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Development Strategy, Poverty and Deforestation in the Philippines

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Abstract

Most thinking on poverty and deforestation in developing countries does so in terms of the influence of one on the other, in either direction. However, the two have common determinants in the underlying economic and institutional conditions that set factor and product prices and the incentives for migration and natural resource-depleting activities. These determinants include property rights failures (open access to forest lands) but also 'government failures' in the form of economic policies that indirectly promote deforestation and retard poverty alleviation. A general equilibrium approach permits the analytical identification of the influences that such distortions exert on poverty and deforestation pressures. Using a numerical general equilibrium model, we consider the likely effects of the reform of industrial and agricultural protection policy, a key component of modern Philippine economic development strategy, on the determinants of poverty and deforestation.

1 Forest and land depletion

Forests

The forest and upland ecosystem of the Philippines covers around 45% of total land area, and its resources directly support about 30% of the population, including some of the poorest in the country. It is experiencing severe pressure of a variety of kinds, the most prominent of which is rapid deforestation. Further, a large proportion of the uplands have steep slopes which, once cleared of permanent vegetative cover, are prone to severe land degradation, particularly soil erosion.[i] Thus the problem of deforestation is linked with other forms of natural resource depletion and the loss of watershed function, which negatively impacts on agricultural productivity both in uplands and in irrigation-dependent lowlands.

Estimates of actual forested area and deforestation vary, reflecting different definitions as well as severe data deficiencies, but there is general agreement that continuing rapid tree cutting has greatly shrunk the area of forested land in recent decades. According to Kummer (1992), national forest cover fell from around 70% of total land to 50% between 1900 and 1950, and by the end of the 1980s was less than 25%. With deforestation proceeding at an average annual rate of 2.9% even according to Philippine government sources, by the late 1990s forest cover was less than 19%.[ii]

The two main causes of deforestation are land clearance for agriculture and commercial exploitation of forests for logs, lumber, fuel (including charcoal), and pulpwood. The relative importance of these two activities is a matter of dispute, but commercial logging, both legal and illegal, appears to bear primary responsibility for the depletion of old-growth *dipterocarp* forests containing valuable timber, with conversion to agricultural uses accounting for much of the deforestation of degraded, secondary or residual forest lands.[iii]

In upland areas, increases in agricultural production have traditionally come to a great extent from expansion at the cultivated margin rather than through improvements in the efficiency with which existing land resources are utilized. Between 1960 and 1987, the upland population more than doubled to an estimated 18 million, and the area devoted to upland agriculture increased six-fold, coinciding with a rapid decline in forest cover (Bee 1987; World Bank 1989; Cruz et al. 1992; WRI 1999). In upland agriculture, the highest fraction of land is planted with upland rice and corn, with smaller amounts given over to vegetables, tree crops, pasture, and other uses. Although the national planted area of major cereals such as corn has declined somewhat since about 1990, this is due more to the conversion of lowland acreage to other crops and to non-agricultural uses than to a contraction at the land frontier.

Deforestation has both direct and tangible economic effects as well as environmental impacts whose economic costs are less immediately visible. In the recent past, Philippine timber and processed wood products were major sources of foreign exchange, accounting for as much as one-third of all exports during the late 1960s. They now account for only 0.2%– or 1.15% if the gross value of finished wood products is included (NSCB 1995). Similarly, gross value added in forestry and wood products fell in absolute terms throughout the 1970s and 1980s. In relative terms, the GDP share of forestry and wood industries fell from 2.5% in 1975 to only 0.3% by 1994. A large part of the population, particularly in rural areas, depends on charcoal and fuelwood for household energy, and deforestation threatens future fuelwood supplies. The potential for irreversible changes in the stock of biodiversity, although more difficult to quantify, has recently risen to the forefront of environmental concerns (Republic of the Philippines 1998; Myers 1988).[iv]

Deforestation and the associated conversion of upland land to agriculture degrades the hydrological functions of watersheds. Annual fluctuations in stream flow are exaggerated in watersheds where water retention capacity has been lost along with forest cover and biomass, making such systems more prone to the effects of drought and flash flooding (Deutsch et al. 2001). Deforestation and the conversion of land to agriculture exacerbates soil erosion. Shifting cultivation (*kaingin*) systems traditionally practiced by indigenous upland communities were environmentally sustainable in the past, but increased population pressure in uplands has reduced fallow periods, and the more intensive farming practices of new immigrants to uplands are more land degrading (Table 1, and see David 1988; Cruz, Francisco, and Tapawan-Conway 1988). Soil runoff raises the total suspended sediment (TSS) loadings of rivers, and silt deposits in dams and canals diminish the capacity and efficiency of irrigation systems and hydroelectric power facilities. In areas where commercial agricultural production is pursued intensively, pesticide runoff is also a problem (Deutsch et al. 2001). Loss or degradation of watershed function as a consequence of deforestation has emerged as perhaps the most important environmental problem in the Philippines, given that its impacts are felt not only in the uplands but also very widely in the lowlands.[v]

Agriculture and croplands

Agriculture remains the single largest sector and employer in the Philippine economy (see Balisacan and Hill 2002; and David 2002). Well over half the population depends either directly or indirectly on income generated through agricultural production. Although investments in irrigation and episodes of technical progress have increased the productivity of some land and the yields of some crops, Philippine agriculture has experienced relatively low overall rates of productivity growth. Cereal and root crop yields and rates of fertilizer use are among the lowest in tropical Asia (WRI 2001).

Whereas expansion of agricultural land area was almost certainly an appropriate strategy in earlier decades when land was abundant, in the final quarter of the twentieth century the conversion of forests and upper watershed areas to agriculture (and especially to production of annual crops) became a significant source of environmental problems. Recent evidence on long-term trends in the productivity of lowlands is equally disturbing. Staple grains (mainly rice and corn) account for most agricultural land use in developing countries. Intensive monoculture of any of these crops is known to be associated with a long-term decline in land productivity, a phenomenon sometimes disguised in recent years by technological progress (Cassman and Pingali 1995). Moreover, the productivity of lowland cropland is directly dependent on the quality of irrigation services. Deforestation and the degradation of watersheds and hydrological systems have clearly diminished the quality of irrigation services in many parts of the country. Current estimates suggest that between 74 and 81 million tons of soil are lost annually, and that between 63% and 77% of the country's total land area is affected by erosion (FMB 1998). Recent studies show that sedimentation has reduced storage capacity at all of the Philippines' major reservoirs, and has measurably affected domestic water consumption, power generation, and irrigation. Furthermore, over the last 25 years dry season irrigated area has fallen by 20–30% in several of the country's key irrigation systems (FMB 1998). With the upland frontier virtually closed and emerging signs of productivity growth slowdown—or even reversal—in the "best" lowland irrigated areas, the degradation of the agricultural land base is a source of serious concern. The decline of agricultural land productivity is of particular concern if the country is to continue to pursue a policy of self-sufficiency in cereals and/or if the dependence of the rural population on agricultural incomes remains high.[vi]

Spatial dimensions of environmental problems

The Philippines is geographically diverse, and poverty, growth and development are strongly spatially differentiated. The three major island groups (Luzon, Visayas and Mindanao) differ markedly in key demographic and socio-economic characteristics as well as in climate, topography, terrain and other bio-physical attributes that influence natural resource endowments, including mineral deposits, land types and crop productivity. Urban-rural contrasts are also stark. By 2000, almost sixty per cent of the population lived in urban areas (of which a third were in Metro Manila); in contrast, in 1948, only 30 percent lived in urban areas. Metro Manila produces a third of the country's GDP, and in general, average family incomes in urban areas are more than twice as high as in rural areas.

