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1. Introduction

The overutilization of forest resources, which is currently taking place in most tropical countries, is the result of two main factors driving a wedge between private and social costs of forest use: *market failure* and *policy failure* (Barbier et al., 1992). Market failure is due to the fact that tropical forests do not only supply timber and land for agricultural conversion but also provide ecological benefits, which because of their public good properties or lacking property rights do not enter into the user's decision making process. Some of these ecological benefits, such as the protection of soils against erosion and nutrient losses, affect only the tropical countries themselves, while others, notably the fixing of carbon and the provision of habitat for a large share of the world's biological diversity, accrue to the whole world. Hence, local as well as global externalities have to be considered. Moreover, ecologically harmful government activities frequently exacerbate the pressure on tropical forests (Repetto, Gillis, 1988). These policy failures range from subsidized settlement schemes to the protection of domestic wood processing industries. Macroeconomic policies, such as trade or exchange rate policies, may as well have a significant indirect impact on deforestation (Capistrano, Kiker, 1990; Thiele, Wiebelt, 1993b).

Since different factors contribute to the suboptimal forest utilization and since different economic sectors, particularly agriculture and forestry, use forest resources, a policy package may be required, which combines the removal of domestic distortions with national resource policy measures and international measures. This paper quantitatively investigates such policy measures for the case of Indonesia by calculating their effects on aggregate output, economic structure as well as on the utilization of forest resources. For this purpose, a computable general equilibrium (CGE) model was developed, which - contrary to a partial equilibrium approach - captures the economy-wide repercussions of sectoral policies and hence allows for conclusions about structural responses and the change in land use patterns. The ultimate objective of the analysis is to sort out policy packages, which simultaneously protect tropical forests and stimulate an efficient resource allocation.

The structure of the paper is as follows. Section 2 outlines the major policy options which are available for the Indonesian government. Section 3 explains the main features of the CGE model, putting particular emphasis on the treatment of the forestry sector. This section also includes a short description of the numerical specification of the model. Section 4 presents the results of the policy simulations for Indonesia. The paper closes with some concluding remarks.

2. Policy Options[1]

Any policy package for a better management of Indonesia's tropical forests has to aim at two different users, namely the timber industry and agriculture,[2] and should contain measures to correct for market failure at the local and global level as well as policies to correct for policy failure. Moreover, one can argue that even such distortions which might be regarded as environmentally friendly - e.g., the taxation of agricultural exports - should be removed in order to achieve efficiency gains and to approximate a first-best starting point for the application of environmental policy instruments.

The creation of adequate property rights is the first step towards internalizing the local externalities of deforestation. In the timber industry, the contractual arrangements for concessionaires have to be improved. One possibility is to base the duration of logging concessions for the state-owned Indonesian forests on the regeneration period of about 35 years, whereas the licences are currently given for 20 years only (Gillis, 1988). Other arrangements, such as conditioning the continuation of short-term contracts on "sustainable" harvesting practices or even the outright sale of the land, could also be applied (Barbier et al., 1992). In any case, the licences should be tradable to provide an incentive for the concessionaires to maintain the value of their timber stands (Repetto, 1988). For the agricultural sector, the establishment of a land market on the Outer Islands is of utmost importance. This would make large areas of underutilized or degraded land on the Outer Islands, which is currently claimed by the local population, available for settlers and thereby would reduce the necessity to clear additional forested areas (World Bank, 1990).

With secure property rights, the remaining external costs can be internalized by means of price or quantity measures. A first-best example of the former is a tax on the use of tropical forest land, because it is levied - as suggested by the theory of domestic distortions (Corden, 1974) - exactly at the point where the externality occurs. Since logging is ecologically less harmful than agricultural conversion and since the cultivation of tree crops like coffee and rubber causes less damage than the cultivation of food crops like rice and cassava (Repetto, 1989), there is a rationale for differentiated tax rates. An alternative way of narrowing the gap between the private and social costs of deforestation is to fix upper limits for the use of forest resources. The government could either reduce the allowable cut under the Indonesian

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1 This section only provides a short overview of the policy options for a more sustainable management of Indonesia's tropical forests. For a more detailed discussion, see Thiele (1994).

2 Agricultural conversion of forest land on the Outer Islands of Indonesia is partly due to government-sponsored settlement and partly due to shifting cultivation (FAO, 1991). Other economic activities, such as the exploitation of minerals and the construction of hydroelectric power plants are not significantly contributing to deforestation in Indonesia.

selective logging system[3] or directly set aside areas, e.g., by establishing national parks. National parks should be located on areas with rich biodiversity and low quality soils which are not suitable for agricultural use. As a prerequisite for the achievement of such an allocation, the government has to carry out a detailed land use planning (Thiele, 1994).

If all local external costs of deforestation are accounted for, the timber concessionaire is still making an economic rent. The government can capture all or part of the rent through fees and taxes (Gray, Hadi, 1990). Low rent capture causes a problem because high excess profits encourage "rent seeking" in acquiring concessions and open the way for corruption. Moreover, low forest fees underprice timber and thus allow inefficient and wasteful logging and processing. The underpricing of timber is further aggravated by an aggressive promotion of domestic wood processing (Barbier et al., 1992). In 1985, Indonesia introduced a log export ban, which was followed by nearly prohibitive export taxes on rough and semi-processed sawnwood in 1989. As it is likely that these trade restrictions have resulted in both economic losses and a waste of forest resources they should be relaxed.

The most powerful incentives for agricultural conversion of forest areas result from the Indonesian Transmigration Program where the government carries all cost of resettling people from the Inner to the Outer Islands. Agricultural production on transmigration sites has traditionally been dominated by low-input cultivation of food crops, especially rice, but recently the planting of tree crops has also been sponsored (World Bank, 1990). Taking the very limited economic potential of food crop production on converted forest land on the one hand and the high direct cost of transmigration as well as the ecological cost of deforestation on the other hand, the Indonesian government should not continue to sponsor food crop production on transmigration sites. If the government regards some transmigration as necessary to ease population pressure in the Inner Islands, it should concentrate on tree crop development, because tree crop schemes promise higher income for transmigrants and lower ecological costs in terms of soil erosion and loss of biodiversity. Moreover, there is a high potential to increase yields per hectare which would make it possible to reduce the conversion of forests without foregoing tree crop production (World Bank, 1990).

General agricultural policies, which may have a significant indirect impact on deforestation, contain two dominant components (Gonzales et al., 1993). First, the government stabilizes the output price of the main staple rice. In general, the government has been successful in keeping domestic prices in line with world market prices while counteracting short-run fluctuations in the world price. Second, essential agricultural inputs like irrigation, fertilizer and pesticides are heavily subsidized. Agricultural trade restrictions do prevail but import tariffs and export taxes, which are imposed on some cash crops, are fairly low. Trade in

[3] The objective of the selective logging system is to account for the renewability of the Indonesian tropical forest in order to achieve a sustained yield of wood products. It has so far shown a poor record, primarily because of high logging damage and relogging before the end of the harvesting cycle (Gillis, 1992).

general has been liberalized stepwise since 1983, starting from a situation with high import tariffs and numerous quantitative restrictions such as quotas and import licenses which is characteristic of an import-substitution strategy (Balassa, 1991). Altogether, there is still room for Indonesia to move towards a more neutral incentive structure.

