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Luz C. Stenberg
University of Notre Dame Australia, lstenberg@nd.edu.au

Mahinda Siriwardana

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Analysing the Causes of Deforestation in a CGE Framework: The Case of the Philippines[1]

Luz Centeno Stenberg, Faculty of Business and Law
Central Queensland University, Sydney International Campus,
333 Kent St., Sydney, N.S.W., Australia 2000
(email: luzstenberg@optusnet.com.au)

and

Mahinda Siriwardana, School of Economics
University of New England, Armidale, N.S.W., Australia 2351
(email: asiriwar@une.edu.au)

Abstract

A computable general equilibrium (CGE) model is developed to evaluate some of the causes of deforestation in the Philippines. To quantify deforestation effects, the elasticities of various parameters of deforestation as identified in the literature are evaluated. The main conclusion derived is that the factors that have a relatively more direct influence on the level of harvest such as annual allowable cut would have a greater effect on deforestation rate than population growth and off-farm employment opportunities.

Keywords list: CGE modelling, Deforestation, Philippines

INTRODUCTION

The Philippine forests have been subjected to land clearing since the 16th century. This continued until the 1980s. Due to its abundance of forests reserves, the Philippines became the main exporter of timber products mainly logs and lumber in 1969 where it supplied 30 per cent of the world's total export of logs and lumber. This also contributed to about 33 per cent of total export earnings of the country. Unfortunately, the various Philippine governments were ineffective in perpetuating the resource and in translating the export earnings from the timber trade to economic development.

In recent times, the forestry sector has been reduced to a small component of the agricultural sector (i.e. agriculture, forestry and fisheries), which is only 0.7 per cent of agriculture and 2.6 per cent of the fisheries sector. Employment in the forestry sector consists only of 4,000 workers while in the wood and paper manufacturing sectors, there are around 100,000 workers. The agricultural sector employed around 11.8 million workers in 2004, which was around 33 per cent of the total labour force, and contributed almost 20 per cent in total Gross Domestic Product (GDP). Considering that more than 50 per cent of total land is classified as forestlands (Forest Management Bureau 1998) and only 5 per cent of total land is declared as nationally protected areas (World Development Report 2000/2001), why is employment in forestry and in wood manufacturing insignificant? Log production stood at 633,797 cubic meters in 1998. Whilst, log exports in 1970 stood at $US256 million and in 2003 this was reduced to $US1,000. Moreover, the contribution of the forestry sector to GDP was reduced from 1 per cent in 1990 to a dismal 0.07 per cent in 2003.

The causes of deforestation as identified in the literature have been varied ranging from decision parameters such as output and input prices, credit availability, off-farm employment, technological change in agriculture, infrastructure, property rights and timber prices to macroeconomic variables such as population pressures, income level and economic growth, technological change, exchange rate regime, trade liberalisation and external debt (Angelsen and Kaimowitz, 1999). Similarly, the deforestation process in the Philippines is complex. It has been characterised by excessive annual allowable cuts, insecurity of tenure and land use concerns.

To analyse deforestation as a problem of competing land-use, the computable general equilibrium (CGE) model used in this paper explicitly identifies four land-using sectors namely, agriculture, forestry, mining and real estate. The pressure from non-agricultural land usage on agricultural land results in additional conversion (or destruction) of forestland to sustain agricultural production.

In this paper it is assumed that the initial phase of deforestation in the Philippines is logging. Aside from logging, the combined pressure on agricultural lands of conversion into commercial land use and maintaining agricultural production remove forestland from reforestation activities. Heavily depleted sites can recover without human intervention after 80 years or more. Conversion of such lands into agricultural use prevents the natural regeneration of forestland. Hence, agricultural expansion is identified as the next phase of the deforestation process after logging. Agriculture also receives pressure from the increasing demand for commercial land especially residential, industrial and recreational land uses, in particular, golf courses. Therefore, commercial land use also contributes to the process of deforestation via the conversion of agricultural land into non-agricultural use. This is the rationale behind the selection of the land-using sectors in the paper.

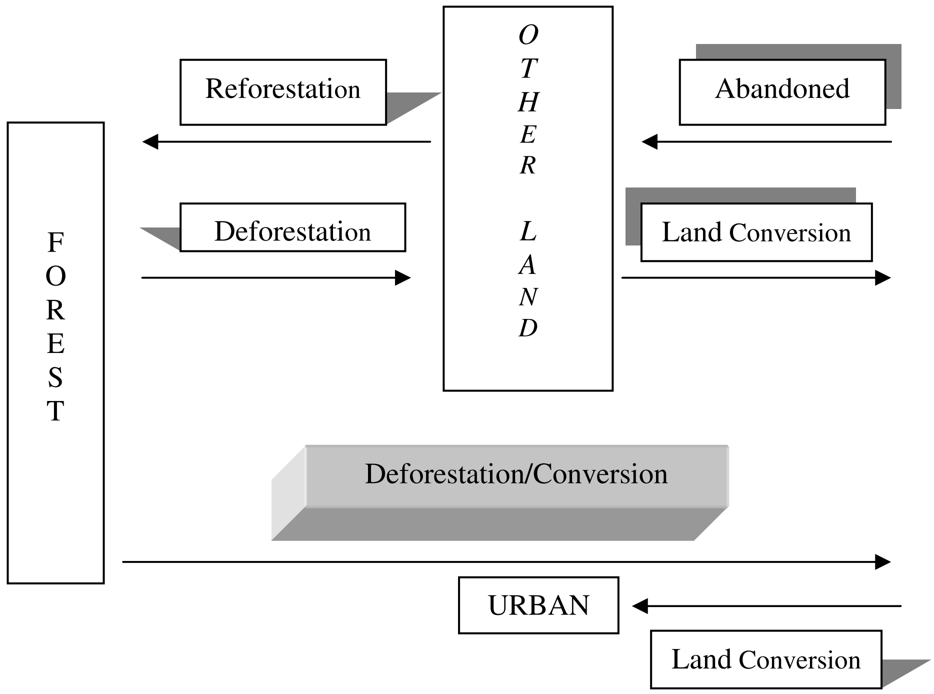
The main objective of the paper is to determine the factors that greatly affect deforestation in the Philippines (e.g. annual allowable cut, tenure security, off-farm employment, population growth, etc.). Apart from secondary effects and the capability to rank outcomes, the use of general equilibrium analysis in this study will shed more light into the economy-wide effects of deforestation. The evaluation of the variables via their elasticities is useful given that the share of the forestry sector to the national product might be considered insignificant.

The paper is structured so as to describe firstly the land classification in the Philippines, secondly the model and the database and thirdly the simulation results in the form of elasticities to compare the importance of the different causes of deforestation.

THE PHILIPPINE LAND CLASSIFICATION PROCESS

A brief discussion on the land classification process in the Philippines is provided to understand the classification adopted in this paper regarding the land-using sectors. The pattern of land use in the Philippines is illustrated in Figure 1. The 'other land' category includes grassland, pasture, wasteland, open land, shrubland, brushland[2], fallow, idle land, barren land and abandoned agricultural land (Kummer and Turner II, 1994). It is apparent from Figure 1 that there is no clear-cut classification of land use in the Philippines. The problem with land classification arises from the classification process itself. The process of land classification involves the delineation of the unclassified lands into forestland, and alienable and disposable lands. The latter are lands, which do not meet the forestry criteria. Clearly, there are only two major uses of land in the Philippines, that is, agriculture and forestry. As forestland was abundant (and timber trade was profitable) during the first half of the 20th century and the demand for agricultural products was small, policy makers were only concerned themselves with agricultural and forestry uses of public land. Alienable and Disposable (A&D) lands comprise mainly of agricultural lands, however, other non-forestry lands are also included in this classification.

