is low. It is hypothesized that development will lead to new employment opportunities and therefore increased economic diversity.

We developed a village EDI using the Shannon–Weaver diversity index, which is a measure used commonly in ecology and information theory. [10] The index is formulated as

$$\mathrm{EDI} = -\sum_{p_i} \ln(p_i),$$

where p_i is the proportion of households in a village that rely primarily on each main income source and $i = 1, \ldots, n$, where n is the number of classes of main income sources. A household is classified into one category based on its main income source and p_i's add up to one. The index ranges from 0 to $\ln(n)$. In a village where all households have the same main income source, EDI = 0. Where there is an even distribution of all possible main income sources among households in a village, EDI = $\ln(n)$. In this case, with four possible main income sources, perfect heterogeneity would give an EDI of ln(4). [11]

The Agricultural Census of the Indonesian Central Board of Statistics 1993 aggregates main income sources into four classes: agriculture, mining, wage, and services. This usefully groups sources of income as farm, mining, and nonfarm wages. [12] It should be noted that the index is sensitive to the number and definition of classes used. In our study area, people typically integrate agriculture and forestry activities in an indigenous agroforestry system, and we follow this in classifying these activities as one.

Because agroforestry is the most common main source of income, the EDI of a village will be increased when some households derive their main income from sources other than agroforestry. The index is used as a measure of increasing economic opportunities in an area where such opportunities are typically limited. A different index would be needed in urban and other areas with higher levels of diversity at time zero.

(ii) *Well-being at the village level (VDI)*

The second index is a measure of people's well-being at the village level, based on their health, education, and wealth relative to other villages in the study area. It loosely follows the idea of the UNDP Human Development Index (HDI), which uses several socioeconomic indicators relating to income per capita, health, and education to compare average national levels of welfare. [13]

The Village Development Index (VDI) is calculated as follows, based on the Agricultural Census Data:

$$\begin{aligned}\mathrm{VDI} = ((h - h_{\min})/(h_{\max} - h_{\min}) \\ + (e - e_{\min})/(e_{\max} - e_{\min}) \\ + (a - a_{\min})/(a_{\max} - a_{\min}))/3,\end{aligned}$$

where h is the infant survival rate; e is the school enrollment rate for children of age 7–11 years; a is the assets (motor bikes and motor boats) per household, [14] and subscripts max and min refer to the maximum and minimum values in the area. The minimum and maximum possible values of VDI are 0 and 1, respectively. The index gives an equal weight to health, education, and wealth. For our dataset, Cronbach's alpha reliability estimate of VDI was 0.65. This is close to the common cut-off point of 0.7 for demonstrating internal consistency in the index data (Nunnaly, 1978).

(iii) *Relationships between EDI and VDI*

Village economic diversity, measured by EDI, is expected to increase as new opportunities are created by improved transportation infrastructure, product markets, labor markets, and land and resource availability. (The last is affected by deforestation.) The VDI is hypothesized to be determined by economic opportunities, measured by the EDI, as well as by the availability of agricultural and forest resources, and agricultural practices. Population density is also expected to contribute to the VDI in this

Table 2. *List of variables*

Variables	Descriptions
Economic diversity index	Measure of heterogeneity of main income sources of households in a village
Village development index	Measure of development or well-being at the village level in terms of health, education, and wealth
Forest cleared over total	Proportion of area cleared from forest over the total cleared area by smallholders
Population	Village population
Time to district	Distance (in hours) from the settlement to the district capital
Time to subdistrict	Distance (in hours) from the settlement to the subdistrict capital
Time to logging	Distance (in hours) from the settlement to the closest active logging company
Time to transmigration	Distance (in hours) from the settlement to the closest transmigration site
Provincial road, district road, mine road, logging/plantation road	Density of provincial road, district road, mine road, and logging/plantation road (km/ha)
Forest 92	Proportion of village area covered by forest in 1992
Deforestation 92–96	Deforestation rate from 1992 to 1996 (changes from forest and regrowth to nonforest land divided by forest cover area in 1992)
Agrosuitability	Proportion of suitable area for agroforestry over total area
Land-use intensity	Proportion of area of young secondary forest in 1992 changed to nonforest land in 1996 over total smallholder deforestation

remote area, through increasing economic interactions. We also included proximity to the district and subdistrict capital as this variable measures access to the local center of trade and services, and also to the government services such as health care, education, and infrastructure development.

(b) *Spatial statistical analyses of EDI and VDI*

We explore the empirical relationships: (i) between village economic diversity and distances from projects and developments and (ii) among well-being at the village level, village economic diversity, and other factors using regression analysis of spatial data and village-level socioeconomic data (Table 2). We use Space Stat, a software designed to build spatial econometric models, in conjunction with ArcView, a GIS software. Space Stat provides a set of diagnostic tools to determine an appropriate model to handle a particular form of spatial dependence when it exists (Anselin, 1999). In order to incorporate spatial dependence in the analysis, a neighborhood matrix is generated by considering villages to be connected when they share boundaries and a transportation link (either road or river).

