Environmental Economics Programme

REPRINT

iied

International
Institute for
Environment and
Development

THE TIMBER TRADE AND TROPICAL DEFORESTATION IN INDONESIA

Edward Barbier
Nancy Bockstael
Joanne Burgess
Ivar Strand

LEEC Discussion Paper

DP 93-01

April 1993

This paper is based on research for the International Tropical Timber Organisation under contract no PCM(XI)4, "Economic Linkages between the International Trade in Tropical Timber and the Sustainable Management of Tropical Forests", October 1992..

London Environmental Economics Centre

This Centre was established in 1988 and operates as the Economic Programme of the International Institute for Environment and Development (IIED). Its aims are the furtherance of policy relevant research in the field of environmental and natural resource economics, particularly in the context of developing countries.

The Authors

Dr Barbier is Director of the London Environmental Economics Centre

Joanne Burgess is Research Associate at the London Environmental Economics Centre

Nancy Bockstael is Professor in the Department of Agricultural and Natural Resource Economics, University of Maryland

Ivar Strand is Professor in the Department of Agricultural and Natural Resource Economics, University of Maryland

Contact Address

Edward Barbier and Joanne Burgess may be contacted at:

London Environmental Economics Centre
IIED
3 Endsleigh Street
London
WC1H ODD

Tel: 071 388 2117
Fax: 071 388 2826

Nancy Bockstael and Ivar Strand may be contacted at:

University of Maryland
Dept of Agricultural and Natural Resource Economics
College Park
MD 20742
USA

Tel (1 301) 405 1263
Fax (1 301) 314 9091

The Timber Trade and Tropical Deforestation in Indonesia

1. Introduction[1]

This paper examines the links between the trade in tropical timber products and deforestation in Indonesia. We briefly review some of the evidence suggesting that timber production is a factor in tropical deforestation, and the role of timber trade policy in Indonesia in influencing this process by affecting forest-based industrialization. These issues are of particular concern to Indonesia, as the country has recently banned the export of sawnwood exports to encourage further rapid development of plywood processing.

We develop a partial equilibrium timber trade model of Indonesia to analyze the effects of various policy interventions on the trade and tropical deforestation. The basic timber trade model is developed as a *simultaneous equation* system determining supply and demand in the logging, sawnwood and plywood sectors of Indonesia. The system is linked to a *recursive* relationship determining tropical deforestation, which is estimated separately. We use the model to simulate several policy options, including the impacts of sawnwood export taxes/effective bans, import bans imposed by consumer countries, revenue-raising import taxes, and increased harvesting costs associated with 'sustainable management'.

This paper concludes by summarizing the results of the policy analysis, and discusses the policy options open to the Government of Indonesia (GoI) and importing countries.

2. The Timber Trade and Tropical Deforestation in Indonesia

South East Asia currently accounts for around 20 percent of the world's tropical moist forest (TMF). Indonesia alone has over 50 percent of the region's TMF and over 10 percent of the world's total (see Table 1). The rate of deforestation in South East Asia, measured in terms of hectares (ha) lost per year, is also fairly high - approximately 2 million ha annually - and the total area deforested is much higher than in Amazonia and Central Africa. Close to 85% of South East Asia's annual deforestation occurs in Indonesia.

The major 'cause' of tropical deforestation in South East Asia and in Indonesia in particular is generally thought to be the conversion of forests to agricultural land. Tropical timber production, although significant in large areas of 'production' forests, is considered to be a less significant factor in overall tropical deforestation. More recently, however, attention has focused on the indirect role of timber production in 'opening up' inaccessible forest areas, which then encourages other economic uses of the forest resources, such as agricultural cultivation, that lead to deforestation on a wider scale. For example, Amelung and Diehl (1992) identify the major shifts in land use changes and the causes of deforestation in tropical countries, including Indonesia. As indicated in Table 2.a., the direct impact of forest activities on deforestation appears to be minimal (i.e. less than 10% of total deforestation), as compared to agriculture. For Indonesia, this is partly because timber is harvested predominately by selective logging, which does not meet the 'strong' definition of deforestation that is commonly used. In contrast, the forestry sector in Indonesia is almost completely responsible for converting virgin forests into productive closed forests or other forms of land use through *forest modification*, and has a much more significant role in *biomass reduction* (see Table 2.b). In short, there are some indications that timber extraction is largely responsible for opening up previously unexploited forest, leading to further forest degradation and outright deforestation.

Other studies indicate the possible acceleration of this process, given the trends in timber production in Indonesia (Burgess 1989). With the exception of Sabah and probably Papua New Guinea, Indonesia has one of the last remaining reserves of virgin forest in South East Asia, yet well over one third of the country's tropical forests have been allocated to conversion or permanent production forest (Table 3.a). As a very large part of the production in Indonesia in the past has come from the conversion forests, which are essentially clear cut and turned over to agriculture, future supplies must depend on the permanent production forests (and any remaining virgin forest reserves allocated to them) - provided that these supplies can be maintained on a sustained basis.

Although Table 3.b suggests that Indonesia's permanent production forests are not being 'mined' to the extent of those in other South East Asian countries, there is concern that Indonesia has over-estimated the extent of its production forest, under-reported current timber extraction (e.g. there is substantial illegal felling), or both (Burgess 1989). Moreover several analysts predict a decline in South East Asia's (and Indonesia's) share of world production and trade, and some deterioration in the quality of hardwood timber produced from forests in the region (Arnold 1991; Burgess 1989; Sedjo and Lyon 1990). Thus, it is unlikely that Indonesia will be able to maintain its current dominance of world production and trade of timber products, as indicated in Table 3.c, without further and extensive exploitation of its remaining old growth reserves.

3. Indonesian Timber Trade Policies

The tropical timber trade has been subject to severe distortions by export restrictions imposed by log producing countries, including Indonesia. One justification often cited for these policies is that they compensate exporters for the import barriers in developed economy markets by making the price of raw logs higher to the processors in the importing country while reducing the cost disadvantage faced by domestic processors within the timber producing countries. This strategy usually has as its primary aim the creation of more export revenues and employment for the forestry sector, with a secondary objective of reducing harvesting pressure on the forests by increasing value added per log extracted.

Several authors have recently reviewed the role of export taxes and bans in encouraging forest-based industrialization and sustainable timber management in tropical forest countries (Gillis 1990; Vincent and Binkley 1991; Vincent 1992b). Initially, the preference seems to have been for export taxes, through employing escalating rates. For most countries, export tax rates on logs generally ranged between 10 and 20%. Export taxes on sawn timber, veneer and plywood have been negligible. Where sawn timber exports were taxed, rates were typically half that of logs. More recently, the use of export tax structures to promote forest-based industrialization has become largely replaced by export bans in tropical forest countries, although export taxes are still being used in certain regions and for specific timber products (see Table 4).

Tropical timber export taxes and bans have proved only moderately successful in achieving the desired results in South East Asia. For example, although expanded processing capacity was established in Malaysia, the Philippines and Indonesia, it was achieved at high economic costs, both in terms of the direct costs of subsidization as well as the additional costs of wasteful and inefficient processing operations (Barbier 1987; Gillis 1988 and 1990; Vincent and Binkley 1991; Vincent 1992a and 1992b).

In addition, as a long-term forest industrialization strategy, ensuring export sales of processed products through denying processors in other countries access to logs may prove difficult to sustain (Bourke 1988). Importers of South East Asian logs, such as Japan, have been known to substitute other raw materials (e.g., cement, steel, plastics, fiberboard, etc.) for timber, and alternative sources of supply, such as sawlogs from temperate and other developing regions (Bourke 1988; Vincent, Brooks and Gandapur 1991).

In Indonesia, the *ad valorem* export tax on logs was doubled from 10 to 20% in 1978, while most sawnwood and all plywood were exempted. Beginning in 1980 controls on the export of logs were progressively enforced, until an outright ban was introduced in 1985 (Gillis 1988). The export tax structure created effective rates of protection of 222% for plywood manufacture, and the drop in export revenue to the government from diverting log exports was not compensated by any gain in value-added in sawmilling, resulting in a loss of US $15 per m^3 at world prices. The consequence has been the creation of inefficient processing operations and expanded capacity, with consequences for the rate of timber extraction and forest management. Gillis (1988) has estimated that over 1979-82, due to the inefficient processing operations resulting from this policy, over US $545 million in potential rents was lost to the Indonesian economy, or an average cost of US $136 million annually. Moreover, as the switch from log to processed exports occurred at a time when forest product prices were falling sharply in real terms, the cost to the economy in export earnings was high. Over 1981-84, the net loss in export earnings amounted to US $2.9-3.4 billion, or approximately US $725-850 million annually. Additional losses were also incurred through selling plywood below production cost, which amounted to US $956 million in 1981-84, or US $239 million annually (Fitzgerald 1986).

Although the switch to value-added processing of timber initially slowed down the rate of timber extraction, the inefficiencies and rapidly expanding capacity of domestic processing may have actually increased the rate of deforestation over the medium and long term.[2] For example, by the early 1980s, the major operational inefficiencies in domestic processing due to high rates of effective protection in Indonesia led to the lowest conversion rates in Asia. As a result, for every cubic meter of Indonesian plywood produced, 15% more trees had to be cut relative to plymills elsewhere in Asia that would have processed Indonesian log exports (Gillis 1988). Thus the protection given to Indonesian mills not only increased rather than reduced total log demand, but the gross operational inefficiencies also ensured that millions more logs may have been harvested than if a more efficient policy to boost domestic processing capabilities than forced industrialization through export taxes and bans had been implemented.