For the internalization of the global external costs of deforestation, i.e., climate change and the loss of biodiversity, two broad categories of instruments are available: import restrictions for tropical hardwood and international compensation payments for the conservation of tropical forests (see, for instance, Barbier et al., 1992).

Import restrictions for tropical hardwood have the advantage that they can be applied directly without any prior bargaining. However, their ecological effectiveness is not guaranteed. A necessary condition for import restrictions to be effective is that the tropical country - as Indonesia does - exports a substantial share of the forestry output. This has to be weighed against the fact that in Indonesia not only the timber industry but also agriculture is a major user of tropical forest resources. It may well turn out that as a result of lower profitability in the timber industry the conversion of land for agricultural use will increase to such an extent that the damage for the tropical forest will be higher than without any policy intervention. Import restrictions have at least three additional disadvantages. First, they have adverse distributional consequences by shifting nearly all the adjustment costs to the tropical countries. Second, they make any complementary protective measures in the tropical countries unlikely. Finally, import restrictions are inferior to national resource policies from a welfare theoretic point of view, because they imply additional deadweight losses by distorting consumption (Braga, 1992).

Compensation payments build on the cooperation between industrial and tropical countries, because they rely on complementary national environmental policy measures. Contrary to development aid, they should not be interpreted as a grant but as a payment for an environmental service (Amelung, Diehl, 1992). The theoretical reference point for the amount of money spent is the gap between the economic losses for the developing country caused by the implementation of a resource policy and the ecological benefits accruing to the developing country through the conservation of its forests (Amelung, 1991). The actual payments will, however, crucially depend upon the bargaining power of the parties involved in the treaty. Since most of the global public benefits are derived by the developed countries, they are in a weak bargaining position with respect to the shrinking rain forests (Sandler, 1993). Furthermore, it has to be decided how the transfer should be used. In order to be effective in compensating the net losers of forest conservation, the transfer must contain some kind of conditionality, e.g., the prescription that the funds have to be invested in the creation of new employment opportunities outside the tropical forest.

The aforementioned measures to reduce market and policy failure will be empirically analyzed with respect to their consequences for the economy and the use of tropical forest resources. But first, the main characteristics of the model have to be described.

3. The Model

The model applied in the simulation analysis is a standard trade-oriented CGE model as described in Dervis et al. (1982), extended by a submodel for the forestry sector (Dee, 1991).[4] A major advantage of the multisectoral approach is that it captures the impacts of different policy measures on land use patterns. This is important, because the question of whether forests should be logged, or left as protected areas, or cleared entirely for agricultural use, is primarily a question of land use allocation. The forestry submodel enables us to examine the conventional forestry policy measures like resource taxes, secure property rights, selective logging regimes, and the setting up of national parks.

3.1 The Forestry Submodel

The treatment of the forestry sector is closely related to the forest economics literature. The traditional economic problem is to find the rotation period[5] that maximizes the present value of net returns from the current and all future harvests, at given timber prices, harvesting costs, interest rates, and physical growth characteristics of trees (Bowes, Krutilla, 1985). While the traditional model does not take into account the environmental services provided by the forest, we do so by constraining harvests via the introduction of a minimum harvest age T^* (Nguyen, 1979). By means of such a selective logging regime the government can ensure that a certain minimum timber stock remains after each harvest. In the modified model, foresters choose the optimal harvest age T so as to maximize

$$PV(T) = \frac{RR \cdot e^{-r(T-T^*)}}{1-e^{-r(T-T^*)}}, \qquad (1)$$

where PV is the present value of net returns per hectare, RR is the net return per hectare per rotation, T-T^* is the rotation period, and r is the discount rate applied by the concessionaire.[6] The first-order condition of the maximization problem is given by

$$RR' = \frac{r \cdot RR}{1-e^{-r(T-T^*)}}, \qquad (2)$$

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4 Thiele, Wiebelt (1993a) present a detailed formal description of the model.

5 The rotation period is the length of time between two harvests on a specific area (here on one ha).

6 Note that $1/\left(1-e^{-r(T-T^*)}\right)$ is equal to the infinite sum $1+e^{-r(T-T^*)}+\left(e^{-r(T-T^*)}\right)^2+\ldots$, i.e., we assume an infinite planning horizon.

with $RR = \left(P_x \cdot HV - RC\right) \cdot \left(1 - t_F\right)$ (2a)

and $RR' = \partial RR / \partial T = P_x \cdot \partial HV / \partial T \cdot \left(1 - t_F\right)$, (2b)

where HV denotes the volume of timber harvested per hectare per rotation, P_x the output price of timber, RC the harvest costs per hectare per rotation, and t_F a factor tax on forest land.

The interpretation of the first-order condition is that foresters should harvest at the age T or, equivalently, choose the rotation period T-T^*, at which the marginal increase in net revenues from further growth of the forest (RR') just equals the opportunity cost of delaying the harvest. The opportunity cost is the potential interest income foregone on the delayed receipt of harvesting revenues. The correction term $1/\left(1 - e^{-r(T-T^*)}\right)$ accounts for the fact that, if the rotation period is extended, not only the current harvest but also future harvests are postponed.

The comparative static properties of the forestry model are as follows. First, equation (2) reveals that an increase in the discount rate, which may be attributed to more insecure property rights for concessionaires, raises the opportunity costs of letting trees grow and hence leads to a shorter rotation period. Second, a rise in the timber output price raises both the marginal revenues from further growth and the opportunity costs. Using the definitions (2a) and (2b), it becomes obvious that , with positive harvesting costs, the increase in RR is stronger than that in RR' so that the rotation period shortens. Finally, higher harvesting costs reduce opportunity costs, leading to an extension of the rotation period.

The physical growth of trees is described by a logistic functional form (Figure 1).[7] Initially, trees grow very rapidly. Slower growth sets in as the stand matures, until growth stops when the climax state (MV) is reached. At any chosen rotation period, the physical growth characteristics of trees determine the volume of timber that can be harvested per hectare per rotation. This can be discerned from Figure 1. Assume that the initial rotation period was $T_o - T^*$. This corresponds to a harvest size of $TV_o - SV$, where TV denotes the volume of timber per hectare before the harvest, and SV the minimum volume of timber that has to be left as a result of the minimum harvest age T^*. Now assume that the forestry sector is forced to shorten the rotation period to $T_1 - T^*$. As a consequence, the harvested volume per rotation is reduced to $TV_1 - SV$.

Logging technology is described by a Leontief function which combines land and a non-land input bundle consisting of capital, labor and intermediate inputs at the top of a multi-level

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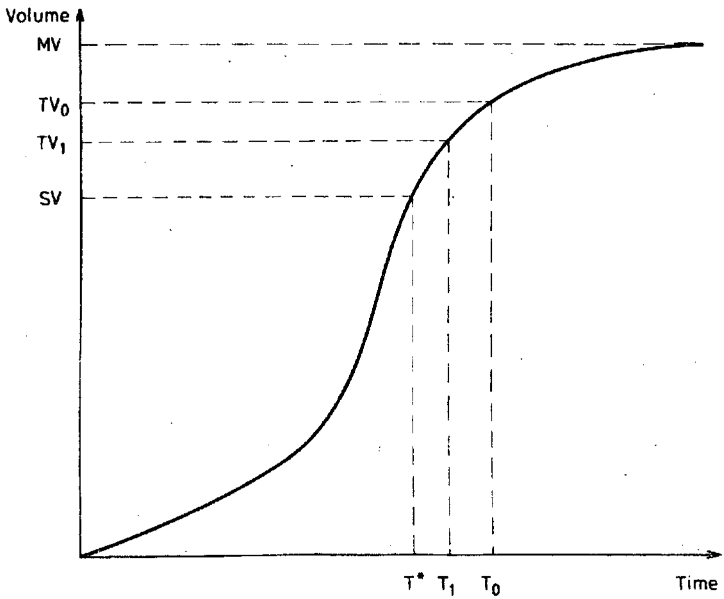
7 The assumption of a logistic growth curve is common in the literature on renewable resources (e.g. Wilen, 1985; Clark, 1990).

