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Economic Growth, Development Policy and the Environment in the Philippines

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1. Introduction

What is the state of the Philippine environment, and what are the links between environment and development in the Philippine setting