More recent analysis of the impacts of the log export ban in Indonesia on the efficiency of timber processing industries confirms that the policy has not increased wood recoveries and thus reduced log consumption compared to pre-ban levels (Constantino 1990). By depressing raw wood prices, the log export ban has led to the substitution of wood for other factor inputs, with substantial wood recovery losses in sawmilling and a slower growth in wood recovery than other factor productivities in plymilling. In both industries, wood consumption has been the main source of output growth over the 1975 to 1987 period, with efficiency gains contributing very little. However, the log export ban has not affected efficiency in the plywood industry so seriously, which could arise from the much newer capital vintages in plywood milling, its export orientation that requires higher production standards, and possibly its access to better quality logs.

Despite the problems with the export restriction policy, it is still being aggressively promoted by the GoI to encourage forest-based industrialization. In Indonesia, not only does the export log ban still remain in place, but in October 1989 export taxes on sawn timber were also increased substantially to prohibit exports and shift processing activities to plywood (see Table 4). A secondary objective of the policy is to eliminate the marginal mills, leaving only the competitive ones operational, thus improving overall industrial efficiency. The implications of the policy for wood recovery, log demand and thus tropical deforestation in Indonesia is less clear.

In this paper we develop a timber trade model for Indonesia, linked to impacts on deforestation through log demand, in order to compare the sawnwood export ban with other possible trade policy options Through the various policy option simulations, we hope to investigate the relative merits of the different policy interventions in terms of production, prices, trade and deforestation in Indonesia. However, we first briefly review other models applied to the tropical timber trade in South East Asia.

4. Other South East Asian Timber Trade Models

Various partial equilibrium models of forest product markets and timber supply have been developed for countries in South East Asia to examine the implications of policies that restrict log exports.

Vincent (1989) employed a simulation model of the timber trade of Malaysia, other South East Asian producers and the major importers from the region to determine the optimal tariffs on intermediate and final goods for log, sawnwood and plywood products. The results of the model indicated that the large export tariffs imposed by Malaysia and other South East Asian exporters reduced domestic prices in those countries, leading to losses in producer surplus. More recently, Vincent (1992a) constructed an economic model of sawlog and sawnwood production, consumption and trade in Peninsular Malaysia during 1973-89 to examine in more detail how the log-export restrictions imposed in 1985 affected the forests products industry in Peninsular Malaysia, and whether the restrictions generated net economic benefits. Although the export restrictions seemed to stimulate growth in the processing industries and employment, the economic costs were high. On an average annual basis, Peninsular Malaysia lost US$6,100 in economic value-added, US$16,600 in export earnings, and US$34,300 in stumpage value for every sawmill job created by the log-export restrictions. No attempt was made in either of the above models to link the impacts of timber trade interventions on timber harvesting levels and tropical deforestation.

As part of the forest sector policy review of Indonesia conducted by the United Nations Food and Agricultural Organization (FAO) and the GoI, a domestic and international trade model of timber products centered on Indonesia was developed (Constantino 1988a and 1988b; Constantino and Ingram 1990). The simulation model had as its main purpose the determination of supply and demand projections for the Indonesian forestry sector, but it was also used to run policy scenarios on different trade interventions, including the implications of Indonesia's log export restrictions. The impacts of different government harvesting policies were simulated through scenario assumptions concerning the elasticity of the supply of forest land in Indonesia. For example, a small elasticity of supply was interpreted as a deliberate government policy to impose sustained yield constraints; whereas large elasticities reflected the GoI allowing expansion of forest land harvested. Using these different elasticity assumptions, the analysis could then focus on whether in response to each policy scenario the GoI should expand the area of forest land harvested, at the risk of greater tropical timber depletion and deforestation, or whether Indonesia would be better off limiting supply through greater harvest restrictions. Detailed results are provided in Constantino (1988a), which are summarized here:

- If international competitors follow conservative harvesting practices, then Indonesia should do the same in order to take advantage of greater employment, foreign exchange earnings and rent capture. On the other hand, if competing countries follow expansionary policies, it is not clear what Indonesia ought to do. Harvest restrictions will lead to a loss in international market share and to declines in employment -- but also increases government revenues.

- Export restrictions on sawnwood and plywood result in a loss in international market share for Indonesia, lower foreign exchange earnings, employment, labour income, royalty revenues for logging and economic rent to forest land. On the other hand, the restrictions lead to lower domestic prices thus benefitting Indonesian consumers, to higher profits in the processing industries and to less forest land harvested. Imposing harvest restrictions as well would improve matters, as employment would decline less, even less forest land would be harvested and economic rent to forest land would increase more, thus leading to more revenues if the GoI increased rent capture.

- A 10% currency devaluation by the GoI coupled with restrictive harvesting policies will lead to the conservation of the resource and greater economic rent from forest land, but at the expense of higher domestic prices and less employment, value added, foreign exchange earnings and royalty revenues. This would suggest that some increase in forest land harvested in conjunction with a currency devaluation would be preferred.

- The impacts of a 10% US import tariff on tropical plywood is dissipated somewhat if it is imposed on all exporters and not just Indonesia, and if there is limited substitution between tropical and temperate plywood. For Indonesia, the overall effects are a decline in total plywood exports, a smaller increase in sawnwood exports, and increased domestic consumption and trade diversion to other regions for both products. If harvesting restrictions are imposed, consumer prices will fall more, but employment, capital, foreign exchange earnings and value added will decline less.

The following simulation model is an additional attempt to examine the relationship between policy interventions, tropical timber product trade and deforestation in Indonesia.

5. Timber Trade and Deforestation Model of Indonesia

The simulation model employed to examine timber trade and tropical deforestation in Indonesia is a static (single-period), partial equilibrium model of the production, consumption and trade of forest products that is related to the impact of log harvesting on forested area. The model is comprised of two components: a *simultaneous equation system* determining supply and demand in the logging, sawnwood and plywood sectors of Indonesia, and a *recursive relationship* determining tropical deforestation. Each component was estimated separately over the period 1968-1988, before the 1989 tax rises on Indonesian sawnwood exports. The resulting estimated relationships were linked together in the simulation model using 1988 data.[3] The model was then used to examine the varying impacts on Indonesia's timber markets and tropical forests of the 1989 sawnwood export tax policy and other policy interventions.

The simultaneous equation system of the supply and demand for Indonesia's roundwood (log), sawnwood and plywood markets was estimated using two-stage least squares employing linear functional relationships (See Table 5). As Indonesia essentially prohibits competing foreign timber product imports, supply comes solely from domestic production. In all three markets, demand is assumed to consist of both domestic consumption and foreign demand for Indonesian exports. Separate relationships for domestic production, consumption and import demand for each of the three products were then estimated. All values were based on 1980 real prices.

In the case of the log market, domestic consumption was assumed to be equal to the level of sawnwood and plywood production, multiplied by the respective wood recovery rates plus any local residual demand. Log export demand was considered to be influenced by log export unit values relative to the price of substitutes in world markets and by macro-economic factors affecting final demand in those countries importing Indonesian logs.[4] Due to insufficient data on domestic log prices, roundwood production (harvesting) was related to log export unit values, net of log royalties and export taxes, and the costs of harvesting. Domestic plus foreign log demand was therefore assumed to equal total log production. However, because the log export ban in 1985 effectively reduced Indonesian export volumes and unit values to zero, estimation of the log supply and foreign log demand relationships was only possible for the period 1968-84. As a check on the recovery rates used as coefficients in the domestic log consumption equation employed in the simulation model (see below), a regression representing this demand was run for the entire 1968-88 period.

In the sawnwood and plywood markets, domestic consumption was assumed to be a final demand, determined by the respective product prices and Indonesian macro-economic factors. Again, as domestic price and taxation time series data were scarce, plywood and sawnwood export unit values were used as proxies for domestic prices for these products.[5] Plywood export demand was considered to be influenced by its export unit value relative to the international price of a substitute (i.e. Philippine luan), but in the case of sawnwood export demand, only the export unit value alone proved significant. Both plywood and sawnwood exports were influenced by macro-economic factors affecting final demand in the main importing countries for each product.[6] Sawnwood and plywood production in Indonesia were determined by their respective prices (as represented by export unit values), processing capacity and costs - including the price of logs.[7] In the sawnwood market, domestic production and consumption was estimated for the entire 1968-88 period; however, as sawnwood was not exported significantly until after 1973, foreign demand could be estimated only for the 1974-88 period. As plywood production did not take off in Indonesia until after 1974, the demand and supply relationships for this market were estimated over 1975-88 only.

The separate recursive relationship linking tropical deforestation to log production (harvesting) was estimated using a logit equation for pooled cross-sectional and time series data across the principal tropical hardwood forest provinces of Indonesia.[8] The relationship estimated the probability of forested relative to non-forested area as a function of log production per square kilometer (km^2), population density and GNP per capita for each province and time period. A dummy variable for 1988 was also employed, as the inventory methods for provincial forestry statistics were modified in this year leading to revisions in the estimates for total forest area.

The results of the estimation of the simultaneous equation system for the three timber product markets and of the deforestation equation are presented in Table 5. The twelve endogenous variables of the timber trade supply and demand system are the prices (export unit values), production levels, domestic consumption levels and export levels for roundwood, sawnwood and plywood respectively. The remaining variables used to estimate the supply and demand equations are exogenous.[9] In Table 5, t-statistics are displayed in parenthesis under each coefficient, and other regression statistics are placed to the right of each estimated equation.