Figure 1 - Logistic Growth Curve of Trees



production function. It is assumed that the bundle of non-land inputs is fixed per rotation, which gives rise to a form of increasing returns to scale (Dee, 1991). Within the input bundle, substitution possibilities between labor and capital and between imported and domestically produced intermediates are allowed.

Since the harvest volume HV above is defined per hectare per rotation, it has to be translated into annual output for the entire forest in order to make the forestry submodel compatible with the rest of the model. Assuming that the harvest per rotation is equally distributed over the years of the rotation period, annual timber output X from the whole harvested area B is

$$X = HV \cdot B / (T - T*). \qquad (3)$$

3.2 The Rest of the Model

The rest of the model follows conventional lines. Domestic supply of all sectors except forestry is given by a constant-returns Cobb-Douglas production function, using labor, land (in agriculture), and sector-specific capital, which is fixed in the short run. A Leontief function combines the aggregate of primary factors and intermediate inputs. The producers in each sector choose their demand for labor (and land in agriculture) and their output so as to maximize profits at the given wage rates, factor taxes, land prices, commodity prices and capital stocks.

Regarding foreign trade, Indonesia is assumed to be a small country not able to influence world market prices. While this is in accordance with classical trade theory, we deviate from its assumptions in some other respects. First, domestically produced goods and imports of the same product category are regarded as imperfect substitutes. The substitution possibilities for domestic consumers are described by a CES (Constant Elasticity of Substitution) function (Armington, 1969). In a similar way, differences in quality between domestically consumed and exported commodities are described by a CET (Constant Elasticity of Transformation) function (Powell, Gruen, 1968). Finally, Indonesia's exports are specified as facing a constant elasticity demand function. This formulation takes account of the fact that as domestic production costs of a commodity rise (fall) relative to those abroad, the country may loose (gain) foreign market shares.

In the household sector, it is assumed that there is only one representative consumer who buys consumer goods according to fixed expenditure shares. This demand system is derived from the maximization of a Cobb-Douglas utility function. Government demand for final goods is defined using fixed shares of aggregate real spending on goods and services. The sectoral allocation of investable funds is determined by exogenously given share parameters. Inventories are a fixed proportion of sectoral supply.

In order to solve the CGE model, market clearing equations for the product and factor markets as well as macroeconomic equilibrium conditions for the balance of payments and the savings-investment balance have to be specified. Supply and demand in product markets is equilibrated by the adjustment of sectoral prices. For the factor markets we assume that the supply of each factor is exogenously fixed.[8] Market clearing requires that total factor demand equals supply, and the equilibrating variables are the average factor prices. While sectoral capital stocks are assumed to be fix, labor is intersectorally mobile. In agriculture, production in the Inner and Outer Islands is distinguished (see Section 3.3) Land is mobile across all agricultural activities and forestry, but not between the two regions. With foreign savings set exogenously, equilibrium in the balance of payments is achieved via adjustments in the real exchange rate. Changes in the real exchange rate are the result of movements in the nominal exchange rate, while the absolute price level serves as the numeraire of the model. Finally,

[8] With respect to land, the assumption of an exogenously fixed aggregate supply seems to be justified for Indonesia. In the Inner Islands, especially in Java, there are virtually no land reserves for agricultural production. In the Outer Islands, the access of the forestry sector is restricted by the provision of concessions; while transmigrants and shifting cultivators are usually not able to open up new primary forests without the provision of infrastructure by the government or the timber concessionaires.

aggregate investment is the endogenous sum of private, government and foreign savings, i.e., the model is "savings-driven".

Despite the intertemporal treatment of forestry the model can be solved within a comparative static framework. For the analysis of compensation payments, however, a dynamic formulation is required, which allows to investigate the growth effects of different allocations of international transfer payments. To take an extreme example: if the money is exclusively spent for consumption purposes, this will mainly cause Dutch Disease effects, if it is invested this will enhance the production capacity and thus lay the ground for the creation of new employment opportunities. The dynamic specification contains equations governing the growth of primary factors over time.[9] While the total supply of labor and land is adjusted exogenously, sectoral capital stocks are built up according to a simple investment model. In this investment model, the sectoral allocation of investable funds is adjusted as a function of the relative profit rate of each sector compared to the average profit rate in the economy. Sectors with higher-than-average profit rates will then get a larger share of investable funds than their share in aggregate profits.

3.3 Numerical Specification of the Model

The theoretical model was calibrated to a consistent data set for the year 1985, which is assumed to represent a benchmark equilibrium of the Indonesian economy. The main source of data is the 1985 Indonesian input-output table (BPS, 1989), supplemented by FAO/UNEP (1981) and Amelung, Diehl (1992) which provide information to calibrate the forestry submodel, as well as BPS (1983) which provides the basis for splitting gross operating surplus into returns to capital and land.

The model distinguishes 13 sectors of production (see Table 1), of which 7 are directly - rice, other food crops, cash crops and forestry - or indirectly via strong linkages to agriculture and forestry - fertilizer and pesticides, wood processing and consumer goods - involved in the exploitation of forest resources. In order to be able to analyze the effects of transmigration policies, three agricultural sectors - rice, other food crops and cash crops - are further disaggregated into Inner Island and Outer Island production. This disaggregation is achieved by calculating regional output figures and assuming identical input and demand structures in both regions. Only with respect to fertilizer and pesticides we take into account the empirical observation that their use in the Outer Islands is lower than in the Inner Islands.

Table 1 summarizes some important structural features of the Indonesian economy. The structure of production reveals a typical composition of output in developing countries where primary sectors and services together contribute more than 60 percent to GDP. Cash crops,

9 It is assumed that agents are myopic, basing their decisions on static expectations about prices and quantities. As a consequence, the dynamic model can be solved recursively for a sequence of equilibria.

mining, wood processing and export-oriented industries (mainly petroleum refining) are the only sectors with considerable export orientation. Oil and natural gas alone account for about 65 percent of total exports. The share of imports in domestic absorption is generally quite low, apart from some capital goods included in the import-substituting industries. Construction is the only pure non-traded sector, but there are some other sectors where both export and import shares are very low. The last three columns of Table 1 show the trade elasticities used in the model. The import substitution and export transformation elasticities are taken from Devarajan, Lewis (1991). With a few exceptions, they indicate a fairly high extent of product differentiation due to differences in quality and the degree of product heterogeneity. The export demand elasticities, which reflect the ease with which foreign users can substitute domestic products, are taken from Rutström (1991). They are of medium size and uniform across sectors.