Figure 1 Overview of national land-use categories in the Philippines



Based on Kummer and Turner II (1994)

As population grows, it is inevitable that land usage increases or even changes. However in many Philippine statistical publications (e.g., 1999 Philippine yearbook, 1998 Philippine forestry statistics, 1995 Philippine yearbook) forestland remains the major land use category despite of the actual diminishing forest cover. Land classification has not changed over the years. For example, land cover in 1935 was classified into six groups namely, commercial forests, non-commercial forests, cultivated land, cogon (grassland) and open land, swamp and unexplored land. In comparison, land use/land cover statistics in the Philippines in 1988 included eight categories, forestland is divided into mossy, pine, old growth and residual while non-forestland is divided into grassland, extensive land use, lakes and other land. After more than 50 years, there is still no clear definition of the 'other land' category. The attachment to the categories of forestland and A&D lands is still evident. In 2003, the National Mapping and Resource Information Authority, the government body in charge of land classification data still use forestland and A&D land categories to estimate land cover/land use.

Given the land classification process in the Philippines, it is implied that urban land uses, built-up areas, abandoned land, mining sites are all lumped into the same land use category (i.e., other land use). At present, there are efforts to classify further the 'other land' category and to establish the extent of urban land use. In 1998, the National Statistical Coordination Board published the *Philippine Asset Accounts* as part of the Integrated Environmental Management for Sustainable Development (IEMSD) supported by the United Nations Development Programme under its 5th Country Programme. In its publication, other land uses are identified as eroded areas, quarries, riverbeds, other barren lands, built-up areas, marshy areas and lakes. Grasslands, brushlands and open lands are under the extensively cultivated land classification.

METHODOLOGY

General equilibrium modelling can be successfully applied to deforestation studies (Stenberg and Siriwardana 2005). It allows the researcher to rank different mechanisms driving the deforestation process. The model employed in this paper is a static CGE model of a small open economy with a forestry sub-model appended following Dee (1991). It is based on ORANI, the multisectoral CGE model for Australia (Dixon et al., 1982). This study incorporates two usages of land (i.e. agricultural and forestry) and the indirect relationship between forestland and non-agricultural land, in particular land devoted to mining and real estate. For simplicity, when comparing different land usages, it is assumed that non-agricultural use pertains to real estate, forestry and mining. The land requirements of, say, households for residential purposes are provided by the real estate sector. Hence, the model assumes that there are four producing sectors that use land intensively namely, agriculture, forestry, mining and real estate. The model is presented in the appendix (see Tables 7-9).

Equations (1-7) in Table 7 describe the representation of each industry's demands for labour, capital, land and various material inputs from both domestic and imported sources. These industries are assumed to maximise profit (or minimise cost) subject to constant returns to scale production functions. The relationship between inputs and output in each industry is given by a Leontief production function and the aggregation of domestic and imported intermediate inputs is described by a constant-elasticity of substitution (CES) production function. The aggregation of factors of production (i.e. capital, labour and land) for non-forestry sectors[3] and the aggregation of the different types of labour are also described by CES production functions. There are 10 occupational groups in this model. Unfortunately, farmers, fishermen and forestry workers are lumped into one occupational group.

Special treatment in terms of modelling is conferred to the forestry sector as shown in equations (8-23). The standard input demand and zero profit equations are replaced by a set of steady state production relationships. The non-land input bundle of the forestry sector combines each intermediate input and a composite of capital and labour in fixed proportions. Land mobility is modelled by the variable f^{vj} (eq. 23). That is, when sectoral land is mobile, f^{vj} 's are treated in the model as exogenous variables and vice versa.

[Place Table 1 here]

There are eight producing sectors and nine commodities as shown in Table 1. All the sectors except for agriculture produce only one commodity. Considerable detail has already been accorded to the agricultural sector in many of the previous CGE models of the Philippines. In this model, the agricultural sector as a whole is disaggregated into two sectors (i.e. agricultural crops and services; and livestock, poultry and fisheries). In other Philippine CGE models, the agricultural sector is disaggregated into three sectors (Bautista, 1986) and into six sectors (Habito, 1984).

Unlike ORANI and Dee (1991) which only have a single representative consumer, this model has three household demand groups, which are based on the classification in the 1990 Social Accounting Matrix (SAM). Equations (24-31) represent household demand and household income. To account for income distribution issues, the SAM's 10 household income groups are used. This further classification of households is needed since the three household classifications exhibit very similar household expenditure shares. The three household aggregation is based on the fact that roughly 50 per cent of the households in the Philippines live below the poverty line. Hence, the first five deciles comprise the first household group, the second household group consists of the sixth to eighth deciles, and the ninth and tenth deciles are grouped into the third income group. Consumers' maximisation of utility and demand is defined by the Stone-Geary linear expenditure system. Consumers are assumed to maximise utility subject to their income levels. The consumption function of household *k* depends on the share of household *k*'s consumption in total household disposable income.

There is a government sector and a foreign sector in the model as represented by equations (32-33). The government derives its income from direct taxes, indirect taxes, stumpage taxes and ownership of forestland as described in equation (34). Zero pure profit conditions (35-42) are specified for each industry to allow non-industry specific inputs to move between industries while also determine the rental prices of factors that are industry-specific. Equations (43-48) represent allocation of investment across industries. There is no attempt to explain aggregate private investment in fixed plant, machinery and buildings.

Market clearing is represented by equations (49-52). Only labour is considered mobile. Capital and land are treated industry-specific, particularly in the short-run and medium-run. The supply of labour, capital and land are assumed to be fixed and exogenously given. Furthermore, for factor markets to clear, these supplies must equal the demands for these factors. The difference between domestic supply and demand for goods is assumed to be equal to net export of those goods to ensure that the market for those goods will clear. A fixed exchange rate regime is assumed since it approximates the managed float exchange rate regime, which has dominated the Philippine foreign exchange market in the past. The economy is treated as a price taker in the world market (53-56). The domestic producer price of a tradable good is equal to the world price of an identical good. The domestic user price of goods produced in the non-tradable sector is given by the domestic producer price plus taxes. The Armington assumption is applied to the imports where imported goods are differentiated from their domestic counterparts, which makes their prices differ. The last group of equations (57-66) provides useful macro-indices. These indices assist in the interpretation of the model results.

DATA BASE AND MODEL ASSUMPTIONS

The 1990 Input-Output (I-O) table is the benchmark used in this study. It is supplemented by the 1990 Social Accounting Matrix (SAM). The values of the elasticity parameters are taken from the literature. The model has nine commodities, eight producing sectors and 10 household income groups. Sensitivity analysis conducted suggests that the simulation results are robust. The model is solved using GEMPACK. The model size was 1,760 variables, and 1,207 equations which allows 553 exogenous variables.

In addition to the I-O table and SAM, data on forestry is based on the *1998 Philippine Forestry Statistics* published by the Department of Environment and Natural Resources

(DENR), *1998 Philippine Asset Accounts* published by the National Statistical Coordination Board (NSCB) and the Philippine Natural Resources Accounting Project headed by DENR. The forestry sub-model used in this study identifies seven forestry growth parameters (i.e. maximum growth, maximum volume, current volume, current age, minimum volume, minimum age, and exponent). The parameterisation of the forestry sub-model is discussed below.

To make the forest sector model operational, a logistic functional form is chosen to describe the physical growth of the forest (Wilen, 1985)

$$F(T) \; = \; \frac{M}{(1\text{-}[1\text{-}M/F(0)]e^{-gT})}$$

where M is the maximum possible volume of timber per hectare and where g is the maximum intrinsic growth rate of trees.

The equations in the forestry sub-model are converted to log-linear form and are parameterised as follows. The maximum stocking rate is set at 247 cubic meters per hectare, equal to the stocking rate in the remaining old growth forests of the Philippines (Philippine Asset Accounts 1998). Along a logistic growth curve, the partial derivative of the timber volume with respect to age is given by

$$\partial F/\partial T = gF(1 - F/M)$$

The maximum intrinsic growth rate is found by solving this expression for g, given $M = 247$, $F = 161.625$, the current average stocking rate across all forests, and $\partial F/\partial T = 1.3$ cubic meters per year (Philippine Asset Accounts 1998). The resulting value is $g = 0.02327$, equivalent to just over 2 per cent per year. $F(0)$, the stocking rate at $t = 0$, is a set value of 100 cubic meters per hectare. Adequately stocked forest is defined as forest area with at least 100 cubic meters per hectare of standing timber. With average harvest assumed at 85 cubic meters per hectare per year[4], F is set at 185 cubic meters per hectare. The values for F, $F(0)$,

g and M are substituted into (A) to derive a value for the rotation period of about 24 years. This seems reasonable, given that the stipulated rotation period in the Philippines is 25 years. However, earlier entry is known to have occurred.

