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The Human Causes of Deforestation in Southeast Asia

The recurrent pattern is that of large-scale logging for exports, followed by agricultural expansion

David M. Kummer and B. L. Turner II

Land-cover change is emerging as a central issue within the community concerned with global environmental change. The importance of this issue is attested by the emerging International Geosphere-Biosphere Programme and the Human Dimensions Programme's science agenda on Land-Use/Cover Change (IGBP-HDP LUCC; Turner et al. 1993), as well as the many international panels, workshops, and symposia devoted to the topic. (Examples include the 1991 Global Change Institute on Global Land-Use/Cover Change of the Office of Interdisciplinary Earth Studies [Meyer and Turner 1994], the 1993 symposium "Land Use and Land Cover in Australia: Living with Global Change," sponsored by the Australian Academy of Science, and the focus on land-cover and land-use change in the developing South East Asian Global Change System for Analysis, Research and Training [START] program, cosponsored by IGBP-HDP and the World Climate Research Program.) This concern is driven by the contributions that land transformations make to a wide variety of global changes—including greenhouse gases and potential global warming, loss of biodiversity, and loss of soil resources— and the regional impacts that follow.

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Subglobal models of land-use change are both necessary and feasible

Turner et al. (1990) described two classes of environmental change; these classes have been incorporated into the international and national agendas on global change. Systemic change results from biogeochemical flows that operate globally (e.g., trace gases). Such change becomes a global concern if the magnitude is sufficient to have significant effects on the flows themselves. Cumulative change, by contrast, results in changes on the surface of the earth, independent of geochemical flows. Cumulative change emerges as a worldwide concern only if a particular state reaches a large enough magnitude or spatial scale to become a global problem (e.g., loss of biodiversity).

The recent interest in land-use change has generated efforts to understand the interactions between land use and land cover in a way that will facilitate modeling and projection. Understanding land-use changes requires assessment of the underlying human and biophysical drivers that direct the course of land use (Turner et al. 1993). We have a broad understanding of the global trajectories of land cover (Turner et al. 1990) and, to a lesser extent, their associations with particular land uses. We do not, however, understand so well the socioeconomic and biophysical forces that drive land-use change. So, the explanatory value of land-use/cover models, particularly at continental and global scales, is limited.

Generalizations at the global level often mask significant regional variation in land cover. For example, the global loss of forest cover is associated with global increases in population and consumption and, yet, several regions of the world that have had significant increases in population and per capita income (e.g., parts of North America, western Europe, and Japan) have experienced increases in forest cover in the twentieth century (Williams 1990).

The literature reveals half a dozen clusters of human-cause variables. These clusters are population, technology, affluence/poverty, political economy, political structure, and beliefs/attitudes (Meyer and Turner 1992, Stern et al. 1992). The first three clusters are associated with the well-known Ehrlich/Holdren formula

$$I = PAT$$

(impact is a result of population, affluence, and technology). These three clusters have been the subject of extended discourse, particularly as applied to global-scale assessments (Stern et al. 1992), and lend themselves to quantitative analysis. Data (or surrogate measures) for each exist, though sometimes of doubtful accuracy.

Statistical analyses of land-use/cover change at national to global levels typically support the claim that these three clusters are significant. Many of the researchers of land-use/cover have been reluctant to embrace these three factors alone, however, because they rarely provide sufficient explanation of land transformations at regional or local levels and, in some cases, show virtually no association with these transformations.

Regional and local case studies typically demonstrate great variety in the combination of human forces giving rise to a change in land cover (e.g., forest to grasslands). These forces frequently include government policy, changing rules of resource allocation, and other variables associated with political economy–political structure and belief/attitudes (Blaikie and Brookfield 1987, Kasperson et al. in press; for South and Southeast Asia see Flint and Richards 1991; for the developing world as a whole see Allen and Barnes 1985). Unfortunately, these kinds of human forces do not lend themselves well to statistical analysis, global or otherwise, due to the lack of standardized worldwide data and the multiplicity of definitions and measures of proposed significant variables.