Table 1 - Economic Structure and Model Parameters, 1985

Sector	Composition of output (percent)	Exports/Gross output (percent)	Imports/ Absorption (percent)	Import substitution elasticity	Export transformation elasticity	Export demand elasticity
Rice	4.4	1.1	—	0.6	0.6	2.0
Other food crops	5.9	0.6	6.8	0.6	0.6	2.0
Cash crops	1.7	39.7	5.6	1.7	0.5	2.0
Other agriculture	4.2	3.0	0.2	0.6	0.6	2.0
Forestry	1.0	5.4	0.2	0.6	0.6	2.0
Mining	10.0	58.5	14.4	0.9	0.6	2.0
Consumer goods	12.0	3.7	2.0	0.9	1.2	2.0
Wood processing	1.6	38.4	0.3	0.9	0.6	2.0
Fertilizer and Pesticides	0.7	7.1	9.2	0.6	0.5	2.0
IS-Industries	6.4	4.0	49.3	0.6	0.6	2.0
EO-Industries	8.1	45.3	10.4	0.9	0.6	2.0
Construction	10.7	—	—	—	—	2.0
Services	33.3	5.3	5.5	0.4	0.4	2.0
Total/Average	100.0	13.5	10.1			

Source: BPS (1989); Devarajan, Lewis (1991); Rutström (1991).

Once having constructed a consistent data set, one can compute the equilibrium prices (or the actually traded quantities, if prices are exogenously given), which in turn determine the allocation of resources and the use of tropical forests. The effects of different policy measures are analyzed by running model simulations. This means that exogenous variables are changed and a new equilibrium is computed. Policy appraisal then proceeds on the basis of pairwise comparison of counterfactual and benchmark equilibria. With capital fixed and labor and land mobile across sectors, the solutions generated by the model should be interpreted as short to medium term results. To capture long-run effects, the model needs to be extended. For example, one has to keep track of the negative stock effects deforestation has on agricultural productivity (Ehui, Hertel, 1989).

4. Simulation Results

The following simulations show how forestry policies, the removal of domestic distortions, a change in transmigration policy and international measures affect the economy and the use of forest resources.

4.1 Forestry Policies

It is assumed in this section that the target of the Indonesian government is to achieve a specified increase in the volume of standing timber. For concreteness the target for each policy measure is set at 500 million m^3, equivalent to about 20 percent of the actual biomass losses caused by deforestation and forest degradation. Altogether, four different policy instruments are distinguished.

The first is an increase in the length of forest leases so that concessionaires have an incentive to take account of the user costs of short-run harvesting and hence to harvest the stand at the private long-run efficient level. This has been modeled as a reduction of the discount rate, which concessionaires apply to calculate their returns from forestry, from 9.5 percent to 6.3 percent. The objective of the remaining three instruments is to deal with the environmental externalities of deforestation and forest degradation. The first option we consider is an increase in the stipulated minimum harvest age of trees by 19 years in order to make forestry more sustainably. The second option is a direct set-aside in the form of a national park. The increase in national parks has been modeled as a reduction in the total area of land on the Outer Islands being available for forestry and agriculture by 3.6 million ha. The final option is a tax on income from forest land.[10] As the ecological damage varies according to land use patterns, the tax rates are differentiated, i.e., 10 percent for forestry, 15 percent for cash crops and 25 percent for rice and other food crops.[11]

Table 2 shows the impact of each forestry policy on real GDP, aggregate exports, and the real exchange rate as well as on sectoral production and producer prices. It is striking that all policies induce a considerable reduction of forestry's production which in turn leads to

[10] A tax on income from forest land is also a means of capturing a sizeable proportion of the resource rent accruing to foresters (Gray, 1983). Because of the similarity of the results, separate simulations for rent capture will not be reported here.

[11] In the agricultural sectors, the taxation is only valid for production on the Outer Islands.

increasing domestic producer prices.[12] The change in the annual forestry activity level is determined by three variables (see Equation 3):

— the rotation period;

— the volume of timber harvested per hectare per rotation; and

— the area of land devoted to forestry.

The forestry sector adjusts these variables in different ways depending on the specific policy measure.

When the discount rate is lowered (Simulation 1), this reduces the opportunity cost of letting trees grow so that there is an incentive for concessionaires to extend the rotation period. Since the subsequent increase in the harvested volume per rotation does not fully compensate for the more infrequent harvests, the net result is a reduction in annual output and a rise in the timber price. As gross harvest revenues increase, because the rise in the timber price is stronger than the decline in output, and annual harvesting costs decrease, because the rotation period is extended, forestry net revenues and the stock value of land increase. This creates the price signal to attract additional land into forestry and thereby eases off the initial output reduction.[13] This reallocation of land significantly contributes to the achievement of the ecological target, because it implies that the planned conversion of some forest areas does not take place. As a consequence of the lower availability of land for agriculture, agricultural output on the Outer Islands declines and producer prices increase.

The primary impact of an increase in the minimum harvest age (Simulation 2) is that foresters have to wait for trees to grow larger before they harvest them, i.e., the rotation period is shortened exogenously. This change in the logging regime reduces the opportunity costs of forest growth by making earlier future harvests possible. As a consequence, concessionaires increase the age at which they actually harvest the trees. On balance, the rotation period is extended. The change in the volume of timber harvested per rotation is the result of two offsetting factors. First, at any given minimum harvest age, the increase in the actual harvest age leads to a higher harvested volume (see Figure 1). Second, the increase in the minimum harvest age reduces the harvestable timber volume by stipulating a higher amount of timber (SV) that has to be left after each harvest. In Indonesia, the second effect dominates the first and hence the harvest per hectare per rotation falls. Both the lower and less frequent harvests translate into a decline in annual output and a drastic rise in timber prices. Via the same mechanism as described for Simulation 1, the negative output effect is partly offset by an

[12] The fact that the contraction in domestic supply forces up domestic timber prices, although log imports are available, is a result of the Armington assumption of imperfect substitution between domestic and imported commodities.

[13] The 4.6 percent decline in annual output is the net result of a 15.1 percent increase in the length of the rotation period and two offsetting factors, namely a 5.4 percent increase in the harvest volume per rotation and a 5.1 percent increase in the land devoted to forestry: -15.1 +5.4 +5.1 = -4.6 (see Table 2).

increase in the area of land devoted to forestry, while agricultural production on the Outer Islands decreases due to lower land use.