RESULTS

The present paper recognises that it is not possible to analyse certain causes of deforestation in a general equilibrium framework. Based on the causes identified by Angelsen and Kaimowitz (1999), Table 2 summarises the selected causes of deforestation, which are applicable to the Philippines and can be tested using a CGE model.

Table 2. Causes: Effect of Increase in Variable on Deforestation

Variable	Model Type	
	Theoretical	Empirical
Land tenure security	Indeterminate	Increase[a]
Annual Allowable Cut	Increase	Increase
Off-farm wages and employment	Reduce	Reduce
Agricultural output prices	Increase	Increase
Technological progress on frontier farms (direct effects)	Indeterminate	Little evidence
Export Taxes	Indeterminate	Indeterminate
Trade liberalisation	Indeterminate	Increase[a]
Population	Increase	Increase

a. Data may not be reliable

To accommodate the land classification process in the Philippines, two land mobility scenarios are employed. That is, when the Philippine government can effectively implement its land use policy, it is then assumed that land between forestry and agriculture is immobile. Forestlands cannot be converted into agricultural lands and vice versa. Land is mobile among the land-using sectors when the land use policy of the government is not enforced. In addition, agricultural lands can be converted into forestry use through replanting.

To assess the causes of deforestation in the Philippine economy, the elasticities of the variables summarised in Table 2 are examined. The elasticities are derived by simulating the model that is, the variables corresponding to the different causes of deforestation are increased (or decreased) by 1 per cent. All the variables summarised in Table 2 are included in the model. Security of tenure and annual allowable cuts are modelled within the forestry sub-model. Higher forestry discount rates which represent less security of tenure are modelled by increasing the discount rate in forestry via the shift variable, f^{r} while higher annual allowable cuts are modelled by decreasing the minimum age (α_{min}) requirements in the logging sector. To simulate non-availability of off-farm employment, out of the 10 occupational groupings in the model, the level of employment in five[5] are reduced by one per cent. Higher agricultural prices and technological improvement in agriculture are imposed through the technological change variables in the model. Similarly for export tax on logs, trade liberalisation and population growth, the corresponding variables in the model are increased (or decreased) by one per cent.

Table 3 shows the elasticity values of timber volume (in forest areas), harvest per hectare per rotation, rotation period and timber price with respect to the selected causes of deforestation in the Philippines. It is evident that regardless of land mobility, the policy on annual allowable cut has a significant effect on timber volume. This supports the authors claim that logging might have been the primary cause of deforestation in the Philippines. Annual allowable cut in the Philippines has been considered excessive and does not contribute to the long-term benefits of the forestry sector (Tomboc and Mendoza, 1993, 1998). The high annual allowable cut also results in a larger harvest and shorter rotation period. The price of timber is reduced. It is accepted in the literature that insecure tenure, which is associated with high discount rates in forestry results in more deforestation. In both land mobility scenarios, the timber volume is reduced given a 1 per cent increase in the discount rate in forestry. However, the use of a forestry discount rate in either increasing or decreasing the level of deforestation is more significant when sectoral land is mobile. This suggests that security of tenure is crucial in the propagation of forestry resources. The Philippine government can limit the uncertainty inherent in forestry production by enforcing land delineation guidelines.

[Place Table 3 here]

The non-availability of off-farm employment is expected to exacerbate deforestation. Regardless of the land mobility scenario, the price of timber is reduced. The effects on timber volume, timber harvest and rotation period when sectoral land is mobile are positive but relatively smaller compared to the results when land is immobile. Land immobility results in a reduction in timber volume as displaced workers move into forestlands to make a living. The opposite is true in the case of higher agricultural output prices. They lead to a reduction in timber volume only when sectoral land is mobile. This suggests that when agricultural land and forestland are treated as non-competing and proper support to the forestry sector is in place, restricting land movement may result in less deforestation. Technological progress in agriculture results in deforestation when land is immobile. Again, this might be brought about by displaced agricultural workers. The price of timber decreases when land is mobile. There is a very negligible increase in timber volume, almost of the same magnitude as the reduction in the price of timber.

The imposition of an export tax on logs is more effective in increasing the timber volume when land between agriculture and forestry is immobile. The effect of trade liberalisation on timber volume is negative when land is mobile and vice versa. As expected, an export tax would decrease the domestic price of timber and a more liberalised trade would increase the timber price. Population growth may not result in deforestation when land is immobile.

In the literature, the effect of timber prices on deforestation is ambiguous. The results in Table 3 show that regardless of the land mobility condition, timber prices decline with a 1 per cent increase in annual allowable cut, in non-availability of off-farm employment, in agricultural output prices and in export taxes. This suggests that there is no strong correlation between lower timber prices and higher timber volume. Trade liberalisation results in an increase in timber prices in both land mobility scenarios but it reduces timber volume when land is mobile and vice versa.

[Place Table 4 here]

Table 4 shows the macroeconomic impact of the selected causes of deforestation in the Philippines. The elasticity values of real GDP are very small except for high agricultural output prices, technological progress in agriculture and trade liberalisation, which are –0.44 per cent, 0.32 per cent and 0.17 per cent, respectively. The results for these variables are insensitive to the land mobility condition. In the case of higher agricultural output prices, the real wage is reduced by more than the reduction in real GDP. This might be partly due to the increase in the consumer price index (CPI). The level of employment among farmers, foresters and fishermen (FFF) increases more than the reduction in the real wage. The converse is true in the case of technological progress in agriculture. This seems to have a positive effect on the economy, however, the level of employment among FFF is reduced by more than half a per cent, which is larger than the improvement in real GDP. Similarly, trade liberalisation has a positive effect on real GDP but reduces employment among FFF by almost the same magnitude. This might be brought about by the increase in the real wage and the reduction in the CPI. The increase in the annual allowable cut results in a minimal improvement in real GDP. In contrast, the non-availability of off-farm employment leads to a very small reduction in real GDP but increases employment among FFF by almost half a per cent. The level of employment among FFF is reduced by the export tax. This conforms the findings that export taxes are associated with negative welfare effects and production losses. The effects of population growth are very similar between the two land mobility scenarios. It results in a minimal reduction in real GDP.

[Place Tables 5 and 6 here]

The percentage changes in sectoral employment are shown in Tables 5 and 6 for both land mobility scenarios, respectively. In general, there is no significant difference in the results between the two land mobility conditions. There are five producing sectors that differ in their employment results when the discount rate in forestry is increased by one per cent. They are the following: mining, manufacturing, wood and paper manufacturing, construction and services. However, the numbers are relatively small.

The change in the level of employment in the agricultural sector is relatively sensitive to two factors, i.e., the increase in agricultural prices and technological progress in agriculture. The former tends to increase the level of employment in the sector, which is in contrast to the latter with the employment levels in the other sectors moving in the opposite direction. These results are intuitive in the sense that higher agricultural prices make agricultural production profitable, thus, firms can afford to hire more labour to boost production. In contrast, technological advancement may lead to lesser labour inputs as one unit of agricultural output can be produced with lower input requirements. The non-availability of off-farm employment and population growth result in almost 0.2 per cent increase in employment in the agricultural sector. Notice that the former leads to a greater increase in the forestry sector's employment level. These results suggest that when population increases, the agricultural sector absorbs excess labour, however, when there is no employment opportunity for less skilled labour, the forestry sector absorbs more of the excess labour than the agricultural sector. Notice that the sectors, which experience a reduction in employment, are those that might employ labour that has been displaced by the reduction in off-farm employment. Trade liberalisation seems to have a negative effect on most of the sectors except on the non-tradable sectors i.e., construction and services. Whilst, the export tax has resulted in almost a third of a per cent reduction in the forestry sector's employment level, there are no significant positive effects on the other producing sectors.