Within rural areas, population density and general indicators of household welfare are correlated with land quality, with irrigated lowlands supporting the wealthiest rural populations. Irrigated lowland rice cultivation is concentrated in the Manila hinterland as well as several smaller areas in northern Luzon, the western Visayas, and southern Mindanao. The largest numbers of the rural poor are found in other parts of Mindanao and in the resource-poor, typhoon-prone eastern Visayas. In these areas, beyond relatively small pockets of irrigated rice land, the major crops are corn (grown both for feed and for human consumption), and coconut, the latter grown mainly in coastal and low-altitude areas.

In the postwar era there has been a geographic bifurcation of population growth rates. Natural increase and internal migration have both resulted in faster increases in urban populations and populations in upland/forest ecosystems. The reasons for this unusual pattern have largely to do with development policies, as discussed below.

The effects of various types of environmental degradation and resource degradation similarly have differential spatial impacts. In general, industrial emissions are concentrated in and around urban agglomerations. Similarly, deforestation and the associated degradation of soils and watersheds in upland ecosystems impact rural (and within rural, upland) populations most directly. The extent of land degradation too varies quite substantially by region.[vii] The spatial distribution of environmental damages, like that of natural resources, becomes important when considering possible tradeoffs between environmental conservation, poverty alleviation and the reduction of disparities in the real incomes of households.

2 Poverty trends and determinants

Trends and proximate causes

Poverty in the Philippines is overwhelmingly a rural phenomenon, and the agricultural labor force, with 40% of the total, makes a highly disproportionate contribution to poverty, about 65% (Balisacan 2002). Since 1985, poverty has fallen slightly, although not consistently. Rather, poverty has fallen during periods of relatively rapid growth of the aggregate economy (1985-88 and 1994-97, and risen during periods of recession or stagnation (1988-91 and 1997-2000). These trends are robust even when controlling for (relatively slight) changes in the distribution of income during these periods (ibid). The largest reduction in poverty, from 32% to 25%, came during the second half of the Ramos administration in 1994-97, a period during which the economy experienced a mini-boom based largely on economic reforms begun in the early 1990s.

In spite of large differences, the biggest disparities in human welfare in the Philippines occur within rather than between groups. Within rural areas, the poor are found disproportionately in uplands.[viii] Upland populations depend more heavily on agriculture, a notoriously unstable source of income in developing countries, and on a resource base in which there has been, in relative terms, very little investment. The incomes of the poor in upland areas are heavily dependent on agriculture, with additional contributions from rural service sector activities (such as shop-keeping) and remittances. Based on the foregoing description, the primary determinants of poverty among rural populations are easy to find. They are a lack of productive complementary resources, low human capital, risk-averse behavior in the face of yield and price instability, lack of opportunities for income diversification due to transport and other transaction costs, and thus low returns on labor and investments.

Analyzing poverty changes

Sen (1981) aggregates these factors into *production entitlements* (the capacity to produce output from own resource endowments) and *exchange entitlements* (the terms of trade at which the poor engage in exchange with the rest of the economy). In this way forest clearing by the poor can be seen as an effort to increase production entitlement— that is, to increase productive capacity by acquiring either more land or more productive land. The commercialization of agriculture, which is ubiquitous in the Philippine case, means that exchange entitlements— as reflected in wages and the prices of goods produced and consumed by the poor— are also important. Both types of entitlement are affected by distortions; open access to forest confers opportunities for upland farmers to increase production entitlements at low cost other than their own labor, while the general equilibrium effects of trade policies and other market interventions affect prices paid and received by farmers for labor and goods. Balisacan's careful study of Philippine poverty since 1985 makes it clear that while overall growth reduced poverty, the pace of reduction was greater when growth was due to policy reforms or other changes increased the production entitlements of the poor (through infrastructure investments, for example) and their exchange entitlements (especially through trade and exchange rate reforms reducing the bias against agriculture).

While income and expenditure data provide important insights into poverty correlates trends, disentangling causal factors is empirically problematic when many variables change simultaneously. Analytically, the causes of poverty change may be identified through their influences on the well-being of the poor by identifying changes in production and exchange entitlements, as follows. Define factor returns by a vector *w*, endowments (per household) by *V*, and prices by *p*. The real income of a poor household is then

$$Y = w \cdot V / \phi,$$

where $\phi = \prod_j p_j^{\alpha_j}$ is a consumer price index over *j* goods, with household-specific budget shares α_j comprising the weights. A partial equilibrium measure of change in real household income is then provided by converting (1) to proportional changes of variables. Let $\hat{Y} = dY / Y$, and similarly for the other variables. Then:

$$\hat{Y} = \sum_i (\hat{w}_i + \hat{V}_i)\gamma_i - \sum_j \hat{p}_j \alpha_j$$

in which the parameters γ_i are the shares of factor endowments in household income. Changes in the *V*s are production entitlement changes, while those in the *w*s and *p*s are changes in exchange entitlements in a market economy.

In general equilibrium, factor prices and product prices are determined by economy-wide endowments, technologies, and policies as well as world market prices. Similarly, household endowment vectors are determined– at least in part– by the institutional environment governing access to non-labor factors, including forested land for conversion to agriculture. Thus (2), embedded within an appropriate general equilibrium framework, can be used to predict changes in household welfare consequent on changes in individual policies, world prices, or access to resources. In a model with sufficiently many households, such that the group initially falling into poverty can be separately identified in terms of incomes and expenditure patterns, predictions of poverty change can be made simultaneously with predictions of the effects of exogenous changes on production, including that of timber products from forests, and the demand for resources, including forested land to be cleared for agricultural cultivation. The general equilibrium methodology thus permits an analysis of the effects of policy or other changes on deforestation both directly, and also indirectly through changes in the causes of household poverty.

3 Philippine development policies

In decomposing the relationship between economy and environment it is important to separate, where possible, the effects of economic policies from those attributable to secular processes of growth and economic change. This is especially important in the Philippines, because development strategies and the institutions that support them have significantly impacted on the pace and nature of economic development. A case can be made that inappropriate land use, involving large scale deforestation and land degradation affecting fragile uplands and watersheds as well as coastal and marine ecosystems, and the associated migration patterns observed in the Philippines are not merely the inevitable consequences of rapid population growth and resulting pressures on the land frontier, but at least partly attributable to effects of policy.

Industrial and agricultural policies

The development strategy pursued by the Philippines from the early post-independence period was based on import substituting-industrialization. In this respect Philippines was not very different from many other developing countries. But unlike many of its neighbors in east and southeast Asia, it failed to make an early transition to an export oriented strategy. Significant trade reforms were initiated only in the late 1980s, and the country really started to shake free of its strong protectionist regime only in the 1990s.[ix] Protectionist policies, together with highly centralized and heavily corrupt administrations, resulted in a boom-bust economic growth pattern that had both direct and indirect effects on resource use patterns and the growth of emissions. Industrial growth behind protective trade barriers discriminated against the labor-intensive export oriented activities in which Philippines enjoyed comparative advantage; the structure of effective protection was such that industries that were least internationally competitive had the highest protection. Not surprisingly, following the early phase of 'easy' import substitution industrialization, manufacturing sector growth slowed, despite large net transfers from other sectors, principally export agriculture.

Agricultural development (or more accurately, growth of cereal production) was a second target of development policy. Imports of rice and corn, the principal food crops, were heavily regulated in pursuit of 'food security'—in practice defined as self-sufficiency (Coxhead 2000). The state exerted a monopoly over international trade in these products and their substitutes. This meant in effect that rice and corn were converted into non-tradables, with domestic prices determined substantially independently of international prices. Domestic market interventions by the National Food Authority aimed at stabilizing supply and prices. Cereals, principally lowland irrigated rice, also benefited from some direct and indirect subsidies in the form of state funded irrigation investments, research and extension, and chemical inputs.