Table 2 - Consequences of Forestry Policies for the Economy and the Use of Forest Resources (percentage change)[1]

Policies / Indicators	45 percent reduction of discount rate in forestry Simulation 1	19 years increase in minimum harvest age Simulation 2	3.6 million ha converted to national parks Simulation 3	Sector-specific factor tax on income from forest-land Simulation 4
Real GDP	-0.4	-0.4	-0.4	-0.5
Real exchange rate	-0.2	-0.4	-0.2	0.6
Total exports	-0.3	-0.2	-0.1	-0.2
Sectoral production				
Forestry	-4.6	-8.5	-3.6	-9.8
Wood processing	-1.3	-3.6	-1.2	-1.0
Rice	-0.5	-1.7	-2.0	-2.4
Other food crops	-6.2	-7.5	-8.9	-9.2
Cash crops	-1.4	-2.3	-2.7	-0.3
Sectoral prices				
Forestry	9.4	35.4	13.1	9.0
Wood processing	1.1	4.8	1.5	0.9
Rice	10.4	17.5	21.4	8.2
Other food crops	9.2	10.1	12.3	7.0
Cash crops	1.8	2.1	2.7	1.0
Use of land in the Outer Islands in agriculture:				
Rice	-18.6	-20.4	-23.7	-26.1
Other food crops	-25.2	-30.4	-35.0	-38.0
Cash crops	-31.1	-32.0	-36.7	-27.2
in forestry:	5.1	9.0	-4.4	-10.0
Rotation period	15.1	2.8	-8.1	0.7
Harvest per rotation	5.4	-14.7	-7.3	0.5

[1]All policies are calibrated to produce an incrase in standing timber of about 500 million m^3 compared to the reference situation. The figures for 'rice', 'other food crops' and 'cash crops' only refer to the Outer Islands. - [2]An increase (decrease) in the real exchange rate indicates an appreciation (depreciation).

Source: Own calculations based on the CGE model.

The establishment of a national park (Simulation 3) initially reduces the area available for forestry activities. As a consequence, annual output declines, pushing up the price of domestically produced timber. The higher output price provides the incentive for concessionaires to undertake more frequent harvests, because it raises the opportunity costs by more than the marginal revenues of forest growth (see Section 3.1). The shorter rotation period, in turn, leads to smaller harvests per rotation. On balance, annual production falls and the output price increases. With gross revenues increasing more than annual harvesting costs, a rising stock value of land attracts land from agriculture thereby cushioning the output reduction in forestry and lowering agricultural output in the Outer Islands.

A general taxation of land in the Outer Islands (Simulation 4) forces up the price of land in forestry as well as in agriculture and thus leads to reduced demand for this factor in both sectors. As the frequency and the intensity of harvests adjust only marginally and compensate each other, the decline in annual output of the forestry sector is solely due to the reduction of land use.

All forestry policy measures have two dominant effects which go beyond the forestry sector. First, as mentioned before, the reallocation of land from agriculture to forestry causes a contraction of agricultural production in the Outer Islands. Second, the price increase of timber penalizes wood processing, which has strong backward linkages to forestry, by increasing input costs. Because of forestry's weak linkages to other sectors there are only minor real adjustments in the rest of the economy. The output losses in forestry, wood processing and agriculture lead to moderate reductions of real GDP in the range of 0.4 to 0.5 percent.[14]

Basically, the ecological target specified above can be realized by each of the four forestry policies. Taking into account the fact that in Indonesia the rotation period is too short and at the same time the harvesting intensity is very high, an increase in the minimum harvest age may be regarded as the best solution from an ecological point of view, because it contributes to the reduction of both problems by extending the rotation period and reducing the harvest volume. If combined with more secure property rights, this measures would extend the rotation period to the 35-year harvesting cycle stipulated by the government and harvests per rotation would be still lower than in the base run.

4.2 Removal of Distortions

This subsection deals with the question of how a more neutral incentive structure in the Indonesian economy might affect the utilization of tropical forests. Are there trade-offs between efficiency and ecological objectives? To answer this question, we examine the effects of removing three of the most significant economic distortions prevailing in Indonesia. First, a liberalization of the timber industry is considered. For modeling this policy change, the export ban on logs was transformed into a prohibitive export tax. This export tax was then eliminated together with the import tariff and the export tax on processed wood. Second, we

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[14] In order to assess the welfare implications of the forestry policy measures, these reductions in real GDP have to be balanced with the long-run ecological gains derived from the protection of the forests.

simulate a removal of the fertilizer and pesticides subsidy, which is by far the dominating distortion in agriculture.[15] Finally, an economy-wide abolition of import tariffs is examined.

Table 3 shows the impact of these policies on some important macroeconomic aggregates, sectoral production and the use of forest resources. All three measures cause real GDP to increase by only 0.2 percent. This does not come as a surprise, because the supply and productivity of primary factors and hence the production possibility frontier of the economy is exogenously fixed in this model so that increases in real GDP only measure static efficiency gains. The low efficiency gains of a general trade liberalization can be explained by the fact that import tariffs were already cut to a relatively moderate average level of 27 percent in the base year 1985 (Balassa, 1991), while quantitative restrictions, which were still widespread in 1985, are not included in the analysis.

The impact of the three policy measures on deforestation and forest degradation depends on how they affect the sectoral allocation of resources. A liberalization of the timber industry (Simulation 5) directly affects relative prices in forestry and wood processing. The removal of the export tax for forestry greatly improves its competitiveness in world markets and pushes up export sales. With lower domestic supply the domestic timber price increases. In wood processing, the elimination of import tariffs and export taxes, both of which were at a rate of about 10 percent in 1985,[16] almost cancel out in their effect on production and domestic prices, but the trade orientation of the sector increases.

Apart from these direct effects which determine the initial response in the deregulated markets, the economy-wide effects must be taken into account in order to determine the final resource shift in the economy. In the present case, the main cross-sectoral effect runs via the strong forward linkage of forestry to wood processing. With increasing domestic timber prices, intermediate input costs for the wood processing industry rise and the sector slightly contracts. Other channels for economy-wide effects are less important. There is no marked change of intermediate input costs in other sectors than wood processing, because forestry has no strong forward linkages to the rest of the economy. Real wages remain almost constant. Finally, only a minor real appreciation is required to restore equilibrium in the trade balance, which has improved due to the removal of export taxes in forestry.

Altogether, the change in the use of forest resources can be traced back to the rising domestic timber price. As shown in Section 3, this provides an incentive for concessionaires to shorten the rotation period which is followed by a lower harvesting intensity. Shorter rotation periods raise annual harvesting costs, but this is overcompensated by higher gross revenues so that land is attracted to forestry. As a consequence, the volume of standing timber substantially

[15] A liberalization of agricultural trade was also examined, but because of low trade taxes and low trade elasticities there were only very small effects so that the results are not reported here.

[16] The tightening of export restrictions for processed wood in 1989 is not examined here.

increases compared to the reference situation. The only disadvantage of this ecologically beneficial outcome is the shortening of the rotation period. To avoid more frequent harvests and the additional logging damage this implies, a policy package containing the liberalization of the timber industry, more secure property rights and a more restrictive selective logging regime is a viable option.

Table 3 - Consequences of a Removal of Distortions for the Economy and the Use of Forest Resources (percentage change)

Policies / Indicators	Removal of incentives for wood-based industrialization Simulation 5	Removal of fertilizer and pesticide subsidy Simulation 6	Across-the-board liberalization Simulation 7
Real GDP	0.2	0.2	0.2
Real exchange rate	2.1	-0.5	-8.5
Total exports	1.6	0.8	6.0
Total imports	0.8	0.7	7.1
Sectoral production			
Forestry	11.2	0.6	-0.2
Wood processing	-2.7	0.6	1.5
Rice	-1.3	-0.5	-0.6
Other food crops	-5.8	-0.6	-1.1
Cash crops	-3.0	-0.6	3.2
Volume of standing timber (absolute change in million m³)	354.5	21.7	-15.9
Use of land in the Outer Islands in agriculture:			
Rice	-17.4	-1.3	-0.2
Other food crops	-29.4	-1.7	-1.0
Cash crops	-35.3	-1.7	5.8
in forestry:	9.7	0.6	-0.4
Rotation period	-15.8	0.0	-1.9
Harvest per rotation	-13.9	0.0	-1.7

Source: Own calculations based on the CGE model.