CONCLUSION

General equilibrium analysis allows the researcher to rank the different mechanisms driving the deforestation process. The paper constructed a CGE model for the Philippines, which included a forestry sub-model that represents the unique characteristics of the forestry sector. The forestry sub-model developed by Dee (1991) is chosen to examine some of the identified causes of deforestation in the literature. The results support the hypothesis that logging is the primary cause of deforestation in the Philippines. The high annual allowable cut and low security of tenure contribute to more deforestation caused by logging processes while trade instruments such as export taxes and import tariffs have minimal effects on the volume of timber. The results also suggest that population growth and other indirect factors such as non-availability of employment in manufacturing and services industries, technological change in agriculture, etc. have less impact on the rate of deforestation than policies directly affecting the harvest volumes (e.g., annual allowable cut). There is no strong correlation between low timber prices and high timber volumes.

Table 1: Mapping of Activities, Commodities and Factors

Activity	**Commodities Produced**	**Factors Used**
Agriculture	Agricultural Crops, Livestock, Poultry, Fishery	Labour, Capital and Land
Forestry	Logs	Composite of Labour-Capital and Land
Mining	Mining	Labour, Capital and Land
Manufacturing	Food and Non-food Products (excluding wood and paper)	Labour and Capital
Wood and Paper Mfg.	Wood and Paper Products	Labour and Capital
Construction	Buildings and Structures	Labour and Capital
Real Estate	Commercial land	Labour, Capital and Land
Services	Services	Labour and Capital

Notes: (a) Labour is divided into 10 occupational groups
(b) Land is considered a homogenous input although when employed by any of the land-using sectors becomes specific to that sector.

Table 3: Elasticities of the identified causes of deforestation in the Philippines (given a 1 percentage-change in the causes, in percentage-change)

Causes	***Land is mobile***				***Land is immobile***			
	Timber volume	Harvest per Rotation	Rotation Period	Timber Price	Timber Volume	Harvest per Rotation	Rotation Period	Timber Price
High discount rate in forestry	-0.1242	-0.2702	-0.8836	0.9229	-0.0088	-0.0191	-0.0625	-0.0652
High annual allowable cut	-1.2751	0.7461	-0.1055	-2.7854	-1.3498	0.5810	-0.6422	-2.1564
Non-availability of off-farm employment	0.0022	0.0049	0.0160	-0.3533	-0.0130	-0.0282	-0.0924	-0.2243
High agricultural output prices	-0.0147	-0.0320	-0.1047	-0.0462	0.0217	0.0473	0.1552	-0.3555
Technological progress in agriculture	0.0143	0.0311	0.1020	-0.0140	-0.0205	-0.0446	-0.1461	0.2821
Export tax	0.0024	0.0052	0.0170	-0.0208	0.0339	0.0739	0.2423	-0.2898
Trade liberalisation	-0.0024	-0.0052	-0.0169	0.0775	0.0041	0.0089	0.0292	0.0226
Population growth	-0.0047	-0.0102	-0.0335	0.0370	0.0023	0.0051	0.0166	-0.0228

Table 4: Macroeconomic impact of the causes of deforestation in the Philippines (in elasticity values)

	Land is mobile						*Land is immobile*					
Given a 1 percentage-change in variables	Real GDP	Exports	Imports	CPI	FFF Empl.	Real wage	Real GDP	Exports	Imports	CPI	FFF Empl.	Real wage
High discount rate in forestry	-0.0069	-0.0025	-0.0019	-0.0030	-0.0011	-0.0092	0.0004	0.0001	0.0000	0.0001	0.0004	0.0011
High annual allowable cut	0.0277	0.0092	0.0075	0.0060	-0.0015	0.0426	0.0229	0.0074	0.0063	0.0039	-0.0027	0.0361
Non-availability of off-farm employment	-0.0092	-0.3001	0.0253	-0.0500	0.4543	-0.0154	-0.0105	-0.2996	0.0251	-0.0503	0.4541	-0.0174
High agricultural output prices	-0.4448	-0.1835	-0.2008	0.1171	0.6223	-0.5012	-0.4416	-0.1839	-0.2010	0.1173	0.6230	-0.4954
Technological progress in agriculture	0.3253	0.2134	0.2044	-0.0884	-0.5658	0.3395	0.3222	0.2137	0.2045	-0.0887	-0.5662	0.3340
Export tax	-0.0007	-0.0006	0.0002	-0.0013	-0.0041	0.0012	0.0013	0.0001	0.0007	-0.0004	-0.0037	0.0040
Trade liberalisation	0.1749	1.1186	0.8206	-0.1648	-0.1222	0.6628	0.1756	1.1183	0.8204	-0.1648	-0.1221	0.6642
Population growth	-0.0096	0.0169	0.0105	-0.0017	0.1649	-0.0054	-0.0087	0.0165	0.0103	-0.0018	0.1650	-0.0037

Table 5: Elasticity of total employment in industries when land is mobile

Causes	Agriculture	Forestry	Mining	Manufacturing	Wood/Paper	Construction	Real Estate	Services
High discount rate in forestry	-0.0016	0.0331	0.0055	0.0056	-0.0326	-0.0067	-0.0020	0.0012
High annual allowable cut	-0.0024	0.0552	-0.0171	-0.0143	0.1000	0.0271	0.0073	-0.0022
Non-availability of off-farm employment	0.1768	0.3554	-0.9091	-0.4752	-0.4276	-0.1967	0.4132	0.0372
High agricultural output prices	0.6427	-0.1355	-0.1102	-0.2802	-0.1924	-0.3410	-0.3153	-0.2531
Technological progress in agriculture	-0.5848	0.1482	0.1546	0.2684	0.2014	0.2661	0.2480	0.2351
Export tax	0.0006	-0.3250	0.0045	0.0023	0.0031	0.0007	0.0000	0.0018
Trade liberalisation	-0.1218	-0.2184	-0.6281	-0.2682	-0.0551	0.0847	-0.1839	0.2002
Population growth	0.1696	-0.0219	0.0356	0.0570	0.0009	-0.0766	-0.3768	-0.0748

Table 6: Elasticity of total employment in industries when land is immobile

Causes	Agriculture	Forestry	Mining	Manufacturing	Wood/Paper	Construction	Real Estate	Services
High discount rate in forestry	-0.0003	0.0440	-0.0005	-0.0005	0.0022	0.0006	-0.0002	-0.0002
High annual allowable cut	-0.0032	0.0295	-0.0130	-0.0102	0.0777	0.0224	0.0062	-0.0012
Non-availability of off-farm employment	0.1767	0.3532	-0.9085	-0.4741	-0.4320	-0.1980	0.4122	0.0375
High agricultural output prices	0.6433	-0.1302	-0.1107	-0.2832	-0.1818	-0.3373	-0.3122	-0.2539
Technoligical progress in agriculture	-0.5852	0.1444	0.1550	0.2712	0.1912	0.2625	0.2450	0.2358
Export tax	0.0010	-0.3233	0.0029	0.0007	0.0126	0.0027	0.0005	0.0015
Trade liberalisation	-0.1217	-0.2176	-0.6280	-0.2689	-0.0533	0.0856	-0.1830	0.2000
Population growth	0.1697	-0.0211	0.0358	0.0561	0.0029	-0.0755	-0.3757	-0.0750

APPENDICES

Table 7
Equations of the CGE Model of the Philippines in Linear Percentage Change Forms