Corn gained increasingly high effective protection through trade policy, rising from near zero in the late 1960s to above 70% in the early 1990s (Pagaluyan 1998). Corn is grown very widely in uplands (with upland rice, it accounted for about 45% of cultivated land on slopes of above 18% in the late 1980s). The land area devoted to corn has expanded significantly, often at the expense of forests, in uplands. Thus protection that raised the profitability of domestic corn production had a direct and negative environmental impact, as corn cultivation in steeply sloping lands is highly erosive under the land and crop management regimes practiced by the majority of Philippine upland farmers.

Though agricultural sectors like rice and corn benefited from some government policies, the overall impact of the policy regime on the agriculture sector was strongly negative (Intal and Power 1990). These policies generated periodic economic crises and related political upheavals, further blurred the rate of return 'signals', and eroded both domestic and foreign investor confidence. As a consequence, despite high tariff barriers, the manufacturing sector's share of GDP and total employment failed to increase, and the Philippines' overall growth performance was the worst in the ASEAN group of countries from the 1970s until the 1997 Asian economic crisis.

Policies that diminished profitability and dampened employment growth in agriculture and traditional, rural-based industries impacted on the spatial and sectoral distribution of increments to the Philippine population. Philippine urbanization, and especially the growth of Manila relative to other urban centers was in part a consequence of the ISI strategy.[x] With few new employment opportunities in traditional, lowland-based agriculture and rural industry, and a high rate of natural increase, Philippine population growth was fastest in urban centers (principally Metro Manila) and at the forest frontier. Migrants from depressed rural areas created a boom in upland populations (Cruz and Francisco 1993). Land colonization, deforestation and agricultural intensification on sloping and marginally arable lands ensued.[xi]

Clearly, the distribution of incentives within agriculture was skewed by policy, with import-competing crops like rice and corn gaining relative to export crops. Technological progress, generated by research conducted in national research institutes as well as at the International Rice Research Institute located outside Manila, also conferred benefits on producers of cereals. The Green Revolution in rice, associated with modern technology and large irrigation and other supplementary investments, had a major impact on rice productivity in the Philippines, but was primarily confined to lowland irrigated regions (David and Otsuka 1993). It was responsible for a significant decline in real rice price during a period of rising demand (David and Huang 1996).

Forest and forestry policies

Policies that directly impacted on the forestry sector can be categorized into three groups. First, there were government programs that encouraged the conversion of forests to agricultural land, including state sponsored settlement schemes.[xii] Second, the state did not always enforce regulations limiting forest conversion, and this was the case not only with respect to activities of large commercial interests but also those of small farmers, often new immigrants to uplands. Third, there was both legal and illegal logging, with logging concessions being disbursed as part of patronage politics to politically powerful groups, and a considerable proportion of 'illegal' logging being carried out with the sanction and often with the complicity of government officials at all levels. In practice both legal and illegal logging facilitated land conversion to agriculture and hence played a critical role in this process even though selective logging, in principle, need not cause deforestation.

Government programs that encouraged conversion of forests to agriculture were not unique to the Philippines; indeed they were ubiquitous throughout developing Asia and globally. With hindsight, the basic thrust of those programs can be criticized on both economic and environmental grounds, but it cannot be denied that they reflected the mainstream development policy thinking of the time. In general, their environmental costs were poorly understood, and in any case were assumed to be much lower than the expected benefits. In both economic and political terms the sponsorship of internal migration to the forest frontier was a policy that was attractive: it eased population pressures in the more densely populated regions, increased agricultural output and exports, and ameliorated the political pressures for land reform that fuelled left-wing insurgencies. But when it came to logging, central to the rapid deforestation process, government activities were driven much more directly by the priorities and interests of privileged elites who controlled the state rather than by any concerns about national development. Discussing the role of the state in the logging-induced deforestation process, Kummer (1992) concluded that population growth was not the primary cause of deforestation in recent times; in reality, "…the Philippine government had a large control over this process and turned this control over to a small group of people. The process did not just happen; rather it served the financial interests of the wealthy and well connected" (pp. 154-5). As in many other areas of Philippine economic life, national interests were made subservient to the narrow private interests of the politically powerful, who used the state as a tool for the exploitation of national resources. Not only did the country lose potential economic rents from timber extraction, but logging also served as a conduit for capital outflows: with judicious undervaluation of export receipts, it provided a mechanism for circumventing exchange controls to repatriate funds overseas.

This review of the actions of the government makes clear that deforestation and associated agricultural land degradation problems in the Philippines cannot be attributed to population growth and/or 'market forces' alone. Development strategy and the institutional and legal context have been very important. As we have argued throughout this book, therefore, environmental outcomes depend not only on direct environment-specific measures but also on the indirect impacts of many other policies as well as exogenous developments in the economy. Many legislative and policy changes, even when they do not specifically target environmental variables, can have potentially large environmental effects. The modern history of the Philippine economy underlines this point.

During the 1990s the Philippines implemented significant economic policy reforms aimed at opening the economy and creating a more liberal environment for trade and investment. manufacturing sector tariffs (and other import restrictions) were substantially reduced. Food and agriculture sector policies were also liberalized somewhat, notably by the abolition of long-standing quantitative restrictions on rice and corn importation, a step required under the terms of the country's accession to the WTO. However, QRs in agriculture were replaced by tariffs set at high rates, with the ironic result that after decades in which trade policy discriminated against agriculture, rice and corn are now among the most heavily protected industries in the economy (WTO 1999).

Given the strength of factor and product market linkages, the environmental implications of major economic reforms may be at least as significant as those of any single environmental protection measure. It is similarly interesting to ask what difference the exclusion of rice and corn from the liberalization agenda makes to changes in the demands on environmental and natural resource assets.

4 A general equilibrium approach

In developing economies, the fundamental long-term source of economic change is growth. However, the pattern of economic growth is subject to many influences, among which a country's factor endowments, trade orientation, and economic policies and institutions (such as property rights regimes) figure very prominently (e.g., Sachs and Warner 1995). Moreover, it is inherent in growth that changes occur in the sectoral structure of production, the allocation of consumption expenditures, the emission–output ratio of industrial technologies, and the spatial distribution of population and economic activity in relation to the resource base. Poor countries that are growing relatively rapidly exhibit these changes in more pronounced fashion than do wealthier and more structurally stable industrialized economies.

Aggregate growth and the environment

A variety of factors broadly associated with economic growth influences economy–environment interactions and the long-run evolution of environmental quality. The effects of these factors can be grouped into three broad categories, scale, composition, and technique effects. [xiii]

The *scale effect* refers to the association between pollution or resource depletion and the size of an economy. More output, with no change in economic structure or in technology and consumption patterns, will lead to more pollution and more demands on the natural resource base. The *composition effect* is the impact of changes in the structure of production and consumption. Economic growth leads inevitably to changes in economic structure, by altering the composition of national output, making possible the production of new goods, and—through growth in per capita incomes—by promoting changes in the composition of demand. An obvious example from developing economies is the decline of natural resource-intensive sectors such as mining, forestry, fishing, and agriculture as a percentage of GDP, and the corresponding rise of manufacturing and services. Structural changes can also be triggered by exogenous changes in relative prices (such as those brought about by opening up to international trade), by changes in technology, endowments, or demand factors (tastes and preferences), and of course by policies. Finally, environmental effects associated with any given output level depend also on techniques of production and consumption. Relative price changes may stimulate shifts in the input mix; new technologies developed domestically or acquired from abroad may alter the ratio of emissions or raw material demand to output. The *technique effect* reflects these supply-side changes and their underlying causes, including changes in consumer preferences for environmental quality and in government policies limiting permissible emissions or intensities. The technique effect is normally expected to reduce environmental damage.