A removal of the fertilizer and pesticides subsidy (Simulation 6) pushes up the domestic price of fertilizer and pesticides by more than 25 percent. This hurts agriculture which faces higher secondary input costs.[17] The effect is, however, mainly limited to agricultural production in the Inner Islands, where the use of fertilizer and pesticides is significantly higher than in the Outer Islands. Consequently, the profitability of agriculture in the Outer Islands is not

[17] Other economy-wide effects do not play a significant role.

changed very much. Nevertheless, there is a small reduction in the area converted to agriculture and hence a small increase in the volume of standing timber. In forestry, only minor adjustment needs occur. With harvesting costs and revenues being roughly constant, foresters have no incentive to alter the rotation length and, hence, the harvested volume remains at the initial level. The small output expansion is solely the result of the reallocation of land.

If import tariffs are eliminated across-the-board (Simulation 7), domestic users substitute imports for domestically produced goods in all tradable sectors. For the import-substituting industries which has a high import share and a relatively high initial protection level, increasing imports correspond to substantial decreases in domestic demand so that it is most heavily affected by the direct effects of a trade liberalization. This picture is qualified, when the economy-wide repercussions are taken into account. First, abolishing tariffs reduces intermediate input cost throughout the economy. This stimulates production in those sectors having strong backward linkages and a high share of imported in total intermediate use, i.e. predominantly in manufacturing. Second, the real exchange rate has to depreciate by 8.5 percent, thereby inducing a reallocation of resources towards traded goods. The real depreciation favors cash crops, mining and most manufacturing sectors, while it hurts construction, the only non-tradable sector, as well as rice, other food crops and forestry, which can almost be treated as additional non-tradable sectors. Finally, the removal of trade restrictions lowers domestic real wages which again works in favor of sectors producing export goods and import substitutes and hence being exposed to international price competition.

On balance, cash crops, mining, wood processing and export-oriented industries are the winners of trade liberalization, while the non-traded and nearly non-traded sectors as well as import-substituting industries, where the direct effect dominates, are the losers. This final resource shift corresponds to a decrease in the volume of standing timber, because cash crops attract land from forestry and food crops so that agricultural conversion increases compared to the reference situation. Hence, the trade liberalization does not overcome the trade-off between efficiency and ecological objectives. The negative side effect of trade liberalization on tropical forests is, however, so small that it can easily be offset by a specific forestry policy measure.

4.3 Transmigration Policy

When analyzing a cut-back of incentives for transmigration, two major problems arise. First, in a model with a disaggregated agricultural sector the available data do not allow to differentiate between production by official transmigrants, who receive direct support from the government, and production by spontaneous migrants as well as shifting cultivators, who only take advantage of the infrastructure created by the government.[18] Second, the numerous different subsidies granted to transmigrants cannot be reconciled with the data base used in the analysis. To overcome these problems it is assumed that all three producer groups profit equally from government support so that they can be treated together[19] and that the support can be approximated by a production subsidy. In view of this simplification, the simulation results should only be interpreted as rough indicators of the actual effects.

Three different policy experiments are considered. The first is a general elimination of subsidies for agricultural production in the Outer Islands. The second experiment takes into account that a complete abolition of the transmigration program may be unrealistic in view of the population pressure prevailing in the Inner Islands. Here, only food crop production in the Outer Islands is discouraged, because it has much lower economic potential than cash crop production. In a final experiment, the cutback of incentives for food crop production is combined with a realization of the estimated potential to increase productivity in cash crop production. The latter is modeled as an increase of the efficiency parameter in the production function for cash crops in the Outer Islands by 30 percent.

Table 4 presents the effects these policies have on some important macroeconomic and agricultural variables as well as on the use of forest resources. Generally, the elimination of subsidies for agricultural production in the Outer Islands results in small efficiency gains. If the removal of subsidies is combined with productivity increases in cash crop production, the increase in real GDP is somewhat higher.

A general cut-back of transmigration incentives (Simulation 8) leads to a substantial increase in the volume of standing timber. Since agricultural profitability in the Outer Islands steeply declines, much less land than in the base run is used in agriculture, i.e., there is a reallocation of land from agriculture to forestry.[20] This raises forestry's annual output (see Equation 3) and lowers the timber price. The price depression in forestry forces timber concessionaires to extend the rotation period (see Section 3.1) and this, in turn is followed by higher harvests per rotation. Since a more intensive harvesting may endanger the sustainability of forestry, the

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[18] Such a differentiation can be achieved if the agricultural sector is modeled as an aggregate.

[19] An important question is whether the activities of the three producer groups are substitutable or complementary. There are plausible explanations for both assumptions. Substitutability can be interpreted in such a way that transmigrants who leave their sites because of lower subsidies attract spontaneous migrants and shifting cultivators. Complementarity means that if some transmigration sites had not been established, spontaneous migration and shifting cultivation in forested areas would also have been lower, because both activities depend on the infrastructure created by the government. If one follows the latter interpretation, there is some justification for taking all three producer groups together.

[20] Since the majority of transmigration sites is established on logged-over stands and not in primary forests, it is assumed here that areas which are not used for transmigration remain in forestry, i.e., the overall supply of forest land is held constant. If lower transmigration preserved primary forests from bein converted into agricultural land, this would have to be modeled as a reduction in the overall supply of land.

cut-back of transmigration incentives could be accompanied by an increase in the minimum harvest age for trees.

Table 4 - Consequences of a Reformed Transmigration Policy for the Economy and the Use of Forest Resources (percentage change)

Policies / Indicators	General reduction of incentives for agricultural production on the Outer Island Simulation 8	Reduction of incentives for food production on the Outer Islands Simulation 9	Reduction of incentives for food production on the Outer Islands plus productivity increase in export crop production Simulation 10
Real GDP	0.3	0.2	0.5
Total exports	0.2	0.3	0.5
Agricultural production	-6.2	-5.1	-2.0
Agricultural employment in the Outer Islands	-82.8	-37.0	-42.7
Volume of standing timber (absolute change in million m³)	538.3	371.9	382.6
Use of land in the Outer Islands			
in agriculture:			
Rice	-46.0	-51.2	-48.9
Other food crops	-55.0	-63.3	-61.4
Cash crops	-77.9	18.3	4.3
in forestry:	14.1	9.7	10.0
Rotation period	14.8	11.0	11.4
Harvest per rotation	13.6	10.0	10.3

Source: Own calculations based on the CGE model.

Two major side effects of a general elimination of the support for transmigration are likely to cause the Indonesian government to refrain from choosing this policy option. First, agricultural production in Indonesia would decrease by 6.2 percent. Second, and more important, agricultural employment in the Outer Islands would almost break down. While it is assumed here that the labor market is flexible enough to achieve a reallocation of the released labor to other sectors such as construction and services in the medium run, this may be a too optimistic assumption in view of the low qualification of most transmigrants so that significant unemployment cannot be excluded. If the government on this grounds regards some transmigration as necessary and if it concentrates its support on the more profitable growing of cash crops, the increase in the volume of standing timber is 30 percent lower, while the release of agricultural labor is halved (Simulation 9). Agricultural production losses, however, remain at a significant level. These losses are kept to a minimum, if cash crop production realizes its estimated productivity potential (Simulation 10).