Identifier	Equation	Number	Subscript range
INPUT DEMANDS AND COMMODITY SUPPLIES			
Intermediate input demand			
1.	$x_{(is)j} = z_j + a_{ij} - \sigma_{ij}\left(p_{(is)j} - \sum_{s=1}^{2} S_{(is)j}\, p_{(is)j} \right)$	$2gh$	$i = 1,\ldots, g$; $j = 1,\ldots, h$; $s = 1, 2$
Demand for labour by occupational groups			
2.	$x_{(g+1,L,m)j} = x_{(g+1,L)j} - \sigma_{(g+1,L)j}\left(p_{(g+1,L,m)j} - \sum_{m=1}^{10} S_{(g+1,L,m)j}\, p_{(g+1,L,m)j} \right)$	mh	$m = 1, \ldots, 10$; $j = 1,\ldots, h$
Demand for primary factors (non-forestry)			
3.	$x_{(g+1,v)j} = z_j + a_{(g+1)j} - \sigma_{(g+1)j}\left(p_{(g+1,v)j} - \sum_{v=1}^{3} S_{(g+1,v)j}\, p_{(g+1,v)j} \right)$	$v(h$-1)	$j \neq 2$; $v = 1, 2, 3$
Demand for primary factors (forestry)			
4.	$x_{(g+1,v)j} = z_j + a_{(g+1)j} - \sigma_{(g+1)j}\left(p_{(g+1,v)j} - \sum_{v=1}^{2} S_{(g+1,v)j}\, p_{(g+1,v)j} \right)$	v-1	$j = 2$; v = 1 (labour), 2 (capital)
Price of labour			
5.	$p_{(g+1,L)j} = \sum_{m=1}^{10} p_{(g+1,L,m)j} S_{(g+1,L,m)j}$	h	$j = 1,\ldots, h$; $m = 1, \ldots, 10$
Supply of commodities by industry			
6.	$x^{(0)}_{(id)j} = z_j + \sigma^{(0)}_{ij}\left(p^{(0)}_{(id)j} - \sum_{i=1}^{g} R_{(id)j}\, p^{(0)}_{(id)j} \right)$	gh	$i = 1,\ldots,g$; $j = 1, \ldots, h$

Table 7 ***(continued)***

Identifier	*Equation*	*Number*	*Subscript range*
Inputs to capital creation			
7.	$x^{K}_{(is)j} = y_j - \sigma^{K}_{ij}\left[p^{K}_{(is)j} - \sum_{s=1}^{2} S^{K}_{(is)j} p^{K}_{(is)j} \right]$	$2gh$	$i = 1,\ldots,g;\; j = 1,\ldots,h;\; s = 1, 2$
FORESTRY SUB-MODEL			
Timber volume per hectare as a percentage of harvest age			
8.	$vol_{tim} = S_{vol}\alpha$	1	$j = 2$
Timber volume per hectare that must be left standing			
9.	$vol_{s\tan d} = S_{env}\alpha_{\min}$	1	$j = 2$
Harvest volume per hectare per rotation			
10.	$vol_{harv} = S_{harv} vol_{tim} + (1 - S_{harv}) vol_{s\tan d}$	1	$j = 2$
Rotation period			
11.	$t_{rot} = S_{rot}\alpha + \left(1 - S_{rot}\right)\alpha_{min}$	1	$j = 2$
Partial derivative of timber volume with respect to age			
12.	$vol_{grow} = S_{vo\lg} vol_{tim}$	1	$j = 2$
Price index of non-land inputs into forestry			
13.	$p^{\tilde{n}}_{(g+1)j} = \sum_{i=1}^{g}\sum_{s=1}^{2} H^{\tilde{n}}_{(is)j}\, p_{(is)j} + \sum_{s=1}^{2} H^{\tilde{n}}_{(g+1,s)j}\, p_{(g+1,s)j}$	1	$j = 2$ $s = 1$ (labour), 2(capital)
Forestry non-land costs per hectare per rotation			
14.	$c_{rot} = p^{\tilde{n}}_{(g+1)j} + x^{\tilde{n}}_{(g+1)j}$	1	$j = 2$

Table 7 *(continued)*

Identifier ***Equation***	***Number***	***Subscript range***
Forestry net revenue per hectare per rotation		
15. $rev_{rot} = S_{rev}\left[p^{(0)}_{(rd)j} + vol_{tim}\right] + (1 - S_{rev})c_{rot} + S_{tn}t^{(1)}_{for}$	1	$j = 2$
Partial derivative of forestry's net revenue with respect to harvestable volume		
16. $rev_{grow} = p^{(0)}_{(rd)j} + t^{(1)}_{for}$	1	$j = 2$
First order condition for optimal rotation		
17. $rev_{grow} + vol_{grow} = r + f^{r} + rev_{rot} - S_{opt}\left[r + f^{r} + t_{rot}\right]$	1	$j = 2$
Forestry total output per year		
18. $x^{(0)}_{(rd)j} = vol_{harv} + x_{(g+1,s)j} - t_{rot}$	1	$j = 2$; $s = 3$ (land)
Forestry total non-land inputs per year		
19. $z_{j} = x^{\tilde{n}}_{(g+1)j} + x_{(g+1,s)j} - t_{rot}$	1	$j = 2$; $s = 3$ (land)
Zero pure profits in forestry		
20. $p^{(0)}_{(id)j} + x^{(0)}_{(id)j} = H^{\tilde{n}}_{(g+1)f}\left(p^{\tilde{n}}_{(g+1)j} + z_{j}\right) + \left[1 - H^{\tilde{n}}_{(g+1)f}\right]\left(p_{(g+1,N)j} + x_{(g+1,s)j}\right)$	1	$j = 2$; $s = 3$ (land)
Stock value per hectare of forestland		
21. $v_{(g+1,N)j} = rev_{rot} - S_{val}(r + f^{r} + t_{rot}) - S_{opt}(r + f^{r} + t_{rot})$	1	$j = 2$
Stock value per hectare of non-forestland		
22. $v_{(g+1,N)j} = p_{(g+1,N)j} + \tau_{(g+1,N)j} - r$	h-1	$j \neq 2$

Table 7 ***(continued)***

Identifier	*Equation*	*Number*	*Subscript range*
Allocation of mobile land			
23.	$v_{(g+1,N)j} = v_{(N^*)} + f^{vj}$	h	$j = 1,\ldots, h$
HOUSEHOLD, FOREIGN AND GOVERNMENT DEMANDS, HOUSEHOLD AND GOVERNMENT INCOME			
Household demand for good i by source			
24.	$x^H_{(is)k} = x^H_{ik} - \sigma^H_{ik}\left[p^H_{(is)k} - \sum_s S^H_{(is)k}\, p^H_{(is)k}\right]$	$2gk$	$i = 1,\ldots,g$; $k = 1, 2, 3$; $s = 1, 2$
Price paid by household			
25.	$p^H_{ik} = \sum_s S^H_{(is)k}\, p^H_{(is)k}$	gk	$i = 1,\ldots,g$; $k = 1, 2, 3$
Household demand for good i			
26.	$x^H_{ik} - q_k = \varepsilon_{ik}(c_k - q_k) + \sum_r \eta_{(ir)k}\, p^H_{rk}$	gk	$i,h = 1,\ldots,g$; $k = 1, 2, 3$
Household disposable income			
27.	$y^H = \sum_{j=1}^{h}\sum_{m=1}^{10}\left(p_{(g+1,L,m)j} + x_{(g+1,L,m)j}\right)\upsilon^H_{(g+1,L,m)j} + \sum_{j=1}^{h}\left(p_{(g+1,K)j} + x_{(g+1,K)j}\right)\upsilon^H_{(g+1,K)j} + \sum_{j\neq 2}\left(p_{(g+1,N)j} + x_{(g+1,N)j}\right)\upsilon^H_{(g+1,N)j}$	1	
Household consumption function			
28.	$c_k = f^H_k + f^H + y^H - \left(T_{(H,Y)} \big/ 1 - T_{(H,Y)}\right) t_{(H,Y)}$	k	
Aggregate household consumption			
29.	$c = \sum_{k=1}^{3} c_k \psi_k$	1	