The deforestation regression indicates that increases in population density have a more significant impact than log production in terms of changes in forested area in Indonesia's forested provinces. For every cubic meter (m^3) of timber extracted per km^2, the proportionate change in forested to non-forested area is - 0.6%. For every additional person per km^2, the proportionate fall in forest area is -1.3%. In contrast, a rise in incomes of Indonesian Rupiah (Rp) 10,000 per person, approximately US$6.00 in 1988, would counteract deforestation at a rate of 0.4%.[10]

However, the deforestation equation in Table 5 may over-estimate the contribution of log extraction alone to regional changes in forest area in Indonesia. First, there is the usual problem of reliability and accuracy of data. More importantly, however, is that data limitations prevent distinguishing in the regression between log production from permanent production forests as opposed to conversion forests. If log production is mainly from conversion forests, then timber extraction is essentially a precursor or by-product to agricultural conversion, which is the principal factor in the resulting deforestation. As indicated in Table 3a, close to 50% of Indonesia's total production forests consist of conversion forests, and anecdotal evidence suggests that a good deal of the log production during the period 1973-88 came from the latter forests (Burgess 1989). To the extent that this is the case, then the deforestation equation may be reflecting mainly the impact of agricultural conversion, rather than the initial logging operations, on changes in forested area. This is supported somewhat by the evidence presented in Table 2, which shows logging much more responsible for 'opening up' the forest rather than outright forest conversion.

On the other hand, in the 1980s Indonesia's permanent production forest began contributing an increasingly larger share to overall log production - and is expected to be the main source of tropical hardwood logs in the future. Although forest regulations for this permanent forest estate are increasingly requiring concessions to harvest timber on a sustained production basis, clear cutting is allowed under certain conditions. Moreover, problems of implementing these regulations and policy failures in forestry management also contribute to over-harvesting and clear-cutting of permanent production forests, as well as illegal felling of non-production forests (Barbier 1987; Burgess 1989; Gray and Hadi 1990; Sedjo 1987; World Bank 1989). Evidence for the 1980-90 period suggest that logging damages alone contributed *directly* to just under 10% of the annual average rate of deforestation in the Outer Islands of Indonesia (Pearce, Barbier and Markandya 1990, ch. 5). Moreover, if timber operations in Indonesia are also 'opening up' permanent production and virgin forests to subsequent encroachment and deforestation, then logging may have a major role in *indirectly* furthering the deforestation process of these forested areas.

In short, it is difficult to determine the extent to which the deforestation equation in Table 5 over-estimates, if at all, the impact of log production on tropical deforestation in Indonesia. The available evidence would suggest that, at the very least, the equation is correct in indicating that this impact is significantly greater than zero and positive.

The key relationships in the simultaneous equation system of the three main timber markets of Indonesia are for price and quantity. Table 6 compares the price elasticity estimates for each of the supply and demand equations of the model with other recent estimates for the South East Asian region. In general, the elasticity estimates compare favorably. According to our estimates, the supply of timber products in Indonesia appears to be fairly price inelastic. In the case of the processed products, this may reflect the Indonesian policy of expanding sawnwood and plywood capacity over the 1968-88 period. In our regressions, export demand for sawnwood seems slightly more elastic than domestic demand, whereas for plywood the opposite seems to be the case. A similar result was obtained by Vincent (1989) for all South East Asian exporters.

The simultaneous equation system and the deforestation regression are combined to form a simulation model of timber trade-deforestation linkages, using data for 1988. The results are displayed in Table 7. Given the Indonesian policy of banning log exports, the export log demand equation from Table 5 was not included in the model. It is assumed the total log production in Indonesia supplies domestic log demand. The latter is again related to sawnwood and plywood production, although in the simulation model actual recovery rates for the mid-1980s were used as coefficients rather than those generated by the regression for 2the entire 1968-88 period.[11]

Table 7 compares the results of the base case scenario with the actual values of key price, quantity and deforestation variables for Indonesia in 1988. The model appears to be a reasonably good simulation of these variables. The impacts of Indonesia's forest industries and log production on the tropical forest are indicated by effects on forest cover and the annual rate of deforestation. The latter indicator was not simulated by the base case scenario; instead, the most recent FAO estimate of annual deforestation in Indonesia was used.

The following sections compares different policy scenarios to the base case, focussing particularly on the sawnwood export tax intervention, the imposition of an import ban, the use of revenue-raising import surcharges and the implementation of improved sustainable timber management practices. There are, of course, a number of important limitations on the use of the simulation model for these policy scenarios.

First, as discussed above, the linkages of the impacts of log production on tropical deforestation do not take into account changes in the type of forests being exploited (i.e. permanent production forests, conversion forests or new forest areas) or in the production management regime (i.e. selective cutting or clear cutting). The deforestation equation also cannot distinguish between the direct versus indirect impacts of logging on the forest.

Second, although the model is well suited to examining the effects of a particular policy intervention on the *internal diversion* of timber product flows in Indonesia, i.e. between export and domestic markets for sawnwood and plywood, the model does not explicitly indicate the effects of an intervention in terms of *external diversion* of timber products, i.e. between different import markets for sawnwood and plywood. That is, elasticities of substitution by product or by sources of origin in existing importing markets are not explicitly modelled, and the possibility of new import markets opening up as a result of the intervention is not taken into account. In addition, 'leakages', or the ability to avoid any restrictions imposed by an intervention, are also not shown.

Finally, the model is capable of only showing 'static', or one-period, partial equilibrium effects of a policy intervention. Many of the impacts may have economy-wide, or general equilibrium, impacts that feedback to effect the timber product markets and deforestation. In addition, the impacts may have lag, or dynamic, effects that manifest themselves over a medium or long term horizon. Some of the policy interventions themselves, such as the implementation of sustainable management practices, would realistically involve a longer process of implementation than a single period (i.e. one year).

Keeping these obvious limitation in mind, it is nevertheless useful to use the simulation model to obtain an approximate indication of the relative impacts of different trade and forest sector policy interventions on Indonesia's timber product markets and forest resource base.

6. Sawnwood Export Taxes

As indicated in Table 4 and discussed above, in 1989 Indonesia imposed substantial taxes on sawnwood exports in an effort to shift processing activities to plywood. A secondary objective of the policy is to improve competitiveness and overall efficiency of sawmills. However, the implications of the policy for wood recovery, log demand and thus tropical deforestation in Indonesia is less clear.

Table 8 displays the results of imposing varying levels of sawnwood export taxes in the simulation model of Indonesia's forest sector. The results compare the changes in key price, quantity and deforestation variables to the 1988 base case scenario.

In the model, the sawnwood export taxes appear to have the effect of reducing export demand for Indonesian sawnwood, thus lowering the export price received and the quantity exported. The price effects appear to be outweighed by the quantity effects. Although some sawnwood production is diverted to domestic consumption, it is not sufficient to overcome the fall in export demand. Thus overall sawnwood production falls. The impacts on Indonesia's sawnwood markets are more severe the greater the tax. As indicated in the model, a tax rate of 700% imposed in 1988 would effectively choke off sawnwood export demand. With proposed taxes of US$250- 2,4000 per m^3, actual government policy would be represented by the higher range of sawnwood export taxes shown in Table 8.

Significantly, the imposition of a tax on sawnwood exports does not appear to instigate a major shift of processing capacity to plywood - at least not in the one-period duration of the simulation model. Only at extremely high rates of taxation does this occur even slightly, and it appears that increased domestic plywood consumption is the most noticeable effect. Evidence would suggest that there are several structural factors limiting diversion of production between Indonesia's sawnwood and plywood industry in the short term, such as the much newer vintages of capital in plywood milling, and its export orientation that requires higher production and possibly access to better quality logs (Constantino 1990). The simulation model therefore confirms that, if a sawnwood export tax is to shift Indonesian processing capacity towards greater plywood expansion, then it will be a long term process. Unfortunately, the economic costs of reduced sawnwood exports and production appear to be severe from the outset.

Only at high rates of taxation does the sawnwood export tax have a modest impact on deforestation. The inability of the policy to increase plywood output in the short term means that the net reduction in sawnwood production translates into less log extraction. At higher rates of taxation, the fall in log production is much larger, thus resulting in a lower rate of deforestation. However, as noted, the economic costs particularly in terms of lost exchange earnings of a prohibitive sawnwood export tax are severe. Moreover, if the policy is successful over the long run in shifting processing to plywood production, then one would expect log demand, and thus deforestation rates, also to be revived.

In sum, a prohibitive sawnwood export tax in Indonesia appears to be a high cost strategy for shifting processing capacity to plywood production and export, which may only be successful - if at all - over the long term. In addition, the policy does not appear to be an effective approach for reducing timber-related deforestation in Indonesia. Only modest reductions in deforestation may occur, and these will be short-lived if plywood production begins replacing the lost sawnwood output.

7. Import Ban

Some environmental pressure groups in Western tropical timber importing countries have been urging their governments to ban the import of tropical timber, or at least imports of timber that is 'unsustainably' produced. Consumer-led boycotts against tropical timber products have also been instigated. The presumption is that an import ban is the most effective way of ending timber-related deforestation in tropical forest countries. Despite the various economic and legal implications of such a move, as well as questions about its effectiveness, an import ban on tropical timber is a realistic possibility in the near future.[12]

The first column of Table 9 indicates the effects of a total import ban, compared to the base case scenario, in the timber trade-deforestation model of Indonesia. In order to simulate an import ban in the model, large price changes were used deliberately to constrain sawnwood and plywood exports to zero. Timber product prices are therefore no longer endogenously generated by the model, and as a result, are not shown in Table 9. Also, the functional form of the deforestation equation and its estimation using regional panel data imply that the large changes in log production associated with the import ban scenario cannot be used to predict reliably the effects on forest cover and deforestation. Thus the impacts on deforestation are also not reported for this policy scenario simulation.