We further explored the links between EDI/VDI and the role of forests in livelihoods using the household survey data from 10 villages. We calculated the proportion of cash income earned by each household from agroforestry products (including rattan, honey, fruit, game, fish, other forest products, and rice) for each sample village. Households that earn more than half of their cash income from agroforestry activities are classified as agroforestry-dependent households. Village-level agroforestry dependence is then measured as the proportion of village households that are agroforestry dependent. The income portfolio for three selected villages is described to illustrate the breadth of income-earning activities.

5. RESULTS AND DISCUSSION

(a) *Factors associated with village EDI*

Spatial statistical analysis was run on the subset of variables that gives the best-fit spatial error model (Table 3), with EDI as the dependent variable. Figure 2 shows the map of EDI. The distances to plantations (timber, rubber, and oil palm), to mines and to transmigration sites are strongly and positively correlated with one another. Therefore, we included only one variable—distance to transmigration site—in the analysis to avoid a collinearity problem. This collinearity reflects the deliberate development of particular economic activities within transmigration projects. In the study area, the main transmigration area was developed in conjunction with an oil-palm plantation and processing factory and, to a lesser extent, with timber plantation and rubber projects. Transmigrants were provided with an oil-palm plantation to manage, and the oil-palm company has actively encouraged neighboring villages to cultivate oil palm in the so-called "plasma" area (the area around the "nucleus estate").

Table 3. *Spatial error model of village EDI*[a]

Variable	Coefficient	z-Value
Provincial road	206.31	5.17**
District road	54.13	3.41**
Mine road	−8.65	−0.41
Logging/plantation road	23.16	2.11*
Time to logging	4.10E−03	0.43
Time to transmigration	0.02	3.35**
Deforestation 1992/1996	2.27	3.55**
Lambda	−0.38	−2.79**

[a] With maximum likelihood estimation, number of observation = 73, R^2 = 0.82, LIK = 5.62, AIC = 2.76.
*Significance level of 0.05.
**Significance level of 0.01.

The best-fit spatial error model suggests that unexplained factors between neighboring villages are strongly correlated. Table 3 shows that better road access increases EDI. The provincial road gives increased opportunities for income and employment, presumably by linking villages to the broad network of markets for different products and labor, improving access to information and facilitating in- and out-migration. Villages connected by provincial roads show high values of economic diversity. District roads have a similar but less pronounced effect. This was expected, as accessibility, in terms of the quality of the road and the places it connects, is less than that provided by the provincial road. The finding that roads are associated with a higher village economic diversity is consistent with findings from Latin America in which access to road infrastructure and closeness to towns are shown to be robust determinants of rural nonfarm employment and incomes (Reardon *et al.*, 2001).

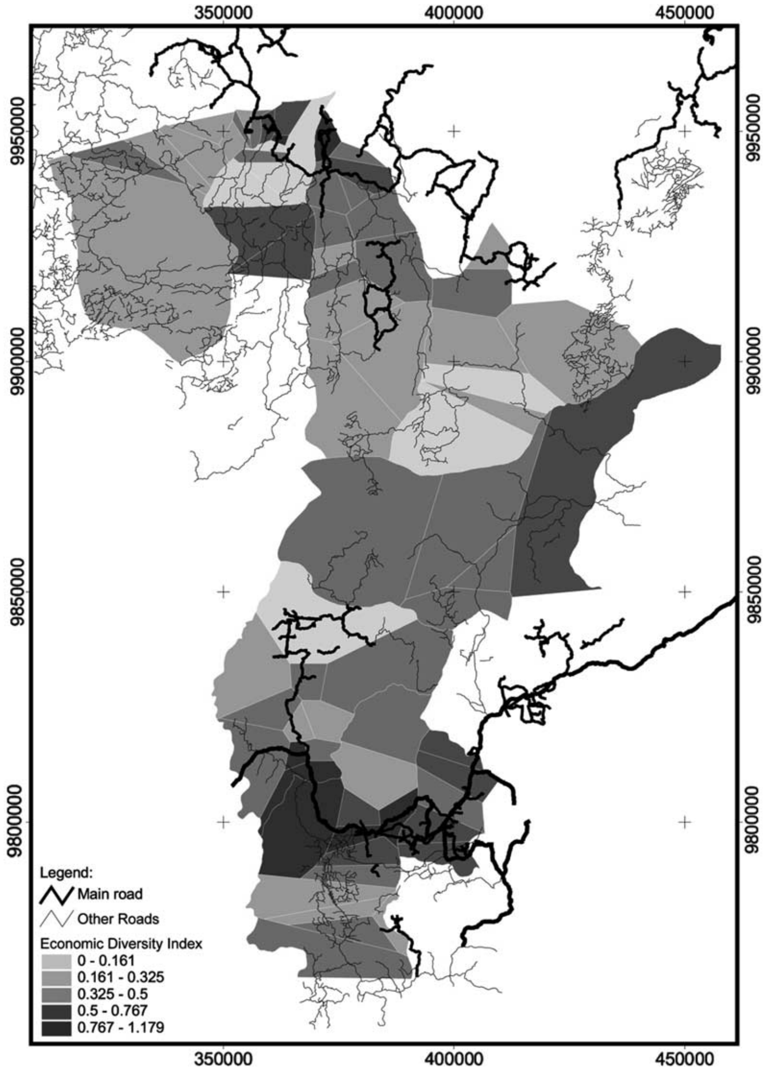

Figure 2. *Village economic diversity index map.*

Logging/plantation roads also lead to a higher EDI, but the effect is smaller than that of other road classes. This class of road typically provides access to smaller markets, both for products and labor, and mainly to markets directly related to the activities of the resource extraction company and its employees. Mining roads do not show statistically significant relationships with EDI, which can be explained by the fact that local people were not permitted to use them during the study period.