In practice, the relative influence of scale, composition and technique effects is expected to change over the range of development experience. It is conjectured that, for some types of pollutants at least, scale and composition effects tending to increase emissions intensities are the dominant environmental features of growth in poor countries. With sustained per capita income growth, the composition effect may eventually reverse itself as the relative importance of manufacturing diminishes and the structure of manufacturing output changes; technique effects driven by investments in new technologies and by changing preferences may then cause pollution production *at the margin* to decline. The net effect, it is hypothesized, is an inverse-U-shaped relationship between emissions and per capita income. . This line of thinking has been formalized in a body of literature on the so-called "environmental Kuznets curve" (World Bank 1992; Grossman and Kreuger 1993).

Empirical tests of the environmental inverse-U hypothesis are largely inconclusive (Stern, Common, and Barbier 1996). Tests based on time-series data for single countries appear to provide some support for the hypothesis with respect to certain types of emissions (Grossman and Kreuger 1995; Vincent et al 1997), but these are contradicted by numerous other studies, especially where the depletion of forests and other natural resources is concerned (Cropper and Griffiths 1992; Selden and Song 1994). What most tests do reveal is that one of the most important factors governing the production, nature, and sectoral sources of pollution in developing economies is their exposure to international trade.

Economy-wide analysis with a multisectoral model

In open developing countries, trade policy (until very recently a major tool of industrialization policy) is unusual among microeconomic interventions in that its effects are both profound and pervasive in the economy, affecting both aggregate growth and the structure of production and demand. Thus it may be hypothesized that trade and trade policies (or their reform) have major effects on environmental quality and natural resource depletion. There are a number of normative analytical explorations of this question (Copeland 1994; Corden 1997; Ulph 1999), all of which focus on the general equilibrium welfare effects of trade policies in the presence of environmental externalities. By extrapolation, these results can also be used to identify differential effects on the welfare of groups within the economy defined by their ownership of factors and/or their patterns of consumption.

Coxhead and Jayasuriya (2003) set out a modeling strategy for the general equilibrium analysis of economic and environmental phenomena in a developing economy with trade policies, spatial variation, and open-access forest lands. The main technological and behavioral relationships of the basic model are derived from the first-order conditions of revenue, cost and utility functions. For an economy consisting of N products and F primary factors, define the following variables and vectors (vectors in bold; set size in parentheses):

P	commodity prices (N)	**W**	mobile factor prices (F)
R	sector-specific factor prices (N)	**Y**	domestic commodity supplies (N)
X	mobile factor demands ($N \times F$)	**D**	domestic final demands (N)
S	net imports (N)	**V**	factor endowments (F)
U	aggregate utility (1).	ϕ	Foreign currency exchange rate (1)

Suppose factor endowments and commodity prices to be given, and let $\phi = 1$ be the numéraire price. Aggregate revenue (i.e. GNP) is given by $G(\mathbf{P},\mathbf{V}) = \max\{\mathbf{P}\cdot\mathbf{Y} \mid \mathbf{V}\}$; from the first-order conditions of this problem we obtain, using the envelope theorem, the sectoral supply functions:

$$Y_j = Y_j(\mathbf{P}, \mathbf{V}) \qquad (j = 1, \ldots, N), \qquad (1)$$

and the prices of mobile and specific factors:

$$W_i = W_i(\mathbf{P}, \mathbf{V}) \qquad (i = 1, ..., F), \qquad (2)$$

$$R_j = R_j\,(\mathbf{P}, \mathbf{V}). \qquad (j = 1, ..., N), \qquad (3)$$

Each sector is assumed to be a price-taker in factor markets. Therefore, the output level that maximizes revenue is also the cost-minimizing level, and from the first-order conditions of the sectoral cost minimization problem $C_j\,(\mathbf{W}, Y_j) = \min\{\mathbf{W}\cdot\mathbf{X} \mid Y_j)$, we obtain demands for intersectorally mobile factors:

$$X_{ij} = X_{ij}\,(\mathbf{W}, Y_j) \qquad (i = 1, ..., F; j = 1, ..., N). , \qquad (4)$$

Domestic final demands for each commodity are found by the envelope theorem from the first-order conditions of the consumer's expenditure minimization problem $E(\mathbf{P},U) = \min\{\mathbf{P}\cdot\mathbf{D} \mid U\}$:

$$D_j = D_j\,(\mathbf{P}, U) \qquad (j = 1, ..., N). , \qquad (5)$$

Net commodity trade volumes are determined by market-clearing conditions:

$$S_j = D_j - Y_j \qquad (j = 1, ..., N), , \qquad (6)$$

where $S_j > (<)\ 0$ indicates a net import (export) good. Import prices are set in world markets, while for M exportables ($M \leq N$), prices are set by inverse foreign demand functions:

$$P_k = P_k\,(S_k) \qquad (k = 1, ..., M). \ , \qquad (7)$$

Finally, the model is closed by an aggregate budget constraint:

$$E(\mathbf{P},U) = G(\mathbf{P},\mathbf{V}) \qquad (8)$$

The system (1) to (8) contains $4N + F + FN + M + 1$ equations, but the model contains $5N + 2F + FN + 2$ variables. A solution requires that the number of endogenous variables be just equal to that of equations. The choice of a *closure*, technically speaking, is the choice of a subset of $(N - M + F + 1)$ variables to be exogenous, such that the condition for a solution is satisfied. In a short-run neoclassical closure, **V** is declared exogenous, and so is a subset $(N - M)$ of the vector **P**. The exchange rate ϕ is selected as numéraire price. The number of equations is thus made equal to the number of endogenous variables, and (1) to (8) solve for **Y**, **W**, **R**, **X**, **D**, **S**, U, and the M endogenous elements of **P**.

Alternative closures may be specified by selecting different combinations of variables to be exogenous. In some economies, for example, the assumption of a fixed wage with 'slack' (unemployment) in the labour market may be judged to be more empirically robust than that of a flexible nominal wage and full employment. The closure reflecting this would require fixing W_L exogenously, and allowing the value of the corresponding factor endowment, V^L (interpreted as total employment), to be solved within the model.

In an economy with complete and competitive markets and constant returns to scale, it is a condition of equilibrium that factor and product markets clear, aggregate expenditure is equal to income, and trade is in balance. In the basic model just sketched, factor market clearing is implied by the conditions for revenue maximization, and the markets for non-traded commodities (for which $S_j = 0$) clear by equation (6). Aggregate expenditures are set equal to income in equation (8). By Walras' law, when these conditions are all met the balance of trade is also zero, thus satisfying the conditions for general equilibrium.

Applied general equilibrium analysis

The rigorous analysis of questions about the fundamental determinants of environmental change is exceptionally difficult. While the broad nature of the economic forces that operate can be gleaned from stylized models, actual outcomes depend on complex general equilibrium relationships. In the remainder of this paper we present the results of simulations using the APEX AGE model of the Philippine economy.