As shown in Table 9, an import ban would have a devastating impact on Indonesia's forest industry in the short term. Although there would be significant diversion of plywood and sawnwood exports to domestic consumption, this would be insufficient to compensate for the loss of exports. Net production in both processing industries would fall. Given its export orientation, the plywood industry would be particularly hurt - reducing its output by over 40%. Net production losses in the sawnwood industry would be closer to 10%. The overall effect is to lower domestic log demand in the short term by around 25-30%.

The policy scenario is of course assuming that the import ban is 100% effective. It is unlikely that all importers of Indonesia's tropical timber products - many of which are also newly industrializing or producer countries with processing capacities - would go along with a Western-imposed ban. In any case, one would expect that over the longer term there would be some diversion of Indonesian plywood and sawnwood exports to either new import markets or existing markets that prove to be less stringent in applying the ban. As discussed above, these effects cannot be captured in our model.

In addition, the long-term implications of an import ban on tropical deforestation are also uncertain. Even if the ban is100% effective in the short term, any resulting reduction in tropical deforestation is likely to be short-lived. There are several reasons for this.

First, as indicated in the model, diversion of timber products to satisfy domestic demand is likely to continue as Indonesian population and economic activity expands (see Table 5). Thus one can expect the wood processing industries to recover somewhat through re-orientation to meet local consumption of timber products. Moreover, past evidence suggests that domestic-oriented processing in Indonesia is less efficient than export-oriented processing, implying poorer wood recovery rates and greater log demand (Constantino 1990). Pressure on the tropical hardwood forests may therefore increase after the initial 'shock' of a ban.

However, it is unlikely that the domestic market in Indonesia will generate the same demand for higher valued timber products as the international market. Instead, domestic demand is likely to be strongest for high-volume but lower valued wood products. As a consequence, it may be difficult for Indonesia to justify holding as large a proportion of its tropical forests as permanent production forests if the expected economic returns from sustainable management decline as a result of the ban. More of the resource may be shifted to conversion forests, and timber production will become residual to satisfying the growing demand for agricultural land. In short, without the timber trade providing increased value added in the form of external demand for higher valued products, there may be less reason for Indonesia 'holding on' to these forests as opposed to converting them to an alternative use, such as agriculture (Barbier 1992; Vincent 1990).

To summarize, a total import ban would cause a major diversion of Indonesian timber products to meet domestic demand. Although in the short term net production of wood products, and thus log demand, would fall, this situation would not necessarily be sustained over the long run. Even if this is not the case, the ban may be ineffective in permanently reducing tropical deforestation because, in the first place, timber production is not the main source of deforestation in Indonesia, and secondly, as the value of holding on to the forest for timber production decreases the incentives to convert more of the resource to agriculture will increase.

8. Revenue-Raising Import Tax

International cooperation and compensation to assist developing countries in achieving sustainable management of timber production forests have also been discussed in recent years. For example, the International Tropical Timber Council (ITTC) unanimously adopted a "Year 2000 Target" that encourages "ITTO members to progress towards achieving sustainable management of tropical forests and trade in tropical forest timber from sustainably managed sources by the year 2000" (Decision 3(X) ITTC 1991). One suggestion for raising additional funds for this strategy is for importing countries to impose a small import surcharge on tropical timber, which is then directed to tropical forest countries that have shown "demonstrable progress" towards achieving the Year 2000 Target.

A recent study has indicated that 1-3% surcharge on the tropical timber imports (excluding plywood and based on 1986 trade levels) of the EEC, Japan and USA would raise approximately US$ 31.4 to 94.1 million with little additional distortionary effects (NEI 1989). Buongiorno and Manurung (1992) also examine the scope for a 5% revenue-raising import levy on tropical timber by the Union pour le Commerce des Bois Tropicaux (UCBT) or the EEC.[13] The results indicate that tropical timber exporters would lose around US$44.8 million in trade earnings, with Indonesia and Malaysia suffering the worse, but importing countries would earn US$87.7 million in additional revenues. Thus, if the funds raised by the tax were rebated to exporting countries, they could be made better off by over US$40 million.

The final two columns of Table 9 show the impacts of a 1 and 5% revenue-raising import tax on Indonesian tropical timber exports in the simulation model. In the case of a 1% surcharge, a total of US$23.1 million (1980 prices) in revenue would be raised, with US$5.8 million and US$17.3 million from Indonesian sawnwood and plywood exports respectively. For the 5% surcharge, a total of US$113.9 million (1980 prices) in revenue would be raised, with US$28.5 million and US$85.4 million from Indonesian sawnwood and plywood exports respectively. When compared to the revenue estimates from the NEI (1989) study, the above figures would suggest that, in the case of Indonesia, applying the import surcharge to plywood would significantly raise the total amount of financing appropriated.

The results shown in Table 9 confirm that a small import surcharge would have very little distortionary effects on Indonesia's timber product flows and prices. There would also be a negligible direct impact on deforestation. However, around the 5% level, the impacts of the surcharge on exports in particular would become more noticeable. Thus from the standpoint of minimizing additional distortionary effects, the policy scenario confirms that an import surcharge of less than 5% would be optimal.

A more pertinent issue is whether it is worth imposing an import surcharge to raise revenue for sustainable management of tropical forests. In the simulation model, the same result, and thus the same amount of revenue, could be achieved if Indonesia raised the money for its own "sustainable management" initiatives by imposing a revenue-raising export surcharge of 1-5%. The NEI study argues that the imposition of an export levy by producing counties themselves has the advantage of directly addressing the forest management systems of these countries, as well as avoiding the transaction costs involved in international transfers, but prevents obvious problems of monitoring and evaluating success in achieving sustainable management. The counter-argument is that an import surcharge not only has problems of transaction costs and administration, but that it is also possibly discriminatory if it is limited only to the *tropical* timber trade. Moreover, the import surcharge-cum-international transfer mechanism would still require the cooperation of producer countries, as well as raise similar problems of monitoring and evaluation of progress towards sustainable management and expenditures. Finally, there is the issue of whether the amount of funds raised through any trade surcharge would be adequate for the task, and whether it would be more appropriate avenue for raising additional large-scale funding *outside* the timber trade altogether (Barbier *et al.* 1992).[14]

In sum, it is possible to raise revenue through an import surcharge of less than 5% with minimal distortionary effects on Indonesia's timber trade and production. The key issue is whether this is the most efficient and appropriate means of raising financing for improved sustainable management of production forests.

9. Sustainable Timber Management

An alternative to the above trade interventions would be a more direct policy initiative by Indonesia to improve 'sustainable' management of its remaining production forests. As discussed above, several studies have pointed to considerable problems of policy failures in Indonesian forestry management that are contributing to over-harvesting and clear-cutting of permanent production forests, as well as illegal felling of non-production forests (Barbier 1987; Burgess 1989; Gray and Hadi 1990; Sedjo 1987; World Bank 1989). Correcting these policy failures would improve sustainable management of Indonesia's remaining tropical forests, and thus reduce timber-related deforestation, but would also mean higher harvesting costs per cubic mere of wood extracted.

Table 10 indicates the most likely effects of such a 'sustainable' management policy scenario, which is represented by an increase in harvesting costs. As there is insufficient data to determine the extent to which costs would rise if such a policy were to be implemented in Indonesia, we have arbitrarily chosen a 25% and 50% harvest cost increase for comparison.

A surprising feature of the scenario is that although log prices are affected significantly by the increased harvest costs, any resulting impacts on the rest of Indonesia's forestry sector seem to be somewhat dissipated. There appears to be several factors at work. First, the price-elasticity of log supply for Indonesia is very inelastic in our model (see Tables 5 and 6). This is not surprising given that Indonesian policy has been to devote log production solely to supplying domestic processing capacity, which of course has expanded considerably over the 1968-88 period. Second, increased log costs are only one component of the total factor costs of Indonesia's processing industries, and have increasingly become the least important component in recent years (Constantino 1990). Finally, Indonesia's sawnwood and plywood exports seem to be the least affected by the increased harvest costs, which would suggest that external demand factors exert an important counter-acting influence.

There is reason to believe that the impacts of the sustainable management scenario on reducing timber-related deforestation may be underestimated in Table 10. As discussed above, the deforestation equation in the model can only record changes in forest cover due to changes in overall log production rates. It cannot distinguish between *qualitative* changes in the management of log production that may also affect timber-related deforestation more indirectly, such as controlling residual stand damage, improved replanting and reforestation, reduced high-grading of stands, limiting trespass, improving the incentives to control stand abandonment and encroachment, and so forth.[15]

These latter factors may be more important in timber-related deforestation than log extraction alone. In addition, some sustainable management techniques, such as utilizing lesser known species and improved harvesting techniques, may actually increase the amount of logs produced from a given timber stand, thus simultaneously limiting harvest costs and reducing the pressure to exploit the remaining tropical forest.

Finally, it is unlikely that the implementation of any sustainable management techniques would occur in a single year, as implied by the simulation scenario. A longer lead time for implementation would mean more time for the Indonesian forest industries to absorb the increased costs, but it would also imply a longer period before the effects on reducing deforestation would be fully felt.

In sum, Indonesia's timber industries may not be badly affected by the higher harvest costs associated with implementing sustainable forestry management policies. Although there would be some reduction in tropical deforestation due to reduced log production, this direct effect may be less significant than the improvement in forest management and protection resulting from qualitative changes in timber stand management practices and ownership.

10. Conclusion

The simulation model developed to examine the relationship between Indonesia's timber trade and tropical deforestation has provided some important insights into this linkage as well as the scope for the use of trade policy instruments to limit deforestation. As discussed throughout, there are obvious constraints on the use of such model to examine such dynamic, complex and pervasive effects. Nevertheless, the model and the policy simulations would suggest extreme caution in the use of broad trade policy interventions as a means to affect timber-related deforestation in Indonesia, and in some cases even as an economic tool to develop further Indonesia's timber processing capacity.