While logging/plantation roads are associated with a higher village economic diversity, proximity to logging companies does not affect EDI. This implies that these projects do not provide sufficient economic opportunities for local people to adopt them as a main source of income. This is consistent with reports that in Borneo most labor for logging companies was hired from outside the area (Brookfield *et al.*, 1995). Logging roads are not perfectly correlated with logging companies because the roads may remain after the company (and associated economic activities) has left the area.

The EDI correlates positively with deforestation (including conversion to agriculture and to

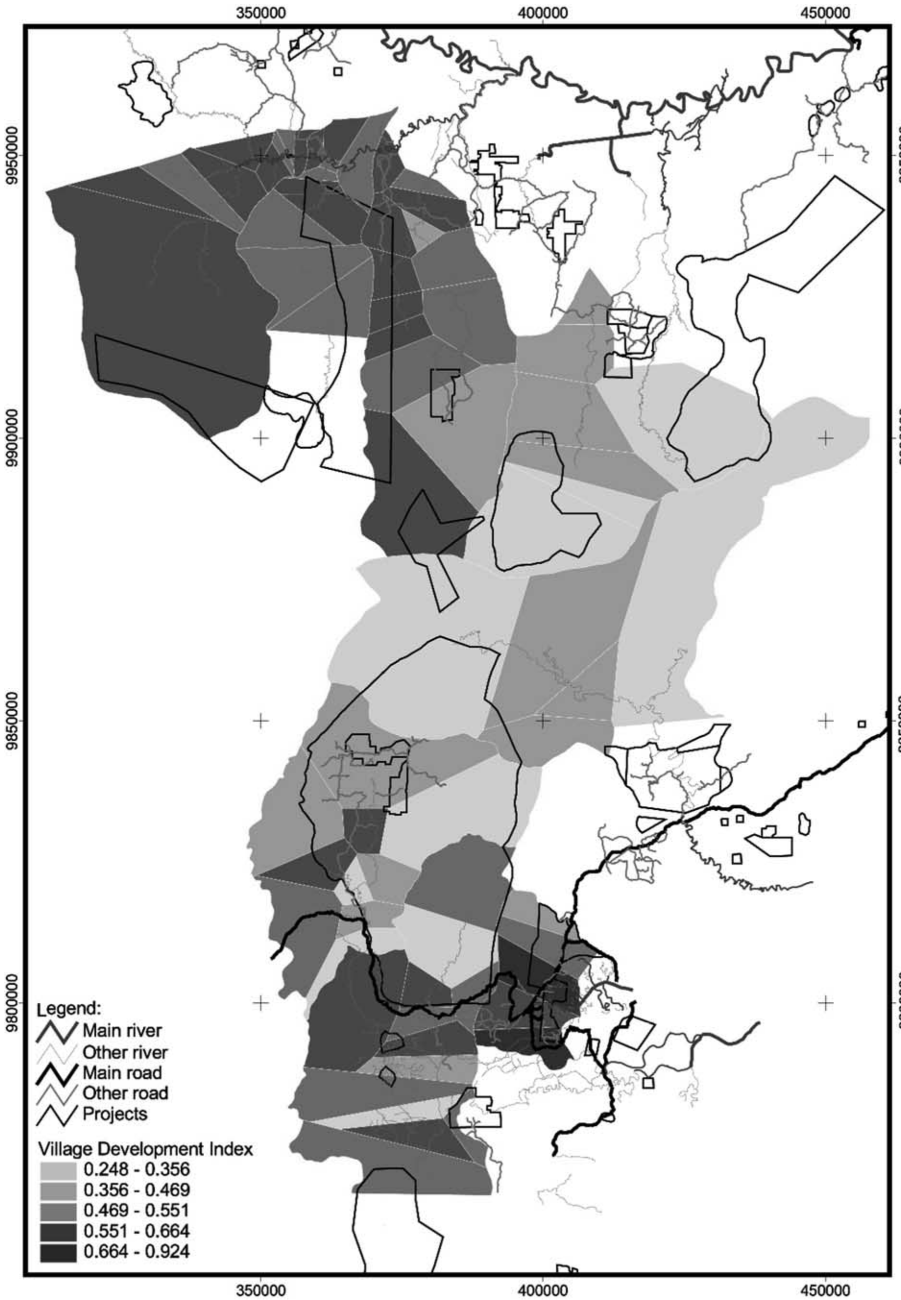

Figure 3. *Village development index map.*

other activities) during the 1992–96 period. This may indicate that some activities that resulted in deforestation also provided nonfarm income opportunities for local people.