The apparent difference between global and regional or local causes of land-use change has become a central theme in the emerging global-change agenda. To become more robust, models must be more sensitive to regional land-use dynamics (Turner et al. 1993). This sensitivity can be achieved only by delineating subglobal spatial units of common land-use and land-cover dynamics.

In this article, we illustrate the significance of regional variation for understanding one example of land-cover change, tropical deforestation. We focus on deforestation in the Philippines, drawing primarily on the work of Kummer (1992), which permits a quantitative assessment between human forces and land-use change. In this example, the *PAT* variables do not correlate strongly

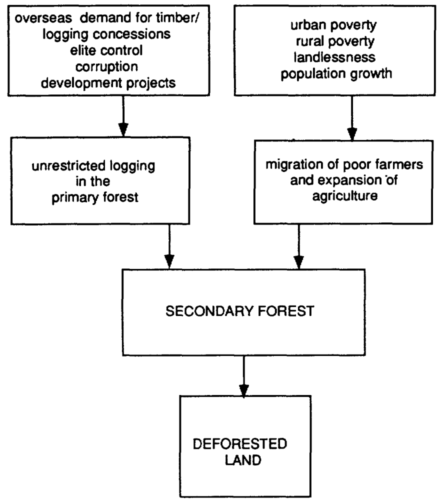

Figure 1. Overview of the deforestation process in the Philippines.

with land-use and land-cover change, but economic and institutional causes do. We then briefly explore the commonalities of the Philippine case with others in Southeast Asia, suggesting that it may constitute a regional example on which a global model could be based.

The case of the Philippines

Forest cover in the Philippines has decreased by approximately 55% in the postwar period (Table 1; Kummer 1992). Rates of deforestation have been high (Table 2), although it must be recognized that the figures vary according to the years and surveys chosen. The forests of the Philippines (and other Southeast Asian countries) are unusual for the tropics in their high concentration of species of the Dipterocarpaceae family, offering high commercial yields (Weidelt and Banaag 1982). Dipterocarp forests throughout Southeast Asia have been heavily logged, largely for export (Byron and Waugh 1988). Approximately 70% of all tropical wood products on the global market after World War II originated in Southeast Asia; this proportion had risen to 83% by the mid-1980s (Gillis 1988).

The causes of deforestation can be explored quantitatively through correlations with individual variables (Bilsborrow and Okoth-Ogendo 1992) or through models that link these variables. This article takes the latter approach, using a model drawn from the Philippine experience. We postulate the two most immediate (proximate) causes of deforestation to be logging and agricultural expansion (see Figure 1). Deforestation, in this model, was seen as a two-step process: conversion of primary to secondary forest by logging (World Bank 1989) and then removal of secondary forests by the expansion of agriculture, largely smallholder subsistence cultivation (Hicks and McNicoll 1971).

The Philippines has 73 provinces that range in size from 209 to 14,896 km^2; average size is approximately 4100 km^2. A panel analysis of province-level data from 1970 and 1980 was used to explore the model. Panel analysis is similar to standard regression except observations are taken at relatively few points in time (in this case, two). The dependent variable was absolute amount of deforestation in each province from 1970 to 1980, and independent variables were change in agricultural area, change in population, distance from Manila (a surrogate for the degree of control of logging activity by the national government), and amount of lumber (annual allow-

Table 1. National forest cover in the Philippines, 1948–1987 (percentage of total land area). Source: Kummer (1992).