First, it is clear that timber production is not the major cause of tropical deforestation in Indonesia. Even where timber production is a factor in deforestation, most timber-related deforestation, including subsequent deforestation by agricultural encroachment, may have more to do with the management and regulation of the timber stand than with the amount of logs extracted from the stand *per se*.

Second, extreme trade interventions, such as the current GoI policy of prohibitive sawnwood export taxes and the imposition of a total import ban on tropical timber products, may have an initial 'shock' impact on tropical deforestation in Indonesia. However, this may be short-lived as dynamic factors in the economy - notably the shifting of processing capacity or the transfer of permanent production forests to conversion forests - may take hold. Both forms of trade intervention clearly impose high economic costs on Indonesia's forestry industries. Surprisingly, a high sawnwood export tax would appear to make little headway in the short run in achieving its stated objective of spurring development of Indonesia's plywood sector.

Third, an import surcharge on tropical timber imports would have minimal distortionary impacts on Indonesia's timber trade - provided that it was imposed at a level of less than 5%. A more pertinent issue is whether this policy is the correct means for raising funds for sustainable management of production forests, and whether the financing raised would be sufficient for the task.

Finally, improvements in sustainable timber forest management and regulation by Indonesia could raise log harvesting costs, but there may not be such significant impacts on Indonesia's processed products and trade. The reduction in timber-related deforestation in Indonesia resulting from the policy may not be fully captured by the model.

In sum, there seems little scope for the use of trade policy interventions as a means to reducing tropical deforestation in Indonesia. If there is concern over timber-related deforestation, a more appropriate approach may be to deal more directly with the problem by improving sustainable production forest management and regulation at the timber stand level. However, a key factor is whether the GoI has sufficient incentive to ensure that better forest management policies are implemented and enforced. By ensuring access of sustainably managed timber to import markets and by providing financial assistance for Indonesian policy efforts, the major tropical timber consumer countries could go a long way toward encouraging the appropriate incentives for action by the Indonesian government.

References

Amelung, T. and Diehl, M. 1992. *Deforestation of Tropical Rainforests: Economic Causes and Impact on Development*, Tubingen, Mohr.

Arnold, M. 1991. "Forestry Expansion: A Study of Technical, Economic and Ecological Factors", Oxford Forestry Institute Paper No. 3, Oxford.

Barbier, E.B. 1987. "Natural Resources Policy and Economic Framework", Annex 1 in J. Tarrant *et al.*, *Natural Resources and Environmental Management in Indonesia*, USAID, Jakarta.

Barbier, E.B. 1992. "Economic Aspects of Tropical Deforestation in South East Asia", Paper prepared for the workshop on "The Political Ecology of South East Asia's Forests", Centre of South East Asian Studies, School of Oriental and African Studies, London, 23-24 March.

Barbier, E.B., Burgess, J.C., Aylward, B.A. and Bishop, J.T. 1992. *Timber Trade, Trade Policies and Environmental Degradation*, LEEC Discussion Paper DP 92-01, London Environmental Economics Centre, London.

Barbier, E.B., Bockstael, N., Burgess, J. and Strand, I. 1992. "Timber Trade and Tropical Deforestation - Indonesia", in Barbier *et al.* 1993.

Barbier, E., Burgess, J., Bishop, J., Aylward, B. and Bann C. 1993. "The Economic Linkages between the International Trade in Tropical timber and the Sustainable Management of Tropical Forests", Final Report for the International Tropical Timber Organisation (ITTO).

Bourke, I.J. 1988. *Trade in Forest Products: A Study of the Barriers Faced by the Developing Countries*, FAO Forestry Paper 83, FAO, Rome.

Buongiorno, J. 1979. "Income and Price Elasticities for Sawnwood and Wood-Based Panels: A Pooled Cross-Section and Time Series Analysis", *Forest Science* 9(2):141-148.

Buongiorno, J. and Manurung, T. "Predicted Effects of an Import Tax in the European Community on the International Trade in Tropical Timbers", *mimeo.*, Department of Forestry, University of Wisconsin, Madison.

Burgess, P.F. 1989. "Asia", Chapter 5 in D. Poore *et al.*, *No Timber Without Trees: Sustainability in the Tropical Forest*, Earthscan Publications Ltd, London.

Cardellichio, P.A., Youn, Y.C., Adams, DM., Joo, R.W and Chmelik, J.T. 1989. *A Preliminary Analysis of Timber and Timber Products Production, Consumption, Trade, and Prices in the Pacific Rim Until 2000*, CINTRAFOR Working Paper 22, Center for International Trade in Forest Products, University of Washington, Seattle.

Constantino, L.F. 1988a. "Analysis of the International and Domestic Demand for Indonesian Wood Products," *mimeo.*, Report for the FAO, Dept. of Rural Economy, University of Alberta, Edmonton, Alberta.

Constantino, L.F. 1988b. "Demand, Supply and Development Issues in the Indonesian Forest Sector", *mimeo.*, Report for the FAO, Dept. of Rural Economy, University of Alberta, Edmonton, Alberta.

Constantino, L.F. 1990. *On the Efficiency of Indonesia's Sawmilling and Plymilling Industries*, D.G. of Forest Utilization, Ministry of Forestry, Government of Indonesia and FAO, Jakarta.

Constantino, L.F. and Ingram, D. 1990. *Supply-Demand Projections for the Indonesian Forest Sector*, D.G. of Forest Utilization, Ministry of Forestry, Government of Indonesia and FAO, Jakarta.

Fitzgerald, B. 1986. *An Analysis of Indonesian Trade Policies: Countertrade, Downstream Processing, Import Restrictions and the Deletion Program*, CPD Discussion Paper 1986-22, World Bank, Washington DC.

Gillis, M. 1988. "Indonesia: Public Policies, Resource Management, and the Tropical Forest", in R. Repetto and M. Gillis (eds), *Public Policies and the Misuse of Forest Resources*, Cambridge University Press, Cambridge.

Gillis, M. 1990. "Forest Incentive Policies", Paper prepared for the World Bank Forest Policy Paper, The World Bank, Washington, DC.

Gray, J.A. and Hadi, S. 1990. *Fiscal Policies and Pricing in Indonesian Forestry*, D.G. of Forest Utilization, Ministry of Forestry, Government of Indonesia and FAO, Jakarta.

International Tropical Timber Council (ITTC), 1992. *Report on Preparations for the 1992 United Nations Conference on Environment and Development*, ITTC(XII)/8, 12th Session, 6-14 May, Yaoundé, Cameroon.

Netherlands Economic Institute (NEI), 1989. *An Import Surcharge on the Import of Tropical Timber in the European Community: An Evaluation*, NEI, Rotterdam.

Pearce, D.W., Barbier, E.B. and Markandya, A. 1990. *Sustainable Development: Economics and Environment in the Third World*, Edward Elgar and Earthscan, London.

Schmidt, R. 1990. "Sustainable Management of Tropical Moist Forests", Presentation for ASEAN Sub-Regional Seminar, Indonesia, Forest Resources Division, Forestry Department, FAO, Rome.

Sedjo, R.A. 1987. "Incentives and Distortions in Indonesian Forest Policy", *mimeo.*, Resources for the Future, Washington DC.

Sedjo, R.A., and Lyon, K.S. 1990. *The Long-Term Adequacy of World Timber Supply*, Resources for the Future, Washington D.C.

Vincent, J.R. 1989. "Optimal Tariffs on Intermediate and Final Goods: The Case of Tropical Forest Products". *Forest Science* 35(3):720-731.

Vincent, J.R. 1990. "Don't Boycott Tropical Timber", *Journal of Forestry*, 88(4):56.

Vincent, J.R. 1992a. "A Simple, Nonspatial Modelling Approach for Analyzing a Country's Forest-Products Trade Policies", in R. Haynes, P. Harou and J. Mikowski (eds.), *Forestry Sector Analysis for Developing Countries*, Proceedings of Working Groups, Integrated Land Use and Forest Policy and Forest Sector Analysis Meetings, 10th Forestry World Congress, Paris.

Vincent, J.R. 1992b. "The Tropical Timber Trade and Sustainable Development", *Science*, 256:1651-1655.

Vincent, J.R. and Binkley, C.S. 1991. *Forest Based Industrialization: A Dynamic Perspective*, Development Discussion Paper No. 389, Harvard Institute for International Development (HIID), Cambridge, Massachusetts.

Vincent, J.R., Gandapur, A.K. and Brooks, D.J. 1990. "Species Substitution and Tropical Log Imports by Japan", *Forest Science* 36(3):657-664.

World Bank 1989. *Indonesia - Forest Land and Water: Issues in Sustainable Development*, The World Bank, Washington DC.

Table 1. Tropical Deforestation in South East Asia and Other Regions 1/

	Total Forest Area (mn ha)	Undisturbed Operable Forest (mn ha)	Annual Deforestation ('000 ha)	Total TMF area deforested (mn ha)
SE ASIA INSULAR	167.3	72	1707	117
Indonesia	108.6		1315	
Papua New Guinea	33.5		22	
Malaysia 2/	18.4		255	
Philippines	6.5		110	
Brunei	0.3		5	
OTHER SE ASIA 3/	39.3	18	346	NA
Myanmar	31.2		102	
Thailand	8.1		244	
TOTAL SE ASIA	206.6	90	2053	>117
AMAZONIA	613.6	453	4129	100
CENTRAL AFRICA	167.1	107	325	30
OTHER REGIONS	58.4	<10	1900	177 4/
WORLD TOTAL	1045.7	652	8480	424

Notes:

1/ Unless indicated, 1990 estimates based on R. Schmidt, "Sustainable Management of Tropical Moist Forests", Presentation for ASEAN Sub-Regional Seminar, Indonesia, Forest Resources Division, Forestry Department, FAO, Rome, January 1990. Note that *tropical moist forests* are defined as broadleaf high closed tropical forests, including wetland and mangrove forests but excluding the deciduous dry forests of South Asia, sub-Saharan Africa and sub-tropical South America. In 1988, the FAO estimated the total area of all *tropical closed forests* (including deciduous dry forests) to be 1269.6 million ha.