(b) *Well-being at the village level (VDI)*

The map of VDI is presented in Figure 3, and the best-fit spatial error model of VDI is

Table 4. *Spatial error model of VDI*[a]

Variable	Coefficient	*z*-Value
Economic diversity index	0.19	3.70**
Agrosuitability	0.27	7.86**
Land-use intensity	0.15	2.39*
Forest 92	0.53	6.79**
Population	8.87E−05	5.39**
Time to district capital	−0.03	−1.13
Time to subdistrict capital	0.01	0.38
Lambda	−0.44	−3.30**

[a] With maximum likelihood estimation, number of observation = 73, $R^2 = 0.98$, LIK = 63.65, AIC = −113.31.
*Significance level of 0.05.
**Significance level of 0.01.

presented in Table 4. A higher village economic diversity leads to a higher VDI. In the case study area, increases in EDI generally mean that a higher proportion of households in a village rely on the nonagricultural sector for their main source of income. The proportion of land cleared by smallholders from land that was a young secondary forest (relative to the amount cleared from mature forests) is positively correlated with VDI. This is mostly related to the availabilities of fertilizer and herbicide and land pressure, which are both driven by market and economic opportunities.

A larger extent of land suitable for agroforestry practices leads to a higher VDI. That is, the traditional system provides a relatively good living if there is an adequate resource base. A large proportion of village land with forest cover, measured at the beginning of the study period, has an even larger positive coefficient, showing that the forest has contributed to higher welfare.

While, on the one hand, a higher initial forest cover and land quality for agroforestry are associated with higher welfare, on the other hand a higher EDI (shift toward less agroforestry-dependent communities) and higher land use intensities are also associated with a higher welfare. The role of forest in the EDI–VDI context is intriguing. While deforestation correlates positively with EDI and with VDI, a larger proportion of village area initially covered by forests also increases VDI. This shows two different possible development paths. The EDI may increase as the forest cover declines, especially where suitable land for agroforestry is limited. Or agroforestry can serve as the main source of livelihood while maintaining a high forest cover when the village has sufficient suitable land. As discussed earlier, opportunities for local livelihoods to improve in the "poverty elimination" sense (see Sunderlin *et al.*, this volume) based on agriculture and forestry have been limited, but appropriate interventions at the project and policy level might help (e.g., Scherr *et al.*, 2002).

Given the fact that the area has a low population density overall (mean = 13.95 persons/sq. km), it is not surprising to find that the population has a highly significant positive coefficient. Small isolated villages are unable to generate economic dynamism.

(c) *Agroforest dependencies/role of forests in village samples*

For the 10 village samples (Figure 1), the EDI (from the census data) tends to increase and then decrease as agroforest dependence (from aggregated household survey data) decreases ($R^2 = 0.84$). On the other hand, the proportion of village area initially covered by forests seems to be the major factor determining the proportion of households that are primarily dependent on forest products and agroforestry with a very strong, quadratic relationship ($R^2 = 0.93$) (Figure 4).

Agroforest dependence shows a weak quadratic relationship with VDI. High agroforest dependence is associated with a relatively high VDI. The VDI declines as agroforest dependence declines, but then they increase together, with the least agroforest-dependent villages having the highest VDI. The two villages with high agroforest dependence and a high well-being index have large areas of good quality forests, but there are obviously other variables involved in determining people's well-being at the village level (Figure 5).

(d) *Agroforest dependence case studies*

Modang, Muser, and Legai, the three villages in the lower end of the agroforest dependence axis have a low forest cover, but a high EDI rank. At the other extreme, Besiq and Rantau Layung villages have a high forest cover and a high dependence on agroforestry and a low EDI. Sample villages with an intermediate level of agroforest dependence and forest cover diverge in their VDIs such as Kendisiq, Muara Siram, and Muara Lambakan have a low VDI while Kasungai and Muara Nilik have a higher VDI.

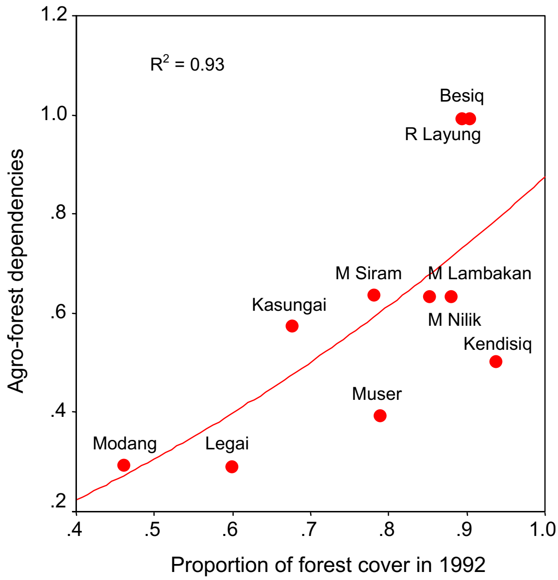

Figure 4. *Scatterplot of proportion of forest cover in 1992 and agroforest dependencies.*