Table 7 *(continued)*

Identifier	*Equation*	*Number*	*Subscript range*
Aggregate real household consumption			
30.	$c_R = c - \xi^H$	1	
Household disposable income by household decile			
31.	$y_d^H = \sum_{d=1}^{10} w_d^H \left[y^H - \left(T_{(H,Y)} \big/ 1 - T_{(H,Y)} \right) t_{(H,Y)} \right]$	10	$d = 1, \ldots, 10$
Foreign demand			
32.	$x_{(id)}^E - f_{(Qi)}^E = -\gamma_i p_{(id)}^E + f_{(Pi)}^E$	g	$i = 1,\ldots,g$
Government demand			
33.	$x_{(is)}^G = c_R + h_{(is)}^G + f_{(is)}^G$	$2g$	$i = 1,\ldots,g$; $s = 1, 2$
Government revenue is given by indirect taxes including the stumpage tax			
34.	$y_G = \sum_{i=1}^{g} t_{(M,i)} G_{t(M,i)} + \sum_{i=1}^{g} \left(p_{(im)}^M + \phi + x_{(im)}^M \right) J_{(M,i)}^G + \sum_{i=1}^{g} t_{(E,i)} G_{t(E,i)} + \sum_{i=1}^{g} \left(p_{(id)}^{(0)} + x_{(id)}^E \right) J_{(E,i)}^G + \sum_{k=1}^{3} \sum_{i=1}^{g} \sum_{s=1}^{2} t_{(H,is)} G_{t(H,is)k} + \sum_{k=1}^{3} \sum_{i=1}^{g} \sum_{s=1}^{2} \left(p_{(is)}^{(0)} + x_{(is)k}^H \right) J_{(H,is)k}^G + \sum_{i=1}^{g} \sum_{s=1}^{2} t_{(G,is)} G_{t(G,is)} + \sum_{i=1}^{g} \sum_{s=1}^{2} \left(p_{(is)}^{(0)} + x_{(is)}^G \right) J_{(G,is)}^G + \sum_{j=1}^{h} \sum_{i=1}^{g} \sum_{s=1}^{2} t_{(Ip,is)j} G_{t(Ip,is)j} + \sum_{j=1}^{h} \sum_{i=1}^{g} \sum_{s=1}^{2} \left(p_{(is)}^{(0)} + x_{(is)j} \right) J_{(Ip,is)j}^G + \sum_{j=1}^{h} \sum_{i=1}^{g} \sum_{s=1}^{2} t_{(K,is)j} G_{t(K,is)j} + \sum_{j=1}^{h} \sum_{i=1}^{g} \sum_{s=1}^{2} \left(p_{(is)}^{(0)} + x_{(is)j}^K \right) J_{(K,is)j}^G + \sum_{k=1}^{3} \left(t_{(H,Y)k} + y_{Hk} \right) J_{(H,Y)k}^G + \left(p_{(g+1,N)j=2} + x_{(g+1,N)j=2} \right) J_{(g+1,N)j=2}^G + p_{(id)j=2}^{(0)} + x_{(g+1)j=2} - t_{for}^{(1)} G_{(stump)}$	1	

Table 7 *(continued)*

Identifier	*Equation*	*Number*	*Subscript range*
ZERO PURE PROFIT EQUATIONS			
Zero pure profits in production			
35.	$\sum_{i=1}^{g} p_{(rd)}^{(0)} H_{(rd)j}^{(0)} = \sum_{i=1}^{g}\sum_{s=1}^{2} p_{(is)j} H_{(is)j} + \sum_{m=1}^{10} p_{(g+1,L,m)j} H_{(g+1,L,m)j} + p_{(g+1,K)j} H_{(g+1,K)j} + p_{(g+1,N)j} H_{(g+1,N)j} + \sum_{i=1}^{g+1} a_{ij} H_{ij}$	h-1	$j \neq 2;\ r \neq 3$
Zero pure profits in capital creation			
36.	$\pi_j = \sum_{i=1}^{g}\sum_{s=1}^{2} p_{(is)j}^{K} H_{(is)j}^{K}$	h	$j = 1,\ldots,h$
Zero pure profits in importing			
37.	$p_{(im)}^{(0)} = p_{(im)}^{M} + \phi + H_{(im)}^{M} t_{(M,i)}$	g	$i = 1,\ldots,g$
Zero pure profits in exporting			
38.	$p_{(id)}^{E} + \phi = p_{(id)}^{(0)} + H_{t(E,i)} t_{(E,i)}$	g	$i = 1,\ldots,g$
Zero pure profits in the distribution of goods to domestic users			
39.	$p_{(is)j} = p_{(is)}^{(0)} + H_{t(Ip,is)j} t_{(Ip,is)j}$	$2gh$	$i = 1,\ldots,g;\ j = 1,\ldots,h;\ s = 1, 2$
40.	$p_{(is)j}^{K} = p_{(is)}^{(0)} + H_{t(K,is)j} t_{(K,is)j}$	$2gh$	$i = 1,\ldots,g;\ j = 1,\ldots,h;\ s = 1, 2$
41.	$p_{(is)k}^{H} = p_{(is)}^{(0)} + H_{t(H,is)k} t_{(H,is)}$	$2gk$	$i = 1,\ldots,g;\ k=1,2,3;\ s = 1, 2$
42.	$p_{(is)}^{G} = p_{(is)}^{(0)} + H_{t(G,is)} t_{(G,is)}$	$2g$	$i = 1,\ldots,g;\ s = 1, 2$

Table 7 *(continued)*

Identifier	*Equation*	*Number*	*Subscript range*
ALLOCATION OF INVESTMENT ACROSS INDUSTRIES			
Rates of return on capital in each industry			
43.	$r_j(0) = Q_j\left(p_{(g+1,K)j} - \pi_j\right)$	h	$j = 1,\ldots,h$
Equality of rates of return across industries			
44.	$-\beta_j\left(k_j(1) - k_j(0)\right) + r_j(0) = \omega$	$h-1$	$j \in J$
Capital accumulation			
45.	$k_j(1) = k_j(0)\left(1 - G_j\right) + y_j G_j$	h	$j = 1,\ldots,h$
Investment budget			
46.	$\sum_{j \in J}\left(\pi_j + y_j\right)\Re_j = \left(\sum_{j \in J}\Re_j\right)i$	1	
Equations for handling exogenous investment			
47.	$y_j = i_R + f^K$	1	$j \notin J$
Real private investment expenditure			
48.	$i_R = i - \xi^K$	1	
MARKET CLEARING EQUATIONS			
Demand equals supply for domestically produced goods			
49.	$x_{(rd)}^{(0)} = \sum_{j=1}^{h} x_{(rd)j} B_{(rd)j} + \sum_{j=1}^{h} x_{(rd)j}^{K} B_{(rd)j}^{K} + \sum_{k=1}^{3} x_{(rd)k}^{H} B_{(rd)k}^{H} + x_{(rd)}^{G} B_{(rd)}^{G} + x_{(rd)}^{E} B_{(rd)}^{E}$	g	$r = 1,\ldots,g$

Table 7 *(continued)*

Identifier	*Equation*	*Number*	*Subscript range*
Total output of commodities (*rd*)			
50.	$x^{(0)}_{(rd)} = \sum_{j=1}^{h} x^{(0)}_{(rd)j} B^{(0)}_{(rd)j}$	*g*-1	$r \neq 3; \quad j \neq 2$
Demand equals supply for labour of each skill group			
51.	$\ell_m = \sum_{j=1}^{h} x_{(g+1,L,m)j} B_{(g+1,L,m)j}$	*m*	$m = 1, \ldots, 10$
Demand equals supply for capital			
52.	$k_j(0) = x_{(g+1,K)j}$	*h*	$j = 1,\ldots,h$
AGGREGATE IMPORTS, EXPORTS AND THE BALANCE OF TRADE			
Import volumes			
53.	$x^M_{(rm)} = \sum_{j=1}^{h} x_{(rm)j} B^{Ip}_{(rm)j} + \sum_{j=1}^{h} x^K_{(rm)j} B^K_{(rm)j} + \sum_{k=1}^{3} x^H_{(rm)k} B^H_{(rm)k} + x^G_{(rm)} B^G_{(rm)}$	*g*	$r = 1,\ldots,g$
Foreign currency value of imports			
54.	$m = \sum_{r=1}^{g} \left(p^M_{(rm)} + x^M_{(rm)}\right) M_{(rm)}$	1	
Foreign currency value of exports			
55.	$e = \sum_{r=1}^{g} \left(p^e_{(rd)} + x^E_{(rd)}\right) E_{(rd)}$	1	
Balance of trade/GDP			
56.	$100\Delta B = Ee - Mm - \left(E - M\right) * gdpe$	1	