APEX (**A**gricultural **P**olicy **E**xperiments) is an applied general equilibrium model of the Philippine economy developed in a collaborative venture by researchers at the Australian National University and the Philippine Department of Agriculture (Clarete and Warr 1992). APEX is a conventional, real, micro-theoretic general equilibrium model designed to address microeconomic policy issues for the Philippines. It belongs to the class of models (sometimes known as Johansen models) that are linear in proportional changes of variables (see Coxhead and Jayasuriya 2003, Chapter 5). APEX shares many features with the well-known ORANI model of the Australian economy (Dixon *et al*. 1982), although these features have been adapted to fit the realities of the Philippine economy. Input-output data in APEX are drawn from the Philippine Social Accounting Matrix. Unlike most other AGE model of comparable size, however, in APEX all parameters describing technology and preferences are constructed from original econometric estimates.

APEX is considerably more complex that the model sketched in the previous section, but does not alter its basic framework. It allows for intermediate inputs, for inputs and products distinguished by source (domestic or foreign), and distinguishes different kinds of labor input. Final demands for domestic and imported commodities are also distinguished by use category—households, government, net trade, and capital creation. Domestic and foreign goods within the same commodity category are differentiated by origin, so domestic and foreign prices may differ. The model also contains taxes, tariffs and subsidies which drive wedges between domestic and foreign prices, and between producer and consumer prices.

The model contains 50 producer goods and services produced in 41 industries. There are 38 manufacturing and services sectors and 12 agricultural sectors, with spatially distinct agricultural production as described below. Producer goods are aggregated into seven consumer goods. There are five households, each representing a quintile of the income distribution and having unique income and consumption characteristics.

Consumer demands are all described by flexible functional forms. Similarly, factor demands and the aggregation of factors of different types all depend on flexible functional forms, allowing for substitution in response to changing relative prices. In agricultural production, primary factors and fertilizer are aggregated, using a flexible functional form with econometrically estimated parameters, into a composite ‘primary factor’ input which is assumed to be used with intermediate goods (other than fertilizer) in fixed proportions. This structure is thus flexible enough to permit primary factor substitution in response to changes in the relative prices of primary factors and fertilizer. Finally, imports and their domestically produced substitutes are aggregated using CES forms with econometrically estimated Armington elasticities. Other details of the model structure can be found in Clarete and Warr (1992), and some illustrative experiments and associated discussion in Warr and Coxhead (1993).

Agriculture produces a vector of intermediate and final consumption goods using land, capital, unskilled labor and fertilizer as well as intermediate inputs. Production takes place in three regions, Luzon, Visayas and Mindanao, which are distinguished by their economic, geographic and climatic characteristics. Each of the three regions has endowments of land and capital that are specific to agricultural uses, while labor and variable capital are intersectorally mobile. Agricultural inputs are non-allocable due to data constraints, so the model cannot directly identify the quantity of each input used in the production of any individual agricultural output. Rather, the model operates as though farmers in each region purchase a production possibilities frontier, then choose their location on the frontier— that is, the product mix— in response to relative output prices.

Within this structure, some groups of agricultural products are presumed to be jointly produced. One such group is the category 'rainfed crops', which consists of rainfed rice, corn, and root crops. We identify this sub-aggregate as the set of agricultural crops in which the potential for measurable soil fertility reduction through erosion can take place. Value-added in the rainfed crops sector is dominated by corn (60% of total value-added); root crops account for 28%, and rainfed rice 12%. Empirically, these crops (especially corn and rainfed rice) account for the greatest part of land use in Philippine uplands. Erosion in uplands comes mainly from their production, particularly that of corn (Coxhead and Shively 1998). Thus changes in the area of corn and rainfed rice determine erosion outcomes in the model.

The joint production function for rainfed crops is nested within that for agriculture as a whole in each region. The composition of production within the rainfed crops sector is altered by changing relative prices of the three crops or by crop-specific technical progress. Similarly, the share of rainfed crops in total agricultural production depends on prices and rates of technical progress of the sub-aggregate relative to those of other agricultural sectors. Each of the three rainfed crops is classed as an importable in APEX, although in practice the shares of imports in total domestic availability are very small due to long-standing trade restrictions.

In addition to solving for price and quantity responses, we are interested in a variety of aggregate economic magnitudes such as employment, GDP, government revenues and expenditures, income distribution and approximations to measures of economic welfare. These are computed in the APEX by means of appropriate addition and aggregation rules. The model is solved in linearized form using Gempack software (Harrison and Pearson, 1996). Tables 2 and 3 show, for the 50 APEX sectors, some basic information from the model database on sectoral size and labor-intensity, and approximate protection levels.

In its base form, APEX contains no explicit environmental information. However, for a given policy reform simulation it does provide detailed predictions of input and output changes at the industry level, as just described. These results can be used in conjunction with estimates of soil erosion rates under different crops, and estimates of changes in the returns to land to calculate the likely effects of a given change on industrial pollution, deforestation and agricultural expansion (for a more detailed exposition see Coxhead and Jayasuriya 2003, Chapter 5). Similarly, while the model does not generate a measure of poverty change *per se*, it does provide all the information required to calculate changes in the welfare of households whose initial income places them in the lower two quintiles of the income distribution, corresponding approximately to the mid-1990s incidence of poverty in the Philippines.

5. The impacts of Philippine trade policy reforms

To illustrate the possible environmental effects of a broad-based policy reform, we use APEX to examine the predicted outcomes of two counterfactuals: a 25% reduction in tariffs on all non-agricultural sectors (in practice, on manufactures), and a reduction of the same amount for *all* sectors. By asking what would happen if protection policies were relaxed, we obtain insights into the effects of past protection policies on economic activity and, by extrapolation with additional information, on environmental phenomena such as the allocation of agricultural land to crops, pressures for agricultural expansion, and the production of industrial emissions.[xiv]

The model closure chosen for the trade reform simulations embodies numerous assumptions about the nature of the Philippine economy. External trade and the government budget are assumed to be in balance initially, and the economy must adjust following a 'shock' (such as the exogenous revision of tariff rates) to restore these balances. Supplies of non-land primary factors (unskilled labor, skilled labor, and capital) are assumed to be fixed; the markets for these inputs clear through factor price adjustments.[xv] The remaining details of the macroeconomic closure are chosen to ensure that the burden of adjustment to a shock falls entirely on household expenditures.[xvi] The model thus yields a measure of welfare change based on increases or declines in real household consumption expenditures. Moreover, real income changes can be examined separately by quintiles of the income distribution and by sources of income, permitting a fairly detailed analysis of likely changes in poverty.

For agricultural land, unlike other factors of production, we assume that acreage can be altered in the short to medium run, in effect creating a flexible supply of land at a constant nominal price per hectare. In other words, at the margin there is fallow land that can be brought into production, or planted land that that can be fallowed. This permits the model to capture pressures for agricultural expansion or contraction in response to economy-wide shocks. In the Philippines, where old-growth forests are a small proportion of total forest cover and agricultural expansion accounts for most new deforestation, agricultural expansion at the margin is a proxy for deforestation pressure.

Economic impacts

Changes in major macroeconomic variables occurring as the result of the trade policy reform experiments are shown in Table 4. Sectoral output and price changes are found in Table 5. Table 4 shows that trade policy reforms have a very small effect on aggregate welfare, measured as the sum of real household consumption expenditures. Because the supply of land is elastic, and with the economy distorted by a number of taxes of which tariffs are only one form, there is neither any expectation nor any assurance that the tariff reduction by itself will raise welfare. In the real world, of course, the Philippine tariff reform program was implemented along with many other types of reform; our experiment captures only one element of the entire package. The observed small negative effect on aggregate real consumption may well be due to rounding errors, reflecting basically unchanged overall welfare. Trade liberalization—whether applied only to manufacturing or to all sectors—has a pro-labor impact, and real wages of both skilled and unskilled labor increase, with the latter increase being greater. While returns to variable capital also rise, those to specific capital in formerly protected sectors decline.[xvii] Intersectoral variations in returns to specific capital indicate pressures for investment or disinvestment in the next period, although of course the model itself, being static, does not quantify actual investment responses.