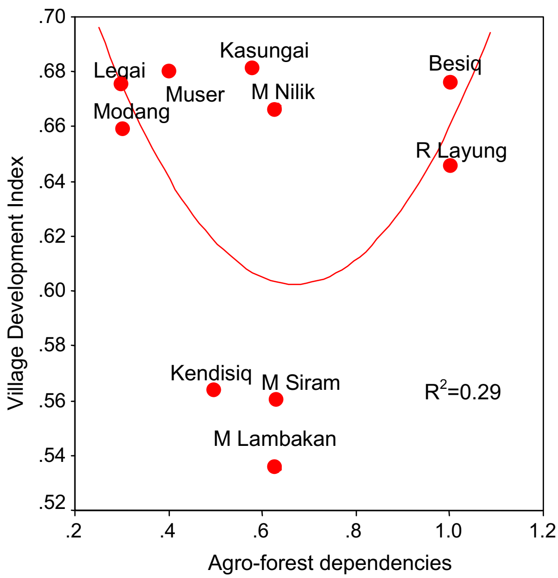

Figure 5. *Scatterplot of agroforest dependencies and village development index.*

We can illustrate this with the examples of the villages of Legai, Muara Lambakan, and Besiq (Figure 6). Legai represents a village with a high EDI, low forest cover, and a high VDI. It is located in the Paser district, very close to the trans-Kalimantan highway and to the sub-district capital. We observed some intensified agricultural practices here with the use of herbicide, pesticide, and short fallow periods. Artisanal gold mining is the primary source of income, followed by agroforestry (rattan, coffee, rubber, and other crops), nonfarm income

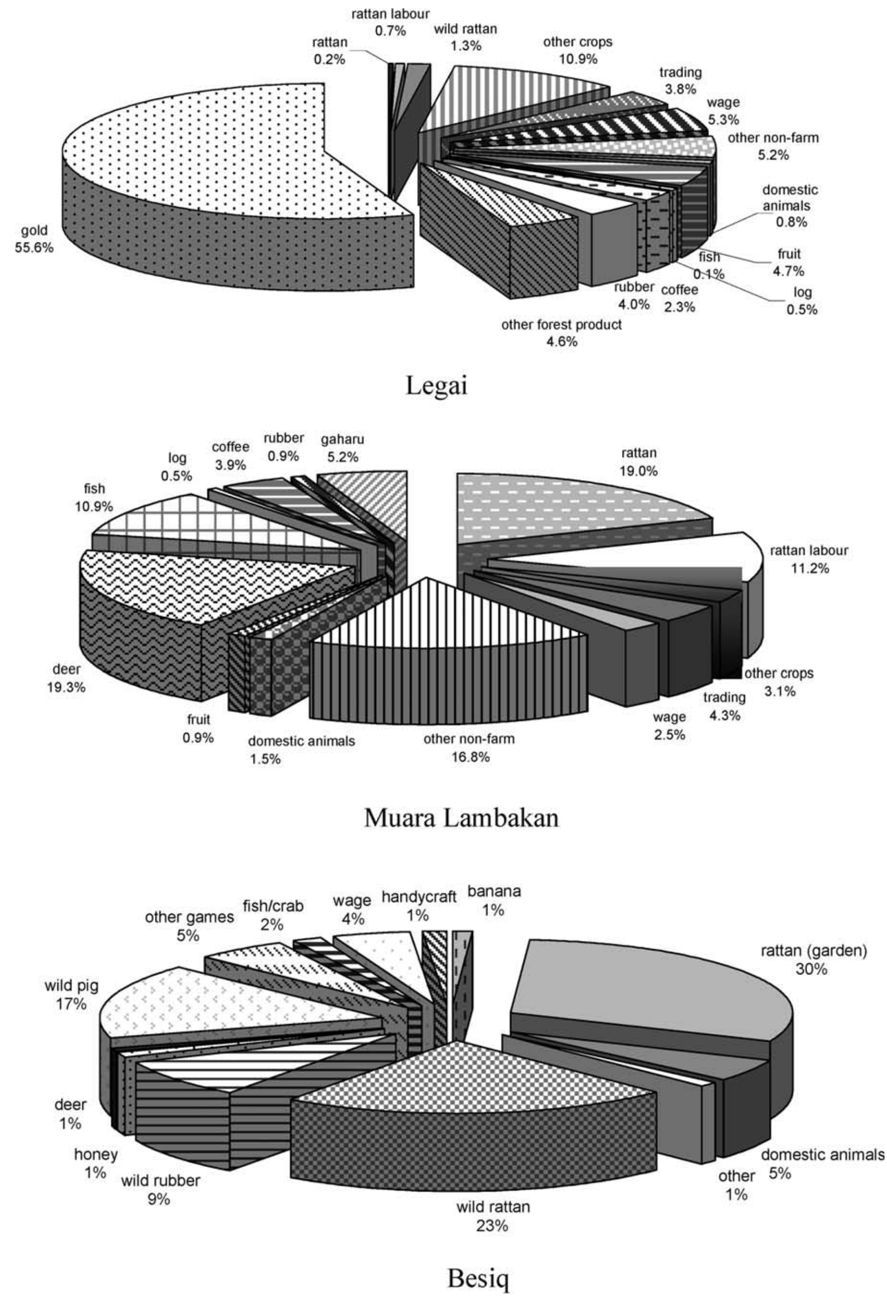

Figure 6. *Mean household income portfolio in three villages.*

(trading, wage labor, services), and forest products (wild rattan, logs).