Table 7 *(continued)*

Identifier	*Equation*	*Number*	*Subscript range*
MACRO INDICES, WAGE INDEXATION AND GROSS DOMESTIC PRODUCT			
Consumer price index			
57.	$\xi^{\mathrm{H}} = \sum_{s=1}^{2}\sum_{i=1}^{g} w_{(is)}^{H} p_{(is)}^{H}$	1	
Capital-goods price index			
58.	$\xi^{K} = \sum_{j\in J}\Re_j \pi_j$	1	
Total employment demand			
59.	$\ell = \sum_{j=1}^{h}\sum_{m=1}^{10} x_{(g+1,L,m)j} B_{(g+1,L)mj}$	1	
Total demand for capital			
60.	$k(0) = \sum_{j=1}^{h} k_j(0) B_{(g+1,K)j}$	1	
Total supply of land			
61.	$n = \sum_{j=1}^{h} x_{(g+1,N)j} B_{(g+1,N)j}$	1	
Flexible handling of wages by occupation and industry			
62.	$p_{(g+1,L,m)j} = h_{(g+1,L,m)j}\xi^{H} + f_{(g+1,L)} + f_{(g+1,L)j} + f_{(g+1,L,m)} + f_{(g+1,L,m)j}$	*mh*	$m = 1, \ldots, 10;\ j = 1,\ldots,h$

Table 7 *(continued)*

Identifier	***Equation***	***Number***	***Subscript range***
Gross domestic product			
63.	$gdpe = \sum_{i=1}^{g}\sum_{s=1}^{2}\sum_{k=1}^{3}\left(p_{(is)k}^{H} + x_{(is)k}^{H}\right)S_{gdp,k}^{H} + \sum_{i=1}^{g}\sum_{s=1}^{2}\sum_{j=1}^{h}\left(p_{(is)j}^{K} + x_{(is)j}^{K}\right)S_{gdp,j}^{K} + \sum_{i=1}^{g}\sum_{s=1}^{2}\left(p_{(is)}^{G} + x_{(is)}^{G}\right)S_{gdp,is}^{G} + \sum_{i=1}^{g}\left(p_{(id)}^{E} + x_{(id)}^{E}\right)S_{gdp,i}^{E} - \sum_{i=1}^{g}\left(p_{(im)}^{M} + x_{(im)}^{M} + \phi\right)S_{gdp,i}^{M}$	1	
GDP price deflator			
64.	$pgdpe = \sum_{i=1}^{g}\sum_{s=1}^{2}\sum_{k=1}^{3} w_{(is)k}^{H}\, p_{(is)k}^{H} + \sum_{i=1}^{g}\sum_{s=1}^{2}\sum_{j=1}^{h} w_{(is)j}^{K}\, p_{(is)j}^{K} + \sum_{i=1}^{g}\sum_{s=1}^{2} w_{(is)}^{G}\, p_{(is)}^{G} + \sum_{i=1}^{g} w_{(id)}^{E}\, p_{(id)}^{E} - \sum_{i=1}^{g} w_{(im)}^{M}\left(p_{(im)}^{M} + \phi\right)$	1	
Average nominal wage			
65.	$p_{(g+1,L)} = \sum_{j=1}^{h}\sum_{m=1}^{10} p_{(g+1,L,m)j}\, w_{(g+1,L)mj}$	1	
Real wage			
66.	$realwage = p_{(g+1,L)} - \xi^{H}$	1	
Total number of equations		$9gh + 10g + 12h + 2mh + m + k + 6gk + 38$	

Notes:
Number of commodities ($g = 9$) and industries ($h = 8$).
When $s,v = 1$ (labour), $s,v = 2$ (capital) and $s,v = 3$ (land).
When $s = 1$ (domestic) and $s = 2$ (imported); $m = 10$ and $k = 3$.

Table 8
Variables of the Model

Notation	*Variable*	*Number*
Basic Demands for commodities (excluding margin demands)		
(all,i,COM)(all,s,SRC)(all,j,IND)		4*gh*
$x_{(is)j}$	-Intermediate basic demands	
$x^{K}{}_{(is)j}$	-Investment basic demands	
(all,i,COM)(all,s,SRC)(all,k,HH)		2*gk*
$x^{H}{}_{(is)k}$	-Household basic demands	
(all,i,COM)(all,k,HH)		*gk*
$x^{H}{}_{ik}$	-Household demand of good *i* aggregated over *s*	
(all,i,COM)		*g*
$x^{E}_{(id)}$	-Export basic demands	
(all,i,COM)(all,s,SRC)		2*g*
$x^{G}_{(is)}$	-Government basic demands	
(all,i,COM)(all,s,SRC)		2*g*
$p^{0}_{(is)}$	-Basic prices by commodity and source	
(all,i,COM)(all,s,SRC)		4*g*
$f^{G}_{(is)}$	-Government demand shift	
$h^{G}_{(is)}$	-Ratio between overall shift in government demand and real aggregate household consumption	
Powers of Commodity Taxes on Basic Flows		
(all,i,COM)(all,s,SRC)(all,j,IND)		4*gh*
$t_{(Ip,is)j}$	-Power of tax on intermediate	
$t_{(K,is)j}$	-Power of tax on investment	
(all,i,COM)(all,s,SRC)		4*g*
$t_{(H,is)}$	-Power of tax on household	
$t_{(G,is)}$	-Power of tax on government	
(all,i,COM)		*g*
$t_{(E,i)}$	-Power of tax on export	
Purchaser's Prices (including taxes)		
(all,i,COM)(all,s,SRC)(all,j,IND)		4*gh*
$p_{(is)j}$	-Purchaser's price, intermediate	
$p^{K}{}_{(is)j}$	-Purchaser's price, investment	
(all,i,COM)(all,s,SRC)(all,k,HH)		2*gk*
$p^{H}{}_{(is)k}$	-Purchaser's price of good *i* from source s for household *k*	
(all,i,COM) (all,k,HH)		*gk*
$p^{H}{}_{ik}$	-Purchaser's price of good *i* household *k*	
(all,i,COM)		*g*
$p^{E}{}_{(id)}$	-Purchaser's price, exports in Pesos (₱)	
(all,i,COM)(all,s,SRC)		2*g*
$p^{G}{}_{(is)}$	-Purchaser's price, government	
Variables relating to usage of labour, occupation m, in industry j		
(all,j,IND)(all,m,OCC)		3*mh*

Table 8 (continued)

Notation	***Variable***	***Number***
$x_{(g+1,L,m)j}$	-Employment by industry and occupation	
$p_{(g+1,L,m)j}$	-Wages by industry and occupation	
$f_{(g+1,L,m)j}$	-Wage shift variable	
Variables relating to usage of fixed capital in industry i		
(all,j,IND)		2*h*
$x_{(g+1,K)j}$	-Current capital stock	
$p_{(g+1,K)j}$	-Rental price of capital	
Variables relating to usage of land		
(all,j,IND)		2*h*
$x_{(g+1,N)j}$	-Use of land	
$p_{(g+1,N)j}$	-Rental price of land	
Variables relating to commodity supplies, import duties and stocks		
(all,i,COM)(all,j,IND)		*gh*
$x^{(0)}_{(id)j}$	-Output by commodity and industry	
(all,i,COM)		*g*
$t_{(M,i)}$	-Power of tariff	
Miscellaneous vector variables		
(all,m,OCC)		2*m*
l_m	-Employment by skill group	
$f_{(g+1,L)m}$	-Occupation-specific wage shifter	
(all,i,COM)		5*g*
$f^{E}_{(Pi)}$	-Price (upward) shift in export demand schedule	
$f^{E}_{(Qi)}$	-Quantity (right) shift in export demands	
$p^{M}_{(im)}$	-C.I.F. foreign currency import prices	
$x^{(0)}_{rd}$	-Output of commodities	
$x^{M}_{(rm)}$	-Total supplies of imported goods	
(all,j,IND)		7*h*
a_{ij}	-All input i ($i = 1, \ldots, g+1$) augmenting technical change	
$f_{(g+1,L)j}$	-Industry-specific wage shifter	
$p_{(g+1,L)j}$	-Price of labour composite	
π_j	-Cost of unit of capital	
$x_{(g+1,L)j}$	-Effective labour input	
z_j	-Activity level or value-added	
y_j	-Investment by using industry	
Investment variables		
(all,j,IND)		3*h*+5