It can be seen from the sectoral results in Table 5 that, as expected, trade liberalization generally reduces output in the import-competing manufacturing sectors, which receive the highest initial protection, and increases it in the labor intensive electronics sector (‘semiconductors’), food processing, and in several primary industries, including forestry and mining. At the same time, most agricultural sectors also contract, even when trade liberalization is restricted to non-agricultural sectors. The agricultural contraction can readily be understood in terms of two factor market effects. First, profitability in the sector is reduced by the significant labor cost increase, which is only partially offset by output price increases. Second, the flexibility of total land area means that the sector can shed even more labor by allowing some land to become fallow.

Environmental impacts

The net environmental effects of the trade reform in land-using industries depend on the environmental effects arising from expanding output of the 'commercial forestry' sector (whose output is the value of marketed timber) and contraction of most agricultural industries. In the 'forestry' sector, trade reforms bring about a rise in the producer price, and output (timber production) expands. What happens to the commercial timber sector in the long run as a result of trade reforms depends on the question of property rights. If property rights in forestry were well-defined and enforced – an implicit assumption of the model - then an increase in the relative price of forestry would promote a sustained expansion of timber output, which in an intertemporal context would imply increased investment in timber tree stocks. On the other hand, if property rights were not well defined or not enforced, then by raizing the stumpage value of existing trees, trade liberalization that increases profits in timber extraction would instead lead to increased cutting of existing forests. In this case trade liberalization would promote accelerated deforestation.

Finally, the trade reforms raise the domestic prices of most exportable agricultural products, and reduce those of rice and corn, which are import-competing crops. Rice and corn prices fall modestly in nominal terms, but by greater amounts relative to the producer prices of other agricultural goods with which they compete for land. The structure of agricultural production thus shifts in the direction of exportables, especially tree crops such as coconut and fruit. Corn and upland rice, the two crops that account for virtually all agriculture-related soil erosion in uplands, both contract in area (Table 6), especially when the tariff reform extends to these industries. With rising labor costs, incentives to use labor to clear additional upland land for agriculture must diminish; indeed, the area of land fallowed increases in all regions, especially when trade reforms include agricultural sectors. As a consequence of these shifts in land use, erosion in uplands diminishes, particularly on Luzon Island. Overall, we may conclude that trade policy reform induces composition effects that are consistent with (or which at least do not run counter to) increased environmental protection in the lowland and upland/forestry ecosystems, provided institutional failures (such as open access in commercial forestry) are not severe.

That some agricultural sectors and some exportable manufacturing sectors should contract as the result of trade liberalization requires further explanation, given that these, along with traditional exportables such as forestry and mining, are normally assumed to be the industries most negatively affected by the ISI regime. When there are many exportable and import-competing goods, each using many inputs and with differing factor intensities, the net impact on a particular sector reflects not only the change in its output price but also the complex set of changes in input prices that affect the cost of production. Sometimes, the change in output price may be more than offset by changes in input prices and overall cost of production so that supply increases (decreases) may take place even when output prices fall (rise).

It should also be noted that rice and corn are both import-competing crops in APEX. Initial trade shares are very low, and estimated Armington elasticities (of substitution between imported and domestically supplied goods) are not high for these commodities. The trade policy reforms reduce the prices of imported grains substantially, and their domestic producer prices fall somewhat as a result. Moreover, the trade reforms promote activity in some highly labor-intensive sectors. Unskilled labor demand rises in semiconductors, wood products, 'other foods' processing, mining, forestry, and construction. Labor-intensive agricultural sectors must compete with these additional demands.

The trade policy reform simulations provide predictions about environmental composition effects and, in a comparative static sense, scale effects. Of course, longer-run growth outcomes are beyond the scope of the model. In the longer run, if trade policy reform leads to faster overall growth, then production of some kinds of environmental 'bads' could increase in spite of the changes in industry structure towards less pollution-intensive industries. A mix of economic policy reforms and environmental protection measures is implied, to ensure that the scale effect is not the dominant influence on the trajectory of environmental quality.

Household welfare impacts

Whatever their effects on aggregate welfare, trade policy reforms and technical progress as simulated in APEX both have markedly regressive impacts on the distribution of real household expenditures. These are shown for quintiles of the income distribution in Table 7, while Table 8 displays changes in the main sources of household factor incomes.

The tariff reforms confer the greatest increases on returns to factors owned mainly by wealthy households, especially intersectorally mobile capital and skilled labour. These disparities are widened when the reform program extends to all sectors rather than to manufacturing only.

Independent of factor market effects, trade reforms also have regressive effects through consumer prices and the structure of the tax system. The most protected sectors produce goods consumed disproportionately by the wealthy. When tariffs are reduced, the prices of the bundles of goods consumed by the wealthy thus fall by more. At the same time, the government loses tariff revenues; in APEX it restores fiscal balance through a lump-sum tax on households. Though this is nominally a distributionally neutral measure, its imposition as a replacement for tariff revenues means that poor households are taxed more heavily than under the tariff.

These changes indicate that the short-run effect of trade reform is to *increase* the depth and severity of poverty among initially poor households. Accordingly, trade liberalization should be accompanied by compensating policies to counteract the transitional costs of sectoral shifts. The fall in land returns, meanwhile, indicates that in the longer run households presently in agriculture will attempt to switch to other sectors. The net environmental effect of these poverty changes is thus ambiguous; poverty increases, but the structure of household incomes provides incentives to move away from farming and into urban, non-agricultural jobs.

6. Conclusions

The general equilibrium analysis of Philippine trade reforms provides an empirical illustration of the ways in which widely implemented economic policies can influence environmental and poverty outcomes simultaneously. The direct and indirect impacts of past Philippine development strategies have aggravated deforestation and natural resource depletion rates, quite severely in some cases. These particular development strategies have more than simply constrained economic growth. By perpetuating poverty in rural areas they encouraged population movement to crowded cities and to ecologically fragile uplands. By distorting agricultural incentives they encouraged both the expansion of agriculture at the forest margin and the cultivation of more soil-erosive crops. The quite blatant use of state power that allowed favored elite groups to exploit national resources further worsened environmental outcomes. In particular, by undermining respect for property rights in nationally owned natural resources, they promoted deforestation. These legacies now weigh heavily on the Philippines.

The 1990s saw the partial dismantling of trade protection and liberalization of domestic markets, with a consequent mini-boom and substantial poverty reduction prior to the Asian economic crisis. Our results show only the contribution of trade policy reforms to this process; by themselves, the reforms reduce direct incentives to clear forest, but increase poverty among poor households, some of which are likely to compensate by seeking new lands in existing forested areas. The net deforestation effect of the reforms is thus ambiguous.

Naturally, trade policy reform in the Philippines has been accompanied by other changes as well, some of which are policy reforms in other areas, so the net effect of these reforms on poverty and deforestation remains to be established. Our analysis reinforces the need to combine liberalized trade with appropriate government action to address market failures (open access, adjustment costs borne by the poor) that may produce harmful environmental outcomes.

Applied general equilibrium analysis, in this case with the APEX model, is a powerful tool for quantifying the complex relationships described in highly stylized form in lower-dimensional models. In the Philippine case this mode of analysis permits a deeper exploration of the indirect environmental implications of development policies unrelated (in direct fashion) to the environment. In particular, these results clarify the multi-stranded composition effects of policy changes which affect prices throughout an open developing economy. Moreover, the model permits a more detailed disaggregation of spatial phenomena; not only within agriculture and natural resources sectors, but also across major geographic regions within the country.