4.4. International Measures

This section deals with the two basic options which industrialized countries have to affect the level of tropical forest exploitation (see Section 2). First, an import ban of Indonesian timber products is considered, the most restrictive among all possible trade policy measures. Second, international transfer payments are investigated. The results of the simulations are presented in Table 5.

Table 5 - Consequences of International Measures for the Economy and the Use of Forest Resources (percentage deviation from base run)

Policies / Indicators	Import ban for Indonesian forest products Simulation 11	Compensation payments (used for investment) Simulation 12	Compensation payments (used for consumption) Simulation 13	Compensation payments (used for investment) plus national park Simulation 14
Real GDP	-0.8	0.4	-0.1	0.0
Real exchange rate	-3.4	2.9	7.6	2.7
Total exports	-0.4	-1.3	-2.9	-1.4
Sectoral output				
Forestry	-18.2	0.3	0.7	-3.3
Wood processing	-23.2	0.5	0.0	-0.7
Rice	0.0	0.6	1.2	-0.6
Other food crops	0.1	0.8	1.5	-8.1
Cash crops	3.5	-1.2	-3.7	-3.9
Volume of standing timber (absolute change in million m³)	2.3	10.7	16.4	492.3
Use of land in the Outer Islands				
in agriculture:				
Rice	0.2	1.6	3.1	-18.8
Other food crops	0.3	1.4	2.8	-29.0
Cash crops	7.8	-2.3	-7.3	-34.3
in forestry:	-18.2	0.2	0.3	-4.2
Rotation period	0.0	-1.1	-1.2	-9.3
Harvest per rotation	0.0	-1.0	-0.8	-8.3

Source: Own calculations based on the CGE model.

As it seems unrealistic that an import ban works perfectly, it is assumed in Simulation 11 that Indonesia after the introduction of the ban is still able to sell 10 percent of its previous timber products exports to outsiders who do not obey the ban. Nevertheless, the decline in exports leads to substantial output losses in wood processing and in forestry, via the strong forward linkage to wood processing. The decrease in export demand for timber products is, however, not fully transmitted to domestic production of the wood processing sector. The foregone exports are partly substituted by an increase in domestic use, especially by the construction sector. Altogether, the relatively high export orientation of the timber industry makes the ban rather effective as concerns forestry activity. The use of land in forestry is reduced by 18.2 percent, while the rotation period and the harvested volume per hectare per rotation remain constant. The effectiveness of the ban in slowing down the activity in the timber industry imposes considerable costs on the Indonesian economy, as is indicated by a decline in real GDP of nearly one percent.

The net effect of the ban on the use of tropical forest resources depends on how agricultural conversion changes. This change is affected by two dominating economy-wide repercussions. First, the income losses in the economy lead to a decreasing demand for domestically produced goods. This effect is particularly relevant for rice and other food crops, which nearly exclusively serve the domestic market, while it does hardly affect cash crops. Second, the drop in exports causes a real depreciation, which favors cash crops and hurts food crops.

On balance, there is a reallocation of land from forestry to agriculture, especially to cash crops, i.e., agricultural conversion increases compared to the reference situation. This effect nearly matches the primary effect on land use in forestry so that the volume of standing timber only increases by an insignificant amount. This outcome shows that a relatively high share of exported timber products is a necessary but no sufficient condition for an import ban to be ecologically effective if, like in Indonesia, exports of forestry products can partly be substituted by domestic uses and agricultural conversion is encouraged as a result of lower profitability in forestry.

With respect to compensation payments for the conservation of tropical forests, we presuppose that tropical and non-tropical countries have negotiated an environmental agreement. Then, three basic questions arise for the individual tropical country: how can it reach the specified ecological target; how much side payments will it receive for the protection of its forests; and how is it going to spend the money. Consequently, one has to analyze a combination of an external transfer and a complementary national forestry policy measure.

In Simulation 14, it is assumed that the Indonesian government directly sets aside tropical forest areas and that the amount of compensation payments injected into the economy - 3.2 billion US dollar - just matches the economic losses resulting from the establishment of a national park.[21] Since the theoretical reference point for transfer payments is given by the difference between economic losses and local ecological benefits of forest conservation, this amount constitutes an upper bound. Furthermore, the transfer is assumed to be provided under the general condition that it has to be used for investment in order to create new employment opportunities.[22]

The effects of establishing a national park have already been discussed in Section 4.1. Simulation 12 shows how the external transfer qualifies these results. As the money is invested and thus adds to the productive capacity of the economy, the increase in demand exerts only moderate pressure on domestic prices. Nevertheless, the resulting small appreciation and the rise in income are sufficient to induce a reallocation of land from cash crops to food crops and forestry, which because of the export ban is almost a non-traded sector. On balance, agricultural conversion increases. Hence, the effects of the compensation payment somewhat dampen the effectiveness of the set-aside, but a substantial ecological gain of 492 million m^3 biomass at zero economic costs remains (see Simulation 14).

If the same amount of money is spent for consumption instead of investment (Simulation 13), a different picture emerges. In this case, the increase in demand forces up domestic goods prices in relation to foreign goods prices as is indicated by a significant real appreciation of the Indonesian Rupiah. The price increase causes a decline in real investment so that economic growth is slightly lowered compared to the base run. This result illustrates that a transfer can only compensate for the losses of forest conservation, if the money is actually invested.

5. Summary and Conclusions

This paper has provided an empirical general equilibrium assessment of policies to reduce tropical deforestation in Indonesia. Four different categories of policy measures are distinguished in the analysis: forestry policies which aim at correcting market failure at the national level; the removal of distortions which may have a positive indirect impact on tropical forests; a cut-back of the transmigration program which aims at reducing the agricultural conversion of forest areas; and international measures which try to internalize the global external costs of tropical deforestation.

It has been shown that a prespecified reduction in the use of forest resources can be reached by each of the forestry policies analyzed: More secure concession; a higher minimum harvest age of trees; the establishment of national parks; a Pigou-tax on land in the Outer Islands.

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[21] Here we neglect the principal-agent problem which may arise, i.e., the possibility that Indonesia does not fulfill its ecological obligations after having received the transfer. Amelung (1991) suggests that a payment in instalments can reduce this problem.

[22] Alternatively, one may formulate more specific conditions, e.g., that the transfers have to be used to finance measures which enhance agricultural productivity outside tropical forest areas.

From an ecological point of view, a combination of more secure property rights and a higher minimum harvesting age is the preferable option. This policy mix causes the rotation period to rise to the length which is recommended by forestry experts and at the same time reduces the harvesting intensity which is currently very high in international comparison. All forestry policies lead to moderate short to medium run losses in aggregate output.

The trade-off between economic and ecological objectives can be overcome, if the government corrects for policy failures. Substantial ecological gains arise from a liberalization of the forestry industry. As this policy change leads to a significant shortening of the rotation period, it should be combined with more secure property rights and a higher minimum harvest age. A removal of the fertilizer and pesticide subsidy also reduces the use of forest resources but the effect is small, partly because low-input cultivation is predominant in the Outer Islands. Contrary to the two specific measures, a general trade liberalization has negative ecological side effects, because it causes a reallocation of land from forestry and food crops to cash crops so that on balance agricultural conversion increases.