Date	Percentage	Source
1948	50.5	Projection from 1969 (Forest Management Bureau 1988)
1957	44.3	National Economic Council (1959)
1969	33.5	Revilla (1983)
1969	34.9	Forest Management Bureau (1988)
1973	38.0	Lachowski et al. (1979)
1974	29.8	Bruce (1977)
1976	30.0	Bonita and Revilla (1977)
1980	25.9	Forestry Development Center (1985)
1980	27.1	Forest Management Bureau (1988)
1987	23.7	Swedish Space Corporation (1988)
1987	22.2	Forest Management Bureau (1988)

able cut) in cubic meters that the Bureau of Forestry determines (based on the area to be cut and stand density) is an appropriate, sustainable yield for each province.

Because logging activity has been consistently underreported in the postwar period and because the annual allowable cuts are consistently larger than reported by the Forest Management Bureau statistics on logging, the annual allowable cut more accurately reflects the amount of timber removed both legally and illegally. Unfortunately, more reliable data on logging are not available.

Other factors may also be important in a quantitative analysis of deforestation. Corruption, for example, has repeatedly been identified as a factor in forest removal in the Philippines (Kummer 1992, Porter and Ganapin 1988). Unfortunately, such factors as corruption and poverty could not be explored statistically because data is insufficient or nonexistent.

Our analysis indicates that deforestation in the 1970–1980 period is positively related to annual allowable cuts in 1970 and changes in the area under agriculture from 1970 to 1980. This result, guided by observations of deforestation in the field, supports the two-step model of deforestation presented in Figure 1 and the claim by Gillis (1988) that, at least for parts of Southeast Asia, logging and the spread of agriculture cannot be considered separately from each other. The correlation coefficient for population change and deforestation from 1970 to 1980 is only 0.05, which suggests that population change is not a major driver of deforestation. In addition, the correlation between change in population density and deforestation during that period is not statistically significant.

These results may appear counterintuitive. Population growth in the provinces has been significant, and it is commonly assumed that most farmers involved in agricultural expansion come from this increasing pool of people. To explore further the role of population growth, a regression of deforestation against rural population change (total population minus urban population) from 1970 to 1980 was run. It yielded a correlation coefficient of 0.20. This result supports a role for rural population growth in the deforestation process.

Table 2. National deforestation rates in the Philippines, 1948–1987. Source: Kummer (1992).

Period	Average annual change		Sources
	km^2	Percentage	
1948–1957	2213	1.56	Projection from 1969, National Economic Council (1959)
1957–1969	2262	1.91	National Economic Council (1959), Forest Management Bureau (1988)
1969–1976	2081	2.14	Forest Management Bureau (1988), Bonita and Revilla (1977)
1976–1980	3048	3.64	Bonita and Revilla (1977), Forest Development Center (1985)
1980–1987	1570	2.17	Forest Development Center (1985), Forest Management Bureau (1988)
1948–1969	2238	1.74	Projection from 1969, Forest Management Bureau (1988)
1969–1987	2103	2.46	Forest Management Bureau (1988)
1949–1987	2179	2.00	Projection from 1969, Forest Management Bureau (1988)
Overall loss	84,900	56.00	

We recognize various problems in such assessments. The deforestation process in the Philippines has been complex and has involved a large number of variables at different geographic and time scales. In addition, the data available to test different hypotheses regarding the causes of this process are less than optimal. The analytical problems are compounded by the high multicollinearity among the independent variables, particularly variables that represent human settlement: roads, land under agriculture, and population.

Under these circumstances, our results demonstrate that large-scale logging (as indicated by annual allowable cuts in 1970) followed by agriculture in the 1970–1980 period was the major process by which deforestation occurred in the Philippines. This process was accompanied by building roads for logging and nonlogging purposes and by population growth, but it is the spread of agriculture that shows up statistically. Logging opened up the forests both by constructing roads into the forests and, at the same time, by removing large amounts of timber, facilitating the clearing of the remaining degraded forests by subsistence migrant farmers.