Muara Lambakan, also in the Paser district, is a remote village with no industries nearby, but with a history of several episodes of logging by different logging companies. Most of the village area is unsuitable for intensive farming due to thin topsoil and a rough terrain. This village represents the group with a moderate agroforest dependence, moderate forest cover, low EDI, and a low VDI. The largest proportion of income is from forest-based activities and the largest part of that comes from game and fish. Income from farming is slightly lower than that from forest. Off-farm income as rattan workers in a few large gardens in the same village comprises a substantial proportion of income. Nonfarm income contributes almost 20% of the total cash income.

Besiq village, in West Kutai, has a large area of forest, high agroforest dependence, low EDI, and a relatively high VDI. The area was remote, with no road access [15] and river access limited during the dry season. Forest products, including rattan, rubber, game, fish, and honey, provide the main source of cash income. Rattan agroforest and domestic animals contribute a small proportion of total cash income, followed by nonfarm income, which adds very little to the total cash income.

6. CONCLUSIONS AND IMPLICATIONS

The indices developed and the analyses conducted have proven useful to explain relationships between various driving forces and village welfare and economic diversity. The approach could also be used as a tool for scenario-based land use planning at the district level. Poor data availability was the main constraint we faced in using this approach. With actual village boundaries rather than approximations, the analysis could have been more accurate. Cloud-free satellite images would give a more comprehensive data set to work with. Also, more frequently collected secondary data from government statistics would allow the use of time-series analysis in conjunction with the spatial analysis to cover both temporal and spatial dynamics.

Under the conditions prevailing during the study period, the local people were highly disadvantaged. In general, health service and education quality were generally low, and the local people were not involved in major resource extraction decisions. They had little opportunity to benefit from the rich natural resources in the areas where they lived. This may change with more decentralized governance (since 2001), but it is too early to assess the impact of that. As forest resources have been depleted, people have turned to alternative activities. A variety of externally controlled projects (mainly resource exploitation projects, but also transmigration) created different opportunities and constraints for local people.

The analysis shows that large-scale commercial logging did not benefit the local people. Mines, oil-palm plantations, and transmigration projects created some new markets for local products that replace traditional activities, but these projects do not show trickle-down effects outside the agricultural sector except through improvement in the transportation network. These projects often focus on one main economic activity such that in the areas around palm-oil estates and transmigration areas, there is a low economic diversity.

Roads are very important to village economic diversity, with a higher quality, better-connected roads being associated with a higher diversity. Mining roads are the exception. They do not result in local economic diversity because they are not open for public access in the study area. Forest conversion to other uses is generally associated with increased village economic diversity, again with both positive (pull) and negative (push) factors involved.

Generally speaking, well-being, as measured by education, health, and assets, increases with more village economic diversity. However, village economic diversity is not the single most important determinant of well-being. Higher levels of forest resources and suitable land for agroforestry are also associated with higher welfare. Relatively remote, well endowed forest villages with limited economic alternatives show a high well-being relative to other villages in the area being studied. A good forest endowment allows people to live well at or near the subsistence level. But opportunities for forest-based poverty elimination, in the sense of lifting people safely out of poverty, have been limited. The worst-off villages are those with poor resource endowments and limited alternative income-earning opportunities.

But the future need not mirror the past. Rich resource endowments could be used in other ways, with more benefits accruing to local people. Forest and agricultural livelihoods can potentially support relatively high levels of welfare. Improving local people's access to resources in their vicinity and their capacity to transform them is critical for enabling them to attain better health, education, and other well-being improvements. More investment in infrastructure, markets, and other factors that support village economic diversity should be encouraged. In areas where land suitable for agriculture and forestry are less available, increasing economic opportunities is even more important.

NOTES

1. Logging roads make areas of forest/land more easily accessible and reduce transportation and marketing costs for local products (Dove, 1996). Logging camps create temporary markets for products and labor, though it is a common practice in the study area to hire workers from outside areas. Logging activities also compete for forest resources with local people; typically, local people have been prohibited from entering concession areas.

2. State policy to assign "degraded lands" for large-scale timber plantations often targets (deliberately or not) managed forest gardens and secondary forests that are part of local peoples' agroforestry systems, resulting in a direct competition for land and, often, conflict. These plantations were usually operated in conjunction with logging concessions, and the plantation concessions were used as "licenses" to clear-cut in the guise of clearing for planting (see, e.g., Manurung, 2001). Benefits for local people are similar to those available from logging concessions. Roads are built, which leads to the employment of some villagers mainly as nonskilled workers, and temporary markets are created for local produce (Brookfield *et al.*, 1995). In our study area, timber plantations were established in conjunction with the transmigration program.

3. The study area has rich coal deposits. Mining in Indonesia has been strictly controlled by the central government, with a top-down approach that has been criticized for its negative impacts on the local people. Conflicts between mining companies and local people are common (Down to Earth, 2001; World Bank, 2001). Mining competes for access to forest lands, and prohibitions against trespassing are strictly enforced. While mining concessions may be smaller than forest concessions, the forest cannot be expected to recover after the end of mining activities. Roads built by mining companies are better made and better maintained than logging roads, and markets for labor, supplies, and services are larger and more long-lasting than those created by logging and timber plantations.