2/ Includes forests from Peninsular Malaysia.

3/ End of 1980 revised estimates based on Forest Resources Division, Forestry Department, *An Interim Report on the State of Forest Resources in the Developing Countries*, FAO, Rome, 1988.

4/ May include estimates for Thailand and Myanmar.

Table 2.a. Sources of Deforestation in Tropical Countries, 1981-1988 a/

	Brazil	Indonesia b/	Cameroon	All Major Tropical Forest Countries
Forestry	2 d/	9	0	2 (10) e/
Agriculture	89	80	100	(83) f/
shifting cultivators c/	13 (23)	59 (67)	92 (95)	na (47)
permanent agriculture:	76	21	8	36
- pastures	40	0	0	17
- permanent crops	4	2	5	3
- arable land	32	19	3	16
Mining and related industries	<3	<0.3	0	na
Hydroelectric production	4 b/	0	0	2 b/
Residual g/	2	11	0	(13) h/

Notes: a/ Percentage shares in deforestation refer to averages for the respective period.
b/ Data refer to the 1980-1990 period.
c/ Figures in parentheses show the results of the FAO for 1980. These data include also market oriented farmers who produce cash and export crops and engage only partly in shifting cultivation.
d/ Deforestation due to logging is due to charcoal production.
e/ The figure in parentheses refers to the estimation of Enquete-Kommission zum Schutz der Erdatmosphäre, *Schutz der tropichen Wälder*, Deutscher Bundestag 11, Wahlperiode, Drucksache 11/7220, 24.05.1990, Bonn, 1990. The calculation includes only Indonesia and Brazil, since these countries account for the largest share in clear cutting by the forestry sector.
f/ This percentage rate is based on the assumption that the percentage share calculated for shifting cultivators can be taken as an average for the 1981-1988 period.
g/ This includes other industries, housing, infrastructure services and fire loss.
h/ The residual has been calculated from the data in this column which includes data from different periods.

Table 2.b. Sectoral Share in Forest Degradation and Forest Modification, 1981-85 a/

	Percentage Share in Biomass Reduction (Degradation)				Percentage Share in Forest Modification			
Sector	Brazil	Indonesia	Cameroon	Total b/	Brazil	Indonesia	Cameroon	Total b/
Forestry	6	44	10	10	(100) c/	(100) c/	98	71
Agriculture d/	85	49	90	76	0	0	2	26
Others d/	9	7	0	13	0	0	0	4

Notes: a/ For the definition of modification and biomass reduction (degradation) see FAO, *Tropical Forest Resources*, FAO Forestry Paper 30, Rome, 1982.
b/ Total refers to all major rain forest countries.
c/ Following FAO statistics, deforestation in virgin forests is 0, since clearing by agriculture and other sectors concentrates on disturbed forests. Even though some clearing occurs in virgin forests, there is reason to assume that the bulk of deforestation is due to forests that have been logged over prior to the clearing of the respective areas.
d/ These figures have been derived from Table 2.a and reflect averages for the 1981-1988 period or, in the case of Indonesia, the 1980-1990 period.

Source: Amelung and Diehl, 1992.

3.a. Forest Areas in Major South East Asian Tropical Timber Countries (sq km) a/

	Total Land Area	Total Forest Area	Permanent Protection Forest	Permanent Production Forest	Conversion Production Forest	Total Production Forest	Remaining Virgin Forest
Thailand	513,115	142,958	NA	NA	NA	NA	NA
Malaysia							
Peninsular	131,596	63,532	10,679	34,507	9,100	43,607	9,600
Sabah	73,711	44,869	6,000	29,984	4,080	34,064	7,815
Sarawak	123,253	94,384	24,200	32,400	37,784	70,184	50,387
Philippines	300,000	63,830	16,800	44,030	0	44,030	10,420
Papua New Guinea	468,860	359,900	NA	NA	NA	NA	NA
Indonesia	1,930,270	1,439,700	490,410	338,666	305,370	644,036	524,000
Total	3,540,805	2,209,173	548,089	479,587	356,334	835,921	602,222

Notes: a/ Based on P.F. Burgess, "Asia", Chapter 5 in D. Poore *et al.*, *No Timber Without Trees: Sustainability in the Tropical Forest*, Earthscan Publications, London, 1989.

3.b. Production and Yield Potential in Major South East Asian Tropical Timber Countries a/

	Permanent Production Forest (million ha)	Sustained Yield at 1.5 m^3 per year	Sustained Yield at 2.0 m^3 per year	Annual Timber Harvest (m^3)
Malaysia				
Peninsular	2.85 b/	4,275,000	5,700,000	7,914,328
Sabah	3.00	4,500,000	6,000,000	11,739,262
Sarawak	3.24	4,860,000	6,480,000	11,470,000
Philippines	4.40	6,600,000	8,800,000	3,433,774
Indonesia	33.87	50,805,000	67,740,000	28,500,000
Total	47.36	71,040,000	94,720,000	63,057,364

Notes: a/ Based on P.F. Burgess, "Asia", Chapter 5 in D. Poore *et al.*, *No Timber Without Trees: Sustainability in the Tropical Forest*, Earthscan Publications, London, 1989.

b/ The author does not explain the discrepancy between Tables 3.a and b over the size of the permanent production forest in Peninsular Malaysia.

3.c. Production and Trade of Wood Products in Major South East Asian Tropical Timber Countries a/

(1989 '000 m³)

	Products	Production	Imports	Exports	ADC b/
Indonesia	logs	23,684.0	0.0	0.0	23,684.0
	sawnwood	10,546.0	0.0	2,692.0	7,854.0
	plywood	8,500.0	0.0	8,040.0	460.0
	veneer	53.9	0.0	29.0	24.9
Malaysia	logs	38,900.0	10.0	21,100.0	17,810.0
	sawnwood	7,660.0	197.0	5,134.0	2,723.0
	plywood	1,001.0	15.0	915.0	101.0
	veneer	445.0	5.3	248.7	201.6
Papua New Guinea	logs	1,700.0	0.0	1,260.0	440.0
	sawnwood	118.0	0.0	3.0	115.0
	plywood	18.0	0.0	0.0	18.0
	veneer	0.0	0.0	0.0	0.0
Philippines	logs	2,773.0	393.5	6.0	3,160.5
	sawnwood	975.0	12.0	438.1	548.9
	plywood	341.0	3.0	130.9	213.1
	veneer	75.0	0.0	53.1	21.9
Thailand	logs	1,770.0	1,135.0	0.0	2,905.0
	sawnwood	1,160.0	744.0	30.0	1,874.0
	plywood	185.0	4.0	35.0	154.0
	veneer	60.0	2.0	5.0	57.0
Total SE Asia Producers	logs	68,827.0	1,538.5	22,366.0	47,999.5
	sawnwood	20,459.0	953.0	8,297.1	13,114.9
	plywood	10,045.0	22.0	9,120.9	946.1
	veneer	633.9	7.3	335.8	305.4
Total ITTO Producers c/	logs	126,967.0	2,536.7	25,749.2	103,754.5
	sawnwood	48,846.0	1,083.5	9,518.1	40,411.4
	plywood	12,115.6	59.2	9,565.2	2,609.6
	veneer	1,705.7	42.5	555.5	1,192.7
Total World Producers d/	logs	1,677,454	130,230	124,846	1,682,838
	sawnwood	500,685	100,231	99,088	501,828
	wood panels e/	129,108	28,692	28,443	129,357

Notes: a/ Based on International Tropical Timber Council, *Elements for the 1990 Annual Review and Assessment of the World Tropical Timber Situation*, Tenth Session, Quito, Ecuador, 29 May - 6 June, 1991.

b/ ADC = Apparent domestic consumption.

c/ ITTO = International Tropical Timber Organization.

d/ All tropical and temperate timber producers, derived from FAO, *Forest Products Yearbook 1989*, Rome, 1991.

e/ Includes veneer sheets, plywood, particle board and fibreboard (compressed and non-compressed).

Table 4. Export Taxes and Bans on Tropical Timber, South East Asia, 1989

Country	Tax Rate/Export Policy	Remarks
Indonesia	20% *ad valorem* on logs	Tax imposed only on some logs in inaccessible regions. Log export ban since 1985 has made the tax irrelevant for other regions.
	Specific export taxes on sawn timber, ranging from US $250-2400 per m^3.	Specific export taxes on sawn timber introduced in 1989; plywood exempt from all export taxes.
Malaysia:		
Peninsular	Log export ban since 1971.	
Sabah	No specific export tax or ban but see remarks.	The Sabah timber royalty has a strong export tax feature: the royalty rate for log exports is almost 10 times the rate for logs used domestically.
Sarawak	15% *ad valorem* of f.o.b. log values	Tax applies to one hardwood species only.
Papua New Guinea	10% of f.o.b. log values	Tax reported to have been widely evaded through transfer pricing. Log export ban proposed.
Philippines	Log exports restricted to 25% of annual allowable cut since 1979.	Ostensibly to control deforestation.

Source: Gillis (1990).