The finding that population change was not the major driving force of deforestation was unexpected, particularly because the Philippines has a high population density compared with most countries and one of the highest population growth rates in Asia (Table 3). It is possible that population growth has driven deforestation in the Philippines in a complex and indirect way that is not detected through the model due to multicollinearity. Alternatively, population may play a secondary role in which demand for land among smallholders (presumably owing to competition for scarce land elsewhere) is met through expansion into areas made accessible by logging roads; in other words, deforestation may not be as population-intensive as assumed by many observers.

Logging per se, however, has been driven by international market demand for tropical woods (Bee 1990, Myers 1992) as mediated by the corrupt political structures of the Philippines (Porter and Ganapin 1988). If large-scale logging had not taken place, the current expansion of smallholder farmers most likely would not have occurred in the manner and rate observed. Rather, we might expect different strategies among the rural poor, including more localized agricultural expansion and intensification, or greater migration to urban areas.

Southeast Asian overview

How relevant to Southeast Asia in general is the Philippine case? Does it represent the rudiments of a regional pattern of change that might be used as a building block for global models of land-use change? We

Table 3. Population densities and annual growth rates for selected Southeast Asian countries. Source: Population Reference Bureau (1993).

Country	Population density (per km²)	Growth rate
Philippines	217	2.5
Malaysia	56	2.3
Indonesia	103	1.7
Thailand	112	1.4

believe that it does and that Indonesia, Malaysia, and Thailand display similar patterns in the loss of their forests. Like the Philippines, these countries have forests with a high commercial value and have been logged heavily for export. Almost all forest land in these countries is owned or controlled by national governments (with the exception of Malaysia, where state ownership prevails) and managed by government forestry departments whose primary objective appears to be (or have been) to increase commercial logging and the export of wood products (Byron and Waugh 1988). The forest sector in all four countries has been a theater of large-scale corruption and illegal activity circumventing regulations designed to control logging (Callaham and Buckman 1981). In addition, agriculture has expanded in concert with logging through both spontaneous settlement after logging and government-planned agricultural projects.

In such a context, Hirsch (1987) suggested that deforestation in Thailand must be seen as a consequence of the development of the national economy over the past hundred years and cannot be ascribed to any one factor (but see Panayotou and Sungsuwan 1989). Two factors associated with development are seen by Hirsch as especially important: the increase in area under commercial crops after logging and the linking of the rural areas of the country with Bangkok. Feeny (1984) offers a similar analysis, noting that the expansion of commercial agriculture has been the primary means by which Thailand has been able to increase agricultural exports.

For peninsular Malaysia, Repetto (1988) links commercial (plantation) agriculture to 90% of all deforestation in the past decade, but logging for export played a significant role from the late 1950s to 1980s. A similar pattern is noted for Indonesia: expansion of large-scale commercial logging in the late 1960s (Daroesman 1979) followed by subsistence and plantation agriculture (Collins et al. 1991). In Sarawak, Borneo, logging has been identified as the primary agent of deforestation followed by shifting cultivation (Repetto 1988). In Sabah, Borneo, however, the shifting agriculture is the primary agent (50% of deforestation), with logging and smallholder cultivation playing lesser roles (Brookfield et al. 1990, Collins et al. 1991, Repetto 1988). In Sarawak and peninsular Malaysia, much of the deforestation was deliberately planned to be followed by plantation agriculture.

These studies indicate a broad, recurrent pattern. Deforestation occurs primarily as a result of government policy intended to develop logging and timber exports to take advantage of the international demand for tropical wood and wood products. The deforestation is followed by both spontaneous and planned agricultural expansion (Potter et al. 1994). The expansion of cultivation varies from plantations to smallholder farming and, in some cases, as in Indonesia, has included government programs to redistribute population to low-density areas. After either timber or agricultural development, spontaneous immigration may occur, although timber roads do not necessarily lead to an influx of subsistence farmers (Brookfield et al. in press). The pattern of deforestation then agricultural expansion has emerged under conditions of elite control and, often, corruption that foster a disregard for control of logging and protection of the land.