Some of the limitations imposed by our simplifying assumptions in this kind of model should be noted. The geography of the Philippines, and the underdeveloped nature of roads and communications infrastructure that links remote regions to other regions and the urban centers means that transactions and trade costs are non-trivial. These drive wedges between the prices faced by different agents even for the same goods or factors, weaken the degree of market integration, and dampen the extent to which changes in the patterns of market signals produce the assumed producer and consumer responses. The importance of such transactions costs is an empirical issue. There are several studies of commodity market integration in the Philippines that suggest that over the medium term, market integration is quite high (Silvapulle & Jayasuriya 1994; Mendoza and Rosegrant 1993; Coxhead, Rola and Kim 2001). Empirical evidence on internal labor migration and occupational labor mobility also indicate that the maintained assumption of the model, that labor moves both inter-regionally and inter-sectorally, is reasonable for the medium term. The outcomes generated by the model in these policy experiments therefore seem acceptable as reflecting at least orders of magnitude of the effects and their general direction.

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Table 1: Erosion rates by land use: Philippines

Land Use	Erosion rates (t/ha/yr)
Undisturbed forest	0.1- 0.4
Second growth forests	1-7
Rice paddies	0.2-10
Plantations (dep. on age and species)	2.4-75
Grasslands	1.5-3
Overgrazed lands	90-270
Shifting cultivation (no conservation measures)	90-240
Annual cash crops (uplands)	30-180

Source of basic data: ENRAP (1994).

Table 2: Agricultural, natural resource and service sectors

	GDP share	Labor cost share %	Implicit tariff 1994
Agr. Commodities	**0.14**		
Irrigated Rice	0.24	0.54	50.0
Rainfed Rice	0.02	0.54	
Corn	0.12	0.56	115.0
Coconut	0.08	0.37	0.0
Sugar	0.05	0.57	..
Fruits	0.11	0.51	40.0
Vegetables	0.06	0.54	21.66
Rootcrops	0.02	0.55	..
Other Comm'l Crops	0.10	0.56	4.34
Hogs	0.16	0.38	..
Chicken and Poultry	0.03	0.49	..
Other Livestock	0.00	0.58	10.95
Natural Resources	**0.08**		
Marine Fisheries	0.47	0.47	19.14
Inland Fisheries	0.15	0.38	
Forestry	0.16	0.28	11.84
Crude Oil & Nat. Gas	0.03	0.22	29.16
Other Mining	0.19	0.44	9.14
Services	**0.57**		
Agricultural Services	0.07	0.46	
Construction	0.08	0.59	
Elect, Gas and Water	0.04	0.22	
Trans. & Comm. Serv.	0.08	0.48	
Transpt/Storage/W'sale	0.37	0.36	
Banks	0.02	0.65	
Insurance	0.09	0.17	
Government Services	0.14	0.98	
Other Services	0.11	0.56	

Note: Value-added shares shown for each sector are within-group shares
Source: Calculated from 1989 data in APEX database. Note: .. = not available.

Table 3: Agricultural processing and manufacturing sectors

Sector	GDP share	Labor cost share %	Implicit tariff 1994
Agric. Processing	**0.07**		
Rice and Corn Milling	0.35	0.47	51.58
Sugar Milling/Refining	0.07	0.31	59.21
Milk and Dairy	0.06	0.28	29.23
Oils and Fats	0.22	0.39	16.12
Meat & Meat Prod.	0.21	0.36	82.21
Feed Milling	0.02	0.37	26.49
Animal Feeds	0.05	0.44	72.69
Other Foods	0.03	0.40	29.52
Manufacturing	**0.15**		
Beverages and Tobacco	0.07	0.37	41.99
Textile & Knitting	0.08	0.49	14.5
Other Textiles	0.02	0.47	19.69
Garments*	0.16	0.65	24.69
Wood Products	0.05	0.53	13.31
Paper Products	0.05	0.46	19.97
Fertilizer	0.01	0.38	4.07
Rubber/Plastic/Chem Prod.	0.11	0.42	28.59
Coal & Petroleum Prod.	0.04	0.12	28.88
Non-Ferr. Basic Metals	0.09	0.19	6.19
Cement & Non-Metallic	0.10	0.28	16.51
Semi-conductors	0.06	0.55	7.70
Metal Products	0.07	0.49	17.24
Electrical Machinery	0.05	0.47	18.78
Transport Equipment	0.01	0.54	23.75
Misc. Manufacturing	0.04	0.56	18.83

Note: Value-added shares shown for each sector are within-group shares. Source: as for Table 2.

Table 4: Macroeconomic effects of trade liberalization (per cent changes)

	Manufacturing sectors only	All tariffs reduced
Overall Economy		
Gross Domestic Product		
Nominal (local currency)	–0.18	–0.24
Real	–0.04	–0.02
Consumer Price Index	0.00	–0.10
GDP Deflator	–0.14	–0.23
External Sector		
Export Revenue (foreign currency)	0.42	0.51
Import Bill (foreign currency)	0.40	0.49
Trade Deficit (in levels, foreign currency)	0.00*	0.00*
Government Budget		
Revenue		
Tariff revenue	–22.14	–24.00
Aggregate revenue		
Nominal, local currency	0.56	0.41
Real	0.57	0.51
Expenditures		
Nominal (local currency)	0.35	0.34
Real	0.36	0.44
Budget Deficit (in levels, local currency)	0.00*	0.00*
Household Sector		
Consumption		
Nominal (local currency)	–0.06	–0.14
Real	–0.06	–0.04
Factor returns		
Wages: unskilled labor	0.66	0.56
Wages: skilled labor	1.26	1.36
Return to variable capital	1.14	1.19

Source: APEX simulation results. 0* indicates figure is identically zero.

Table 5: Sectoral effects of trade liberalization (per cent changes)

	Manufacturing tariff reduction		Across-the-board tariff reduction	
	Price	Output	Price	Output
Agriculture				
Irrigated Rice	.37	–.16	–.38	–.75
Rainfed Rice	.37	–.18	–.38	–.61
Corn	.11	–.45	.00	–.44
Coconut	.45	–.21	.33	–.04
Sugar	.22	–.22	.22	–.17
Fruits	.17	–.38	.11	–.31
Vegetables	.51	–.01	.56	.11
Rootcrops	.59	–.01	.54	.10
Other Comml Crops	.25	–.15	.24	–.14
Hogs	.48	–.06	.40	–.10
Poultry	.35	–.13	.15	–.15
Other Livestock	.37	–.12	.19	–.19
Nat. res & ag. processing				
Marine Fisheries	.21	–.29	.21	–.22
Inland Fisheries	.33	–.06	.30	–.07
Forestry	.90	.84	.90	.87
Crude Oil	–.49	–.02	–.55	–.07
Other Mining	–.19	.67	–.20	.71
Rice & Corn Mills	.53	–.12	.15	–.01
Sugar Milling	.11	–.24	.11	–.18
Dairy	–1.52	–.15	–1.60	–.14
Oils	–.06	.20	–.08	.33
Meat	.44	–.06	.35	–.08
Feed Milling	.24	–.08	–1.80	.17
Animal Feeds	–.17	–1.74	–.50	–1.74
Other Foods	–.48	.79	–.60	1.05

Table 5 continues next page…

Table 5: Sectoral effects of trade liberalization (per cent changes) (Continued)