An elimination of incentives for transmigration to the Outer Islands is another possibility to protect tropical forests without suffering short and medium run output losses. A general cut-back of transmigration promises high ecological gains, but two consequences have to be considered: First, agricultural employment in the Outer Islands steeply declines so that a substantial reallocation of labor has to be achieved in order to avoid unemployment. Second, aggregate agricultural production decreases. If the government regards some transmigration as necessary, a compromise might be to concentrate the support on cash crop production which has much higher economic potential than food crop production. Under this option, the conservation of biomass is 30 percent lower but the release of agricultural labor is halved. Losses in agricultural production can be kept to a minimum, if the potential for increasing productivity in cash crop production on the Outer Islands is realized.

An import ban for Indonesian timber products does not protect the tropical forests, although a significant share of the timber products is exported. This is due to the fact that exports are partly substituted by domestic uses of wood and agricultural conversion increases as a result of lower profitability in forestry. Apart from being ecologically ineffective a ban would place considerable costs on the Indonesian economy. International compensation payments can be a powerful tool to compensate for the economic losses of forest conservation, if the money is used for investment in order to create new employment opportunities. A crucial question is, however, how it can be ensured that Indonesia fulfills its ecological obligations after having received the transfer. Answering this question goes beyond the scope of the paper because it requires a different analytical framework.

References

Amelung, T. (1991), "Internationale Transferzahlungen zur Lösung globaler Umweltprobleme dargestellt am Beispiel der tropischen Regenwälder". Journal of Environmental Law and Policy, Vol. 14, pp. 159-178.

Amelung, T., M. Diehl (1992), Deforestation of Tropical Rain Forests: Economic Causes and Impact on Development. Kiel Studies, No. 241. Tübingen: J.C.B. Mohr.

Armington, P. (1969), A Theory of Demand for Products Distinguished by Place of Production. IMF Staff Papers, Vol. 16, pp. 159-178.

Balassa, B. (1991), Economic Policies in the Pacific Area Developing Countries. Basingstoke: MacMillan, pp. 121-141.

Barbier, E., J. Burgess, B. Aylward, J. Bishop (1992), Timber Trade, Trade Policies and Environmental Degradation. LEEC Discussion Paper 92-01, London Environmental Economics Centre. London.

Biro Pusat Statistik (BPS) (1983), Agricultural Census. Jakarta.

Biro Pusat Statistik (BPS) (1989), Indonesian Input-Output Table 1985, Volume 1. Jakarta.

Bowes, M.D., J.V. Krutilla (1985), Multiple Use Management of Public Forestlands. In: A.V. Kneese, J.L. Sweeney (Eds.), Handbook of Natural Resource and Energy Economics, Vol. I. Amsterdam: North-Holland, pp. 531-569.

Braga, C.A.P. (1992), Tropical Forests and Trade Policy: The Cases of Indonesia and Brazil. In: P. Low (Ed.), International Trade and the Environment. World Bank Discussion Paper No. 159. Washington, D.C.

Capistrano, A.D., C.F. Kiker (1990), Global Economic Influences on Tropical Closed Broadleaved Forest Depletion, 1967-1985. Food Resources Economics Department, University of Florida. Miami.

Clark, C. (1990), Mathematical Bioeconomics. New York: Whiley, Second Edition.

Corden, W.M. (1974), Trade Policy and Economic Welfare. Oxford: Oxford University Press.

Dee, P.S. (1991), Modeling Steady State Forestry in a Computable General Equilibrium Context. Working Paper Series. No. 91/8. National Centre for Development Studies. Canberra.

Dervis, K., J. de Melo, S. Robinson (1982), General Equilibrium Models for Development Policy. Cambridge: Cambridge University Press.

Devarajan, S., J. Lewis (1991), Structural Adjustment and Economic Reform in Indonesia: Model-Based Policies versus Rules of Thumb. In: D. Perkins, M. Roemer (Eds.), Reforming Economic Systems in Developing Countries. Cambridge, Mass.: Harvard University Press.

Ehui, S.K., T.W. Hertel (1989), "Deforestation and Agricultural Productivity in the Côte d'Ivoire". American Journal of Agricultural Economics, Vol. 71, pp. 703-711.

FAO (1991), Indonesian Tropical Forestry Action Programme. Country Brief. Jakarta.

FAO/UNEP (1981), Tropical Forest Resources Assessment Project. Technical Report, No. 3. Rome.

Gillis, M. (1992), Forest Concession Management and Revenue Policies. In: N.P. Sharma (Ed.), Managing the World's Forests. World Bank. Washington, D.C., pp. 139-175.

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

Gonzales, L.A., F. Kasryno, N.D. Perez, M.W. Rosegrant (1993), Economic Incentives and Comparative Advantage in Indonesian Food Crop Production. International Food Policy Research Institute, Research Report 93. Washington, D.C.

Gray, J.A. (1983), Forest Revenue Systems in Developing Countries. FAO Forestry Paper, No. 43. Rome.

Gray, J.A., S. Hadi (1990), Fiscal Policies and Pricing in Indonesian Forestry. Ministry of Forestry, Government of Indonesia and FAO. Jakarta.

Nguyen, D. (1979), " Environmental Services and the Optimal Rotation Problem in Forest Management". Journal of Environmental Management, Vol. 8, pp. 127-136.

Powell, A., F. Gruen (1968), "The Constant Elasticity of Transformation Production Frontier and the Linear Supply System". International Economic Review, Vol. 9, pp. 315-328.

Repetto, R. (1988), The Forest for the Trees? Government Policies and the Misuse of Forest Resources. World Resource Institute. Washington, D.C.

Repetto, R. (1989), Economic Incentives for Sustainable Production. In: G. Schramm, J. Warford (Eds.), Environmental Management and Economic Development. World Bank. Washington, D.C., pp. 69-86.

Repetto, R., M. Gillis (1988), Public Policies and the Misuse of Forest Resources. Cambridge: Cambridge University Press.

Rutström, E.E. (1991), The Political Economy of Protectionism in Indonesia: A Computable General Equilibrium Analysis. EFI Report, Stockholm Institute of Economics. Stockholm.

Sandler, T. (1993), "Tropical Deforestation: Markets and Market Failures", Land Economics, Vol. 69, pp. 225-233.

Thiele, R. (1994), "How to Manage Tropical Forests More Sustainably: The Case of Indonesia". Intereconomics (forthcoming).

Thiele, R., M. Wiebelt (1993a), Modelling Deforestation in a Computable General Equilibrium Model. Kiel Working Papers, No. 555. Kiel Institute of World Economics. Kiel.

Thiele, R., M. Wiebelt (1993b), "National and International Policies for Tropical Rain Forest Conservation - A Quantitative Analysis for Cameroon". Environmental and Resource Economics, Vol. 3, pp. 501-531.

Wilen, J.E. (1985), Bioeconomics of Renewable Resource Use. In: A.V. Kneese, J.L. Sweeney (Eds.), Handbook of Natural Resource and Energy Economics, Vol. I. Amsterdam: North-Holland, pp. 61-124.

World Bank (1990), Indonesia: Sustainable Development of Forests, Land and Water. World Bank Country Study. Washington, D.C.