Table 5. Indonesia - Timber Trade Simultaneous Equation System and Deforestation Equation

1. Roundwood Market

$$QLI = 30868.4 + 0.172*(RPXLI-XTLI-ROYLI) - 0.433*CSTLI$$
(2.43) (2.59) (-1.1)

t = 1968-84
SE = 5534.3
DW = 0.76

$$XLI = -165246.2 - 34562.3*(RPXLI/(PLTENC*EXR)) - 4.74*YPCML + 1.397*POPML$$
(-2.64) (-2.03) (-1.51) (2.83)

t = 1968-84
SE = 6131.6
DW = 0.89

$$CONLI = 2513.5 + 2.09*QSWI + 1.43*QPWI$$
(0.96) (2.08) (1.43)

t = 1968-88
SE = 3679.5
DW = 0.86

2. Sawnwood Market

$$QSWI = 776.3 + 0.011*RPXSWI + 0.427*CAPSWI - 0.021*(CSTSWI+RPXLI-XTLI)$$
(1.32) (2.00) (3.94) (-1.41)

t = 1968-88
SE = 702.8
DW = 1.53

$$XSWI = -2149.3 - 0.029*(JEXR*RPXSWI) + 68.27*JAPIND - 0.201*YPCMSW$$
(-2.24) (-1.96) (5.66) (-0.98)

t = 1974-88
SE = 315.5
DW = 2.13

$$CONSWI = -5914.5 - 0.106*RPXSWI + 0.000077*POPI + 34.6*GDFI - 0.209*INDVA$$
(-0.89) (-2.43) (1.19) (2.90) (-1.82)

t = 1968-88
SE = 452.8
DW = 1.63

3. Plywood Market

$$QPWI = 537.8 + 0.0042*(RPXPWI) + 0.706*(CAPPWI) - 0.008*(CSTPWI+RPXLI-XTLI)$$
(0.73) (1.41) (5.45) (-1.48)

t = 1975-88
SE = 371.3
DW = 1.75

$$XPWI = -43836.4 - 1537.9*(RPXPWI/(PHIPW*EXR)) + 0.943*YPCMPW$$
(-9.45) (-2.34) (4.71)

$$+ 0.148*POPMPW - 104.2*MFXUV$$
(8.33) (-6.65)

t = 1975-88
SE = 370.9
DW = 1.97

$$CONPWI = -7014.6 - 0.0033*RPXPWI + 0.000055*POPI$$
(--3.96) (-2.59) (4.16)

t = 1975-88
SE = 219.7
DW = 1.75

Deforestation Equation

$$LN(F/A) - LN(1-FA) = 0.875 - 5.695*LOGA - 0.013*POPD + 0.00037*GDPA + 0.997*D88$$
(4.45) (-1.98) (-5.82) (2.84) (4.40)

$R^2 = 0.51$
SE = 0.82
DW = 1.57

Table 5. Indonesia - Timber Trade Simultaneous Equation System and Deforestation Equation (cont.)

Dependent Variables

QLI	Industrial roundwood production ('000 m^3)
XLI	Industrial roundwood exports ('000 m^3)
CONLI	Apparent domestic log consumption ('000 m^3)
QSWI	Sawnwood and sleeper production ('000 m^3)
XSWI	Sawnwood and sleeper exports ('000 m^3)
CONSWI	Apparent domestic sawnwood and sleeper consumption ('000 m^3)
QPWI	Plywood production ('000 m^3)
XPWI	Plywood exports ('000 m^3)
CONPWI	Apparent domestic plywood production ('000 m^3)
F/A	Forest area(F) per total land area (A), km^2

Independent Variables

RPXLI	Log export prices (unit values) in domestic currency (Rp/m^3)
XTLI	Log export taxes (Rp/m^3)
ROYLI	Log royalties and other taxes (Rp/m^3)
CSTLI	Logging and log transport costs (Rp/m^3)
PLTENC	Average world price of temperate non-coniferous logs (US$/$m^3$)
EXR	Exchange rate, Indonesian Rupiah (Rp)/US$
YPCML	Average GNP per capita of Indonesian log importers (US$)
POPML	Average population of Indonesian log importers
RPXSWI	Sawnwood and sleeper export prices (unit values) in domestic currency(Rp/m^3)
CAPSWI	Sawmill capacity ('000 m^3)
CSTSWI	Total input sawmill costs (Rp/m^3)
JEXR	Exchange rate, Japanese yen (¥)/Rp
JAPIND	Japan - industrial production index 1985 = 100
YPCMSW	Average GNP per capita of Indonesian sawnwood importers (US$)
POPI	Indonesia - population
GDFI	Indonesia - GDP deflator index 1980 = 100
INDVA	Indonesia - industrial value added, Rp billion
RPXPWI	Plywood export prices (unit values) in domestic currency (Rp/m^3)
CAPPWI	Plymill capacity ('000 m^3)
CSTPWI	Total input plymill costs (Rp/m^3)
PHIPW	Export wholesale Tokyo spot price of Philippine (luan) plywood (US$/$m^3$)
YPCMPW	Average GNP per capita of Indonesian plywood importers (US$)
POPMPW	Average population of Indonesian plywood importers
MFXUV	Average world manufactures export unit values index 1980 = 100
LOGA	Roundwood production per total area ('000 m^3/km^2)
POPD	Population density (per km^2)
GDPA	GDP per capita ('000 Rp/km^2)
D88	Dummy variable for 1988

Statistical Data

t	Time period of the regression
SE	Standard error of the regression
DW	Durbin-Watson statistic
R^2	R-squared statistic

Notes All values are in constant (1980) prices; t-statistics are indicated in parentheses under the relevant coefficients.

Table 6. Comparative Price Elasticity Estimates for South East Asian Tropical Timber

	Time Period	Short Run	Long Run
1. This Study			
Indonesia - log supply	1968-84		0.20
Indonesia - log export demand a/	1968-84		- 1.51
Indonesia - sawnwood supply	1968-88		0.27
Indonesia - sawnwood domestic demand	1968-88		- 0.36
Indonesia - sawnwood export demand	1974-88		- 0.68
Indonesia - plywood supply	1975-88		0.31
Indonesia - plywood domestic demand	1975-88		- 0.91
Indonesia - plywood export demand b/	1975-88		- 0.46
2. Constantino (1988a) c/			
Indonesia - sawnwood export demand d/	See note	- 0.08	- 0.21
Indonesia - plywood export demand	1975-85	- 0.26	- 0.58
Importers - elasticity of subst., tropical and temperate sawnwood	1975-85	1.30	2.11
Importers - elasticity of subst., tropical and temperate plywood	1975-85	0.75	1.23
World - elasticity of substitution, source of origin, sawnwood	1979-85	2.50	4.39
World - elasticity of substitution, source of origin, plywood	1979-85	4.56	12.3
3. Vincent (1992) e/			
Peninsular Malaysia - log supply	1973-89		1.1
Peninsular Malaysia - sawnwood supply	1973-89		1.7
Peninsular Malaysia - sawnwood domestic demand	1973-89		- 0.55
Other tropical exporters - log export supply	1973-89		2.7
Other tropical exporters - sawnwood export supply	1973-89		0.7
Importers - tropical log demand	1973-89		- 1.59
Importers - tropical sawnwood demand	1973-89		- 5.67
4. Vincent (1989) f/			
Malaysia - log supply	1960-85		0.64
Malaysia - sawnwood supply	1960-85		1.00
Malaysia - plywood supply	1960-85		1.00
Malaysia - sawnwood domestic demand	1960-85		- 0.27
Malaysia - plywood domestic demand	1960-85		- 0.94
Other SE Asia exporters - log supply	1960-85		0.46
Other SE Asia exporters - sawnwood supply	1960-85		1.00
Other SE Asia exporters - plywood supply	1960-85		1.00
Other SE Asia exporters - sawnwood domestic demand	1960-85		- 0.53
Other SE Asia exporters - plywood domestic demand	1960-85		- 0.85
Importers - SE Asian and Malaysian sawnwood demand	1960-85		- 1.22
Importers - SE Asian and Malaysian plywood demand	1960-85		- 0.46

Table 6. Comparative Price Elasticity Estimates for South East Asian Tropical Timber (cont.)

Notes a/ Export price of Indonesian logs relative to average world price of termperate non-coniferous logs.

b/ Export price of Indonesian plywood relative to export wholesale spot price of Philippine (luan) plywood.

c/ Elasticity of substitution between sources of origin is defined as the percentage reduction in the ratio of imports from two different countries if the ratio of import prices of the two countries increases by one percent.

d/ Based on Buongiorno (1979) for coniferous sawnwood.

e/ Elasticities based on Cardellichio *et al.* (1989). Note that in the latter study, Indonesian sawnwood and plywood supply are both estimated to have elasticities of 0.7, and Indonesian sawnwood and plywood domestic demand have own-price elasticities of - 0.92 and - 1.55 respectively.

f/ Elasticities for sawnwood and plywood supply were assigned a value of one in the analysis.

Table 7. Indonesia - Timber Trade and Tropical Deforestation Simulation Model

Base Case (1988)

Key Variables	Base Case 1988 Values	Actual 1988 Values
1. Prices (Rp/m^3)		
Log border-equivalent price (unit value)	36,714	NA a/
Sawnwood export price (unit value)	333,930	262,013
Plywood export price (unit value)	458,179	464,124
2. Quantities ('000 m^3)		
Log production	28,766	29,819
Log domestic consumption	28,480	28,887
Sawnwood production	9,351	10,290
Sawnwood exports	2,923	3,083
Sawnwood domestic consumption	6,427	7,207
Plywood production	7,770	7,733
Plywood exports	6,383	6,372
Plywood domestic consumption	1,387	1,361
3. Deforestation (km^2)		
Total forest area	1,401,163	1,401,144
Annual rate of deforestation a/	13,150	13,150

Notes: a/ No data available
b/ Not calculated in simulation model but based on Schmidt (1990). See Table 1.