4. As with timber plantations, development of oil-palm estates implies a direct competition for land with small-scale farmers (Manurung, 2000). Positive contributions to the area include road construction, development of processing facilities, and creations of markets.

5. The main rubber producers in Indonesia are smallholders. There have been attempts to support the sector by providing planting materials, fertilizer, pesticides, equipment, and land titles, as well as cash payments to cover subsistence expenses during the period before the trees mature. Two important projects in the vicinity of the study area were the Tree Crop Smallholder Development Project funded by the World Bank (IBRD), started in 1974, and by the Asian Development Bank, started in 1992 (Budiman, 1999).

6. Transmigrants were typically settled in purpose-built communities, often on lands claimed by local people. This resulted in competition and some conflict for forest resources and land between transmigrants and the local people. As part of these projects, new roads, as well as housing, schools, and health facilities were built. Some transmigration projects in the study area were developed in conjunction with timber plantations, oil-palm plantations, and processing factories. The projects created new markets for various products and for labor. Also, there is usually some technology transfer as in-migrants bring different ideas and approaches that may be adopted by local people.

7. The Trans-Kalimantan Highway, the most significant road development in the area, was built in the mid-1980s by the provincial government to connect major cities in Kalimantan. Many of the transmigration roads were built around the same time. Project-related roads have been built (and abandoned) as and when needed for companies' operational purposes such that from the villagers' point of view, they only provide a temporary access to resources and sometimes to the market. The history of road building in the area is not well documented.

8. Local village heads reported that boundaries were defined by agreement, using natural landmarks close to a midpoint that fairly divided resources between two neighboring villages.

9. Village Potential data include human capital (demography, workforce), natural captial (forest, mine, wetlands, etc.), social captial (institutions, networks), and produced capital (health facilities, school buildings, infrastructure, mills, factories, etc.). These data were collected by village administrative officials and then compiled by the Central Board of Statistics (BPS)

(Suhariyanto, K. pers. com. 2004). The data were cross-checked by our enumerators with several key informants and were found to be consistent.

10. The Shannon–Weaver index measures diversity in a way very similar to that of the Simpson index (Baumgärtner, 2002). Using the Shannon–Weaver index, our data are normally distributed, while computation using the Simpson index shows a tendency to depart from the normal distribution, that is, with insensitivity in the lower diversity.

11. This index is very different from the diversity index proposed by Chang (1997), which measures diversity of household income portfolios and its contribution to the total, and from diversification indices presented in Wagner and Deller (1998), which measure economic diversity and industrial linkages at the state level in the United States. This index does not capture diversification at the household level, but rather at the aggregate level, in this case, the village. Therefore, our EDI does not link explicitly with the household income portfolio or household economic diversification that is often discussed in the livelihood literature (e.g., Ellis, 2000; Reardon *et al.*, 2001). Using the index as a measure of economic diversity one assumes that improved opportunities generated by external developments and the capabilities of people to take advantage of those opportunities reduce the dominance of agriculture in people's livelihoods at the village level.

12. The BPS's 10 income categories are agriculture (fishery, crop, cattle ranching, fish farming, forestry), mining (including sand and rock), wage earning, crafts and home industries, electricity and water, construction, trading, transport, finance, services, and others. Except for agriculture, mining and wage earning, the last eight categories were aggregated into one class called "service" for the purpose of our analysis. This was done because the data of our study area showed low frequencies in most of those eight categories. For our study area, "wage labor" includes labor in construction, rattan harvesting, oil-palm harvesting, rubber tapping, sawmilling, logging, etc.

13. The HDI has been criticized on several counts. In particular, Hicks (1997) has pointed out the problem of distributional inequality within countries, which is overlooked in the HDI. We share Hicks's concern about distribution and the need for disaggregating the population. However, as we are using much smaller units of analysis (small villages as opposed to national populations), inequalities are much less pronounced. Our VDI and the HDI are not comparable as they are measured at different scales with different data for different purposes.

14. We use the number of motorcycles and motor boats per capita as a proxy for wealth. Barham, Takasaki, and Coomes (1999) argue that the wealth of households in tropical rainforest areas is best measured by assets that are related to livelihood strategies. In their study, key assets are land, productive capital, and nonproductive assets that together provide a basis for producing subsistence and cash income, a buffer against bad times, and a better life style. In our study area, boats and motorcycles perform all three functions. People rely on private transport to travel to forests and farms for their productive activities, to transport their products to the market and at times to generate income through providing transport services. People will buy an extra motorcycle or a boat in good times and sell during bad times, using these goods, in effect, as a "savings account." Motorcycles and boats also have a role in "conspicuous consumption," as a common way to demonstrate wealth. There are other assets that we think should be important in measuring wealth (e.g., chainsaws), but these are not included in the data collected by BPS.

15. A road was opened after the study period.

REFERENCES

Angelsen, A., & Wunder, S. (2003). *Exploring the poverty-forest link: Key concepts, issues and research implications*. Occasional Paper No. 40. Center for International Forestry Research, Bogor.

Anselin, L. (1999). *SpaceStat Version 1.80 User Guide*, Urbana Champaign.