Deforestation throughout a region does not seem to be a simple function of population growth or demands emanating from an expanding regional economy. Such drivers appear to be external to the Southeast Asian countries examined or embedded within a larger array of human causes, as indicated by the work on Philippine deforestation.

National population growth per se, for example, has not been demonstrated to be an adequate predictor of the patterns and scale of deforestation. In some cases, migration of farmers into particular areas of the region may not have taken place without the convenience of logging roads, partially cleared forests, and/or government sponsorship.

Likewise, affluence and technology have been linked to deforestation in roundabout ways. Both are registered primarily by external relations between deforested areas and the sources of affluence demanding the forest resource and providing the technology.

Little evidence has been generated to date to suggest that tropical deforestation is largely a product of local or national increases in per capita consumption. In the Philippines, the lack of country-level and/or regional-level quantitative studies of land-use change hampers ability to generalize to higher geographic scales of analysis. A comparison of the results from the Philippines to those from other countries in the region would be of interest.

Regional to global land-use models: issues and problems

The Philippine and Southeast Asian experience illustrates the regional variability in human land-use relationships, the dynamics of which may not follow a consistent pattern that can be traced from the global to regional or local scales. This observation does not mean that regional and global models of land-use/cover

Table 4. Annual rates of deforestation, 1980 and 1987, for different national forest inventories in the Philippines. Source: Kummer (1992).

1980 data sources	1987 data sources	Absolute rate	Percentage rate
Forestry Development Center	Forest Management Bureau	1571	2.71
Forestry Development Center	Swedish Space Corporation	951	1.28
Forest Management Bureau	Forest Management Bureau	2103	2.84
Forest Management Bureau	Swedish Space Corporation	1483	1.95

change cannot be connected in a systematic way. It does mean, however, that this connection requires greater regional sensitivity. A major research question of the IGBP-HDP LUCC program is, what level of sensitivity is needed? The answer, of course, is lodged in the aims of the questions to be addressed. If we seek to aggregate to the global scale, much local and regional variation will be sacrificed; however, if we insist on retaining more local and regional specificity, our ability to link to global models will be impeded.

Data problems are central to the regionalization, comparison, and aggregation themes of the IGBP-HDP science agenda. Fine-tuned data required for understanding land-use change are sparse and not readily comparable across cases. Two examples from the Philippine case are illustrative.

First, a disturbing feature of the data in Tables 1 and 2 is that each source or inventory leads to different calculations of the rates of deforestation, as illustrated in Table 4. Although the various calculations all indicate forest loss, the differences among the four possible combinations of the surveys are considerable. The smallest and largest rate differ more than twofold.

Such differences in the inventories and in the calculated rates of deforestation raise perplexing questions with regard to the historical reconstruction of forest cover, the projection of deforestation rates into the future, and the modeling of global land-cover change (Skole and Tucker 1993). A more general question involves the compatibility of survey data. If different surveys use different land-use or land-cover categories, it may not be possible to trace changes in land use over time. This problem is particularly relevant given the increase in different remote-sensing technologies. A major task before the international community is to ensure that ongoing data collection efforts use consistent categories of land use and land cover throughout the world.

Second, Table 5 illustrates some of the difficulties in attempting to analyze the paths of land uses over the past 45 years in the Philippines. The biggest problem is that the sum of farmland, forest land, and urban land does not equal the total area of the nation. A review of the literature indicates that the "other" category apparently includes: grassland, pasture, wasteland, open land, shrubland, brushland, fallow, idle land, barren land, and abandoned agricultural land.

Table 5. National land-use categories in the Philippines, 1948–1987. "Other" is a residual category.

Year	Farmland (km^2)	Forests (km^2)	Urban (km^2)	Other (km^2)	Total (km^2)
1948	57,000	152,000	5000	88,000	300,000
1960	78,000	126,000	6000	90,000	300,000
1970	85,000	103,000	7000	105,000	300,000
1980	97,000	78,000	9000	116,000	300,000
1987	113,000	67,000	11,000	109,000	300,000

All figures rounded to the nearest 1000.