Table 8. Indonesia - Timber Trade and Tropical Deforestation Simulation Model

Policy Scenario - Sawnwood Export Tax (% Change over Base Case)

Key Variables	10% Tax	50% Tax	100% Tax	250% Tax	700% Tax
1. Prices (Rp/m³)					
Log border-equivalent price (unit value)	- 0.70%	- 3.35%	- 6.39%	- 14.07%	- 29.03%
Sawnwood export price (unit value)	- 0.98%	- 4.72%	- 9.01%	- 19.84%	- 40.93%
Plywood export price (unit value)	- 0.05%	- 0.23%	- 0.44%	- 0.97%	- 2.00%
2. Quantities ('000 m³)					
Log production	- 0.16%	- 0.77%	- 1.47%	- 3.23%	- 6.66%
Log domestic consumption	- 0.15%	- 0.74%	- 1.42%	- 3.12%	- 6.44%
Sawnwood production	- 0.33%	- 1.58%	- 3.01%	- 6.64%	- 13.69%
Sawnwood exports	- 2.26%	- 10.89%	- 20.79%	- 45.79%	- 94.47%
Sawnwood domestic consumption	0.55%	2.66%	5.07%	11.17%	23.06%
Plywood production	0.01%	0.07%	0.13%	0.29%	0.60%
Plywood exports	0.01%	0.03%	0.06%	0.13%	0.26%
Plywood domestic consumption	0.05%	0.25%	0.48%	1.06%	2.18%
3. Deforestation (km²)					
Total forest area	0.00% a/	0.02%	0.03%	0.06%	0.13%
Annual rate of deforestation	- 0.3%	- 1.60%	- 3.06%	- 6.73%	- 13.88%

Notes: a/ A negligible increase over the base case forest cover of 44 sq km.

Table 9. Indonesia - Timber Trade and Tropical Deforestation Simulation Model

Policy Scenario - Import Ban and Revenue Raising Taxes (% Change over Base Case)

Key Variables	**Total Import Ban a/**	**1% Revenue Raising Import Tax b/**	**5% Revenue Raising Import Tax d/**
1. Prices (Rp/m³)			
Log border-equivalent price (unit value)	--	- 0.17%	- 0.82%
Sawnwood export price (unit value)	--	- 0.11%	- 0.54%
Plywood export price (unit value)	—	- 0.21%	- 1.03%
2. Quantities ('000 m³)			
Log production	- 28.33%	- 0.04%	- 0.19%
Log domestic consumption	- 27.37%	- 0.04%	- 0.18%
Sawnwood production	- 10.64%	- 0.03%	- 0.14%
Sawnwood exports	- 100.00%	- 0.23%	- 1.12%
Sawnwood domestic consumption	30.01%	0.06%	0.30%
Plywood production	- 43.84%	- 0.04%	- 0.22%
Plywood exports	- 100.00%	- 0.10%	- 0.51%
Plywood domestic consumption	214.51%	0.23%	1.12%
3. Deforestation (km²)			
Total forest area	--	0.00% c/	0.01%
Annual rate of deforestation	--	- 0.41%	- 0.72%

Notes:

a/ Large price changes were used deliberately to constrain sawnwood and plywood exports to zero in this simulation and therefore are no longer endogenously generated by the model. Also, the functional form of the deforestation equation and its estimation using regional panel data imply that the large changes in log production associated with the import ban scenario cannot be used to predict reliablely the effects on forest cover and deforestation. Thus both price and deforestation effects are eliminated from this policy scenario simulation.

b/ A total of US$23.1 million (1980 prices) in revenue would be raised, with US$5.8 million and US$17.3 million from Indonesian sawnwood and plywood exports respectively.

c/ A negligible increase over the base case forest cover of 53 sq km.

d/ A total of US$113.9 million (1980 prices) in revenue would be raised, with US$28.5 million and US$85.4 million from Indonesian sawnwood and plywood exports respectively.

Table 10. **Indonesia - Timber Trade and Tropical Deforestation Simulation Model**

Policy Scenario - Sustainable Timber Management (% Change over Base Case)

Key Variables	25% Rise in Harvest Costs	50% Rise in Harvest Costs
1. Prices (Rp/m^3)		
Log border-equivalent price (unit value)	41.59%	83.06%
Sawnwood export price (unit value)	4.04%	8.09%
Plywood export price (unit value)	2.86%	5.72%
2. Quantities ('000 m^3)		
Log production	- 0.94%	- 1.87%
Log domestic consumption	- 1.37%	- 2.73%
Sawnwood production	- 1.89%	- 3.77%
Sawnwood exports	- 1.03%	- 2.05%
Sawnwood domestic consumption	- 2.28%	- 4.55%
Plywood production	- 0.87%	- 1.73%
Plywood exports	- 0.38%	- 0.75%
Plywood domestic consumption	- 3.12%	- 6.24%
3. Deforestation (km^2)		
Total forest area	0.02%	0.04%
Annual rate of deforestation	- 2.28%	- 4.23%

Notes

1. This Paper is based on Annex I 'The Timber Trade and Tropical Deforestation - Indonesia' by Barbier *et al.* 1992 in 'The Economic Linkages between the International Trade in Tropical Timber and the Sustainable Management of Tropical Forests' by Barbier *et al.* 1993.

2. Barbier (1987) points out that much of the reported decline in log production over the initial period 1979-82 can be attributed to depressed world prices for all timber products, and therefore, was not necessarily attributable to less exploitation because of increased processing activities. Moreover, there has always been a discrepancy between officially reported harvesting levels and rates based on processing industry output. For example, official logging statistics suggested that total log production peaked, before the ban in 1985, at around 25.3 million m^3 per year and declined initially with the ban. In contrast, estimates of log demand based on processing industry output, capacity and conversion rates indicate that log demand reached 27.3 million m^3 per annum soon after the ban, and of course *continues to increase as capacity and output expands.*

3. The time series and cross-sectional data used in estimating these relationships and constructing the model came from a variety of sources, including World Bank, FAO, IMF and GoI publications, and previous studies on the Indonesia forestry sector cited in this Paper.

4. The main importers of Indonesian logs over 1968-84 were China, Hong Kong, Japan, Korea and Singapore.

5. Given that Indonesian sawnwood and plywood are tradeables, the assumption that domestic and export prices of these product are highly correlated over time seems reasonable. This is confirmed by the limited time series data available on both export and domestic prices.

6. The main importers of Indonesian plywood over 1975-88 were China, Hong Kong, Japan, Singapore and USA. The main importers of Indonesian sawnwood over 1974-88 were China, Hong Kong, Italy, Japan, Korea, Malaysia, the Netherlands, Singapore, Thailand and UK. Given the predominance of Japan and its main South East Asian newly industrializing competitors among these importers, the Japanese/Indonesian exchange rate and Japanese industrial activity proved to have strong explanatory power in the demand for Indonesian sawnwood exports (see Table 5).

7. However, because the price of logs was represented by log export unit values, it is only included in the estimation for the period before the ban, 1968-84.

8. Twenty provinces selected, spread over the Indonesian islands of Sumatra, Kalimantan, Sulawesi, Maluku, Irian Jaya, and Nusa Tenggara. Data were available for the years 1973, 1979, 1981, 1982, 1984 and 1988.

9. As some of the instrumental variables were highly correlated, the list of instruments included in each two-stage regression was sometimes modified.

10. Indonesia's real GNP per capita in 1988 (1980 prices) was approximately US$230. A rise in income reflects economic development and may be associated with reduced pressure on deforestation in a number of ways: i) through an increasing concentration of the population in urban centres which reduces the direct pressure of rural populations og tropical forests; ii) through changing the composition of the economy from being based on primary extractive industries (i.e. timber, agriculture, etc) to industrial processing and service based industries; and iii) through improved efficiency and management of resource use which may accompany economic development, again reducing the indirect pressure of natural resource consumption on tropical forests.

11. In the simulation model, the log domestic demand equation is therefore CONLI = 77.95 + 1.5*QSWI + 1.85*QPWI. A comparison with the regression for CONLI of Table 5 indicates that, by the mid-1980s, recovery rates for sawmills in Indonesia had improved slightly, whereas they had deteriorated somewhat for plymills. This seems reasonable intuitively, given that by the 1980s the expansion in sawmill capacity as the GoI attempted to improve efficiency and quality, whereas plymill capacity was deliberately encouraged to expand.

12. For a review of the arguments, see Barbier *et al.* (1992).

13. The UCBT countries are Belgium, Denmark, France, Germany, Luxembourg, the Netherlands and the United Kingdom.

14. One problem is that the scale of financing required may be well beyond what can be raised from either an import or export surcharge levied on the trade. For example, Agenda 21 of the UN Conference on Environment and Development has estimated that international of over US$1.5 billion annually will be required by tropical forest countries to reduce deforestation (ITTC 1992).

15. *Trespass* is a forestry term that refers to losses due to logging theft, which could also be extended to include losses due to graft. *High-grading* refers to the removal of high-valued timber and leaving a degraded timber stand.

The London Environmental Economics Centre (LEEC) is now known as the Environmental Economics Programme, at the International Institute for Environment and Development. The former name dates from 1987 when the Centre was established by IIED and the Economics Department of University College, London.

Today, all environmental economics staff and research projects are based at IIED where the Programme has become a core area of Institute activity.

The Environmental Economic Programme conducts economic research and policy analysis for improved management of natural resources and sustainable economic growth in the developing world.

iied

International Institute of Environment and Development
3 Endsleigh Street, London WC1H 0DD
Tel: 0171-388 2117 Fax: 0171-388 2826