Arnold, M. (2001). *Forestry, poverty and aid*. Occasional Paper No. 33(E). Center for International Forestry Research, Bogor.

Ashley, C., & Maxell, S. (2002). Rethinking rural development. *Development Policy Review, 19*(4).

Barham, B. L., Takasaki, Y., & Coomes, O. T. (1999). Rain forest livelihoods: income generation, household wealth and forest use. *Unasylva, 198*.

Baumgärtner, S. (2002). Measuring the diversity of what? And for what purpose? A conceptual comparison of ecological and economic measures of biodiversity.

Bigman, D., & Fofack, H. (2000). Introduction and overview. In D. Bigman & H. Fofack (Eds.), *Geographical targeting for poverty alleviation: Methodology and applications*. Washington, DC: The World Bank.

Brookfield, H., Potter, L., & Byron, Y. (1995). *In place of the forest: Environmental and socioeconomic transformation in Borneo and the Eastern Malay Peninsula*. Tokyo: The United Nations University.

Budiman, A. F. S. (1999). Partnership of rubber producer association with smallholders. Paper presented at the *Agricultural Producer Organizations: Their Contribution to Rural Capacity Building and Poverty Reduction, Washington, DC*.

Cooke, M. F. (2002). Vulnerability, control and oil palm in Sarawak: Globalization and a new era? *Development and Change, 33*(2), 189–211.

Dove, M. R. (1993). A revisionist view of tropical deforestation and development. *Environment Conservation, 20*.

Dove, M. R. (1996). So far from power, so near to the forest: A structural analysis of gain and blame in tropical forest development. In C. Padoch & N. L. Peluso (Eds.), *Borneo in transition: People, forest, conservation, and development* (pp. 41–58). Kuala Lumpur: Oxford University Press.

Dove, M. R., & Kammen, D. M. (2001). Vernacular models of development: An analysis of Indonesia under the New Order. *World Development, 29*(4), 619–639.

Down to Earth (2001). Communities and companies. *Down to Earth Newsletter, 50*(August).

Edmunds, D., & Wollenberg, E. (Eds.). (2003). *Local forest management*. London: Earthscan Publications.

Ellis, F. (2000). *Rural livelihoods and diversity in developing countries*. New York: Oxford University Press.

Inoue, M. (2000). Mechanism of changes in the Kenyah's swidden system: Explanation in terms of agricultural intensification theory. In E. Guhardja, M. Fatawi, M. Sutisna, T. Mori, & S. Ohta (Eds.), *Rainforest ecosystems of East Kalimantan: El Niño, drought, fire and human impacts*. Tokyo: Springer-Verlag.

Lahjie, A. M. (1996). Traditional land use and Kenyah Dayak farming systems in East Kalimantan. In C. Padoch & N. L. Peluso (Eds.), *Borneo in transition: People, forests, conservation, and development* (pp. 150–161). New York: Oxford University Press.

Manurung, T. (2000). Pembangunan perkebunan kelapa sawit di Indonesia: Ancaman terhadap hutan alam. *Warta Fahutan Online*, 1–6.

Manurung, T. (2001). Potret pembangunan hutan tanaman industri di Indonesia. Paper presented at the *Seminar Nasional: Hutan dan Lingkungan, Tema: "Era Menanam: Membangun Kelestarian Hutan dan Lingkungan"*. Auditorium Rektorat IPB, Kampus Darmaga, Bogor.

Nunnaly, J. C. (1978). *Psychometric theory*. New York: McGraw-Hill.

Padoch, C., & Peluso, N. L. (Eds.). (1996). *Borneo in transition: People, forests, conservation, and development*. New York: Oxford University Press.

Potter, L., & Lee, J. (1998). Tree planting in Indonesia: Trends, impacts and directions. *Occasional Paper, 18*, 1–76.

Reardon, T., Berdegué, J. A., & Escobar, G. (2001). Rural nonfarm employment and incomes in Latin America: Overview and policy implications. *World Development, 29*(3), 395–409.

Sardjono, M. A., & Samsoedin, I. (2001). Traditional knowledge and practice of biodiversity conservation: The Benuaq Dayak community of East Kalimantan Indonesia. In C. J. P. Colfer & Y. Byron (Eds.), *People managing forests: The links between human well-being and sustainability*. Resources for the Future and Center for International Forestry Research (CIFOR).

Scherr, S. J., White, A., & Kaimowitz, D. (2002). *Making markets work for forest communities*. Washington, DC: Forest Trends and CIFOR.

Sunderlin, W. D., Angelsen, A., Belcher, B., Burgers, P., Nasi, R., Santoso, L., *et al.* (this volume). Livelihoods, forests and conservation in developing countries: An overview. *World Development*.

Vandergeest, P., & Peluso, N. (1995). Territorialization and state power in Thailand. *Theory and Society, 24*.

World Bank (2001). *Indonesia: Environment and natural resource management in a time of transition*. Washington, DC: The World Bank.

World Bank (2002). *A sourcebook for poverty reduction strategies: vol. 1*. Washington DC: World Bank.

Wunder, S. (2001). Poverty alleviation and tropical forests: What scope for synergies. *World Development, 29*(11), 1817–1833.