The Agricultural Policy and Strategy Team (1986) estimated that urban areas totalled approximately 11,000 km^2 in 1986. If the urban area for 1987 is assumed to be the same for 1986, and areas are assigned to the urban category for the other years on the assumption that urban area roughly doubled since 1948, then the category called "other" appears as a residual. This category increased from 86,000 km^2 in 1948 to 116,000 km^2 in 1980 before declining to 109,000 km^2 in 1987. The "other" category of land use in 1987 was approximately 37% of total land area, almost equal to land under cultivation and two-thirds larger than forests.

Understanding rural land-use change in the Philippines or elsewhere will be impeded until we know more about this "other" land category. In the Philippines, much land in this category appears to be grassland, but we know little about the uses to which it is put or the processes of change taking place in it. This problem is not restricted to the Philippines (see Houghton page 305 this issue). Potter et al.'s research (1994) indicates that as much as 26% of all land in Southeast Asia falls into the "other" category.

Such problems play havoc with modeling efforts such as Grainger's (1987) forest-agricultural model, which assumes a one-to-one correspondence between the expansion of agriculture and deforestation. For the Philippines, the area of expansion of agriculture between 1948 and 1980 was only 60% of the area of deforestation. The category "other" expanded considerably over this period. The simple dichotomy of forest and agriculture for the Phil-

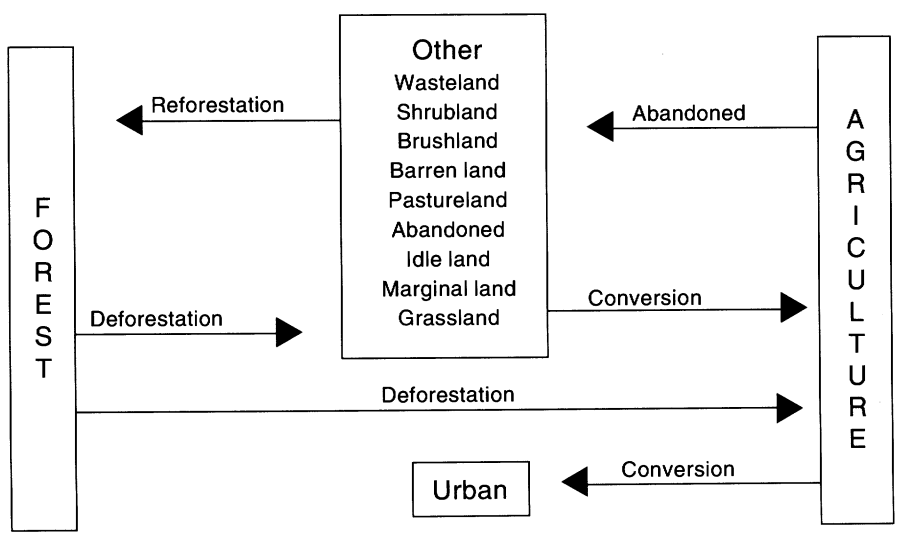

Figure 2. Overview of national land-use categories in the Philippines.

ippines is, therefore, inadequate and should be replaced by more precise land-use categories. In addition, the dynamism of land-cover change among these categories is not adequately captured in the data. Figure 2 illustrates how this dynamic may operate among different land uses in the Philippines.

Conclusions

Data problems notwithstanding, the Philippine/Southeast Asia case study suggests that subglobal (in this case, national and regional) models of land-use change are possible. Although the precise geographic scale of these models is still open to question, the need for such models is not. We suggest that the experience of the region may constitute a broad but common form of deforestation, or what the LUCC program refers to as a cause-to-cover situation. The development of global sets of these kinds of situations is essential for modeling global land-use/cover change.

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