Table 8 (continued)

Notation	*Variable*	*Number*
$r_j\,(0)$	-Rates of return on capital	
$k_j\,(0)$	-Current capital stocks	
$k_j\,(1)$	-future capital stocks	
f^K	-Investment shifter	
ω	-Economy wide expected rate of return on capital	
i	-Aggregate private investment expenditure	
i_R	-Aggregate real private investment expenditure	
ξ^K	-Aggregate investment price index	
Variables in Household consumption equations and Household and government income (All,k,HH)		3*k*+14
c_k	-Nominal household k's consumption	
q_k	-Number of Households	
f_k^H	-Shift Term for the consumption of household *k*	
c	-Nominal total household consumption	
y^H	-Total household income	
y_d^H	-Income of household decile *d*	
$t_{(H,Y)}$	-Tax rate on household income	
y_G	-Government income from tax collection and forestland ownership	
Forestry Variables (all,j,FOR)		16
$p_{(g+1)j}^{\tilde{n}}$	-Price index of non-land inputs into forestry	
$x_{(g+1)j}^{\tilde{n}}$	-Non-land inputs into forestry	
c_{rot}	-Total cost per rotation for given harvest age	
rev_{rot}	-Net revenue per hectare per rotation for varying harvest ages	
t_{rot}	-Rotation period	
α	-Age of Trees	
α_{min}	-Minimum harvest age	
vol_{harv}	-Harvest volume per rotation	
vol_{tim}	-timber volume	
$vol_{s\tan d}$	-environmental constraint (i.e. standing timber volume left after harvest)	
vol_{grow}	-Partial derivative of volume with respect to age	
rev_{grow}	-Partial. derivative. of net revenue with respect to harvestable volume	
f^r	-Shift in discount rate in forestry	
r	-(interest) discount rate	
$v_{(N^*)}$	-Economy-wide stock price of land	

Table 8 (continued)

Notation	*Variable*	*Number*
$t_{for}^{(1)}$	-Power of the tax on land income of forestland	
(all,j,IND)		3h-1
$v_{(g+1,N)j}$	-Stock value per hectare of land	
f^{vj}	-Shift term in the stock price of land	
$\tau_{(g+1,s)j}$	-Power of tax on land on income of non-forestland	
Scalar or macro variables		*17*
ΔB	-(Balance of trade)/GDP	
ξ^{H}	-Consumer Price Index	
c_R	-Real Household Consumption	
ℓ	-Aggregate employment: wage bill weights	
$k(0)$	-Aggregate capital stock	
n	-Total supply of land	
$f_{(g+1,L)}$	-Overall wage shifter	
f^{H}	-Ratio of total household consumption to total household disposable income	
$h_{(g+1,L,m)}$	-wage indexation parameter	
Φ	-Exchange rate, ₱/\$world	
m	-Foreign currency value of imports	
e	-Foreign currency value of exports	
gdpe	-Nominal GDP from expenditure side	
pgdpe	-GDP price deflator	
$p_{(g+1,L)}$	-average nominal wage	
realwage	-real wage	
Total number of variables	=13gh + 23g + 17h + 3mh + 2m + 3k + 6gk +50	

Notes:
When k = 3, m = 10 and s = 1 (domestic) and s = 2 (imported).
When (all,j,IND) means for all industry *j*.
When (all,i,COM) means for all commodity *i*.
When (all,s,SRC) means for all source *s*.
When (all,k,HH) means for all household *k*.

Table 9
Parameters and Coefficients of the Model

Notation	Description
	Defining coefficients of the forestry sub-model based on a logistic yield curve
S_{vol}, S_{env}	-parameters in the growth equation and the environmental constraint, respectively
S_{rot}	-parameter in equation defining rotation period
S_{harv}	-parameter in equation defining harvest yield
S_{volg}	-parameter in the partial derivative of growth equation
S_{rev}	-parameter in the net revenue equation
S_{tn}	-share of stumpage fees in the total value of forestland
S_{opt}	-parameter in the Faustmann formula
S_{val}	-parameter in the stock value of land equation
	Input demand, household demand and prices
$S_{(is)j}$	-share of intermediate input in total cost of intermediate inputs
$S_{(g+1,L,m)j}$	-share of labour input in total cost of labour inputs

$S_{(g+1,v)j}$	-share of primary factor input in total cost of primary factors inputs
$S^{K}_{(is)j}$	-share of intermediate input in total cost of capital production
$S^{H}_{(is)k}$	-share of good (*is*) in total demand of household *k*
ψ_k	-share of household *k*'s consumption in total household consumption
σ, γ_i, ε_{ik}, $\eta_{(ir)k}$	-elasticity of substitution, expenditure, own- and cross- price elasticity and export demand elasticity
	Shares in Zero-pure profit equations, price index
$H^{\tilde{n}}_{(is)j}$	-share of intermediate inputs in total cost of non-land inputs
$H^{\tilde{n}}_{(g+1,s)j}$	-share of capital and labour inputs in total cost of non-land inputs
$H^{\tilde{n}}_{(g+1)f}$	-share of non-land inputs in total cost of production in forestry
$H^{(0)}_{(rd)j}$	-share of industry *j*'s revenue accounted for by its sales of commodity *rd*
$H_{(is)j}$	-share of industry *j*'s costs accounted for by inputs of (*is*)
$H_{(g+1,L,m)j}$	-share of industry *j*'s costs accounted for by inputs of labour *m*
$H_{(g+1,K)j}$	-share of industry *j*'s costs accounted for by inputs of capital
$H_{(g+1,N)j}$	-share of industry *j*'s costs accounted for by inputs of land
H_{ij}	-share of technological coefficients
$H^{K}_{(is)j}$	-share of good (*is*) in the costs of constructing a unit of capital for industry *j*
$H^{M}_{(im)}$	-share in the basic price of (*im*) accounted for by the foreign currency price including tariffs
$H_{t(E,i)}$	-share accounted for by the export tax for units of (*id*) at Philippine ports
$H_{t(U,is)}$	-share accounted for by the sales tax in the purchaser's prices of good (*is*) for intermediate production, for capital formation (*K*), for household consumption (*H*) and government consumption (*G*)
	Output supply, household income and government income
$R_{(id)j}$	-share of commodity *i* in the total production of industry *j*
$J^{H}_{(g+1,L,m)j}$	-share of labour income in total household income
$J^{H}_{(g+1,K)j}$	-share of capital income in total household income
$J^{H}_{(g+1,N)j}$	-share of income from non-forestland ownership
$T_{(H,Y)}/(1-T_{(H,Y)})$	-taxes on household income as a fraction of net household income
w^{H}_{d}	-share of household decile *d*'s income in total household disposable income
$G_{t(M,i)}$	-value of imports of commodity *i* divided by government income
$J^{G}_{(M,i)}$	-revenue from tariffs on good *i* as a share of government income
$G_{t(E,i)}$	-value of exports of commodity *i* divided by government income
$J^{G}_{(E,i)}$	-revenue from export taxes on good *i* as a share of government income
$G_{t(H,is)\,k}$	-value of commodity *i* consumed by households divided by government income
$J^{G}_{(H,is)\,k}$	-indirect taxes on good *i* consumed by households as a share of government income
$G_{t(G,is)}$	-value of good *i* consumed by the government divided by government income
$J^{G}_{(G,is)}$	-indirect taxes on commodity *i* consumed by the government as a share of government income

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FOOTNOTES

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[2] The Department of Environment and Natural Resources (DENR) defines brushland as 'degraded or untimbered areas dominated by a discontinuous cover of shrubby vegetation (1998 Philippine Forestry Statistics).

[3] The forestry sector aggregates labour and capital only.

[4] Harvest is allowed from 60 cubic meters to 110 cubic meters per hectare per year. These figures are gathered during an interview with Dr. Antonio Carandang, one of the members of the Philippine Natural Resources Accounting Project.

[5] The five occupational groupings are as follows: (1) service and shop market sales workers; (2) craft and related workers; (3) plant, machine operators and assemblers; (4) elementary occupations; and (5) other occupations. The other five groupings consist of professionals and agricultural workers.