	Manufacturing tariff reduction		Across-the-board tariff reduction	
	Price	Output	Price	Output
Manufacturing				
Bev. & Tobacco	–.83	.08	–1.10	.17
Textile	–.58	–1.01	–.67	–.97
Other Textile	–.06	.11	–.07	.12
Garments	.10	–.73	.09	–.68
Wood Products	–.34	2.08	–.36	2.19
Paper Products	–.48	–.53	–.52	–.52
Fertilizer	–.05	.18	–.08	.07
Other Rubber Prod.	–.95	–.07	–.99	–.10
Coal & Petroleum	–.17	–.12	–.20	–.15
Basic/Non-ferr Met	.06	–.43	.06	–.44
Cement	–.81	–.48	–.86	–.47
Semiconductors	–.31	1.95	–.31	1.97
Metal Products	–2.51	–.36	–2.68	–.31
Elect. Machinery	–.96	–.41	–1.00	–.42
Transport Equipt	–1.15	–.47	–1.21	–.47
Misc. Mfg	–.71	–.88	–.72	–.87
Services				
Agric.Services	.18	–.16	.10	–.35
Construction	–.56	.21	–.61	.22
Elect, Gas & Water	.13	–.01	.13	–.02
Tc Services	.41	.12	.40	.07
Transport & Storage	.52	–.05	.52	–.03
Banks	.47	–.10	.49	–.13
Insurance	.50	.00	.50	–.04
Gov't Services	.98	.03	1.05	.02
Other Services	0.01	–.22	–.06	–.22

Table 6: Agricultural land use changes due to trade liberalization in non-agricultural sectors

Industry	Luzon		Visayas		Mindanao	
	Manuf. tariffs	All tariffs	Manuf. tariffs	All tariffs	Manuf. tariffs	All tariffs
Irrigated rice	.08	–.60	–.09	–.64	–.18	–.71
Rainfed rice	.06	–.49	–.01	–.34	–.27	–.61
Corn	–.04	–.31	–.16	–.12	–.44	–.37
Coconut	.14	.11	.02	.00	–.25	.08
Sugar	–.03	–.03	–.19	–.14	–.28	–.15
Fruits	–.06	–.10	–.24	–.25	–.32	–.24
Vegetables	–.17	.23	.05	.19	–.06	.14
Root crops	–.89	.46	–.08	.05	.90	–3.41
Fallow land	–.04	.26	.08	.17	.29	.33
Erosion	–.03	–.30	–.14	–.13	–.42	–.38

Source: APEX simulation results. For definitions of 'fallow' and 'erosion' see text.

Table 7: Changes in real household consumption expenditures, by quintile

Household group	Manufacturing tariff reduction	Across-the-board tariff reduction
Poorest 20%	-.22	-.21
Second	-.16	-.15
Third	-.12	-.11
Fourth	-.09	-.08
Richest 20%	.02	.05

Source: APEX simulation experiments

Table 6.12: Changes in household incomes, by source

Household group	Manufacturing tariff reduction	Across-the-board tariff reduction
Labour	.77 to 1.09	.71 to 1.15
Agricultural land	-.05	-.26
Agricultural capital	.44	.13
Non-agric. capital	.99	1.05
Variable capital	1.14	1.19

Source: APEX simulation experiments. Note: households also derive income from non-factor sources (not shown). Range of labor income figures is due to differing mix of skilled and unskilled labor per quintile; the lowest figure in each range is for the lowest quintile.

Notes

* This paper draws in part on analysis reported in Coxhead and Jayasuriya (2002, 2003). Financial support was provided by the United States Agency for International Development (USAID) through the Sustainable Agriculture and Natural Resources Management Collaborative Research Support Program (SANREM CRSP).

[i] About 45% of the "uplands" have 18–30% slopes, while more than half of the land area in the country is over 18% in slope (World Bank 1989)

[ii] The rate of 2.9% for the 1990–95 period is given in Republic of the Philippines (1998). As seen in Table 12.2, FAO data indicate deforestation at rates of 3.3% per year in the 1980s, and 1.4% per year in the 1990s. Kummer (1992) presents a detailed discussion of data issues in the forestry sector. Fujisaka, Sajise, and del Castillo (1986) also provide a useful overview of the nature and evolution of the upland ecosystem.

[iii] Commercial logging facilitates subsequent conversion of logged forests to agriculture.

[iv] Of the endemic Philippine flora, 60% is considered already to be extinct, and a great many other species are endangered.

[v] See, for example, World Bank (1989). By 1993, 17% of the total land area was estimated to be badly eroded, 28% moderately eroded, and a further 29% slightly eroded (Republic of the Philippines 1998). In this source the annual cost of on-site damage from erosion *only* was estimated to be about 0.25% of GDP.

[vi] The downstream effects of deforestation and watershed degradation are not the only sources of environmental concern in Philippine agriculture. In cereal crops, production growth has been associated with increasingly intensive use of inorganic fertilizers and pesticides, in spite of the introduction of "environment-friendly" techniques such as integrated pest management (IPM). Health and other problems associated with chemical use in rice production have been documented by Rola and Pingali (1993).

[vii] In 13 provinces, more than half of total land area is considered to be severely eroded and degraded. These are: Batangas (83%), Cebu (76%), Ilocos Sur (73%), La Union (70%), Batanes (60%), Bohol (66%), Masbate (66%), Abra (65%), Iloilo (63%), Cavite (60%), Rizal (56%), Capiz (55%), and Marinduque (51%) (Maglinao et al., 1996).

[viii] Statistical estimates in Balisacan (2002) show the most significant correlates of poverty in Philippine provinces (sign of correlation in parentheses) to be landlocked (+), irrigation (–), typhoon-prone (+), agricultural terms of trade (–), and roads as a proxy for infrastructure (–).

With the exception of typhoon-prone, upland areas normally score higher on all of the positive correlates and lower on the negative correlates.

[ix] For discussions of the nature and consequences of trade policy in the Philippines, see Baldwin 1975 and Bautista and Tecson (2002). The following discussion draws on their analysis of the impact on industry structure and growth.

[x] This does not imply that ISI policies alone are responsible for the urban bias in Philippine industrialization, particularly the Metro Manila bias. While ISI policies clearly contributed to this phenomenon, powerful economic forces of agglomeration tend to generate an urban bias in growth, and that would have occurred even under a more open trade regime (see Fujita, Krugman and Venables, 1999).

[xi] Irrigation investments and the Green Revolution, by raising productivity in lowland agriculture, helped somewhat to offset these trends. However, the rapid increase in rice yields did not last for much more than a decade, and the derived labor demand effect was itself diminished by implicit and explicit subsidies for capital-intensive agricultural techniques (Jayasuriya and Shand 1985; Coxhead and Jayasuriya 1986).

[xii] See Paderanga (1986) for a historical review of land settlement policies in the Philippines.

[xiii] See Grossman and Krueger (1993). Although this taxonomy originated in the literature on trade and the environment, it is readily applicable to the broader setting of economic growth.

[xiv] Strictly speaking, changes in the prices of goods and services, and in the production and valuation of pollution, cause optimizing agents to respond by adjusting their abatement expenditures. These effects are not captured in the model.

[xv] Empirically, the Philippine labor market is characterized by considerable unemployment and under-employment, and labor supply is quite elastic at the going wage rate. Coxhead and Jayasuriya (2002) report the analysis of trade liberalization under the assumption of a 'slack' labor market with fixed nominal wages.

[xvi] Specifically, any shortfall or surplus in the government budget is made up by a lump-sum tax on household incomes, while nominal household savings remain fixed.

[xvii] The latter figures, although not shown in the tables, are available as part of the complete set of simulation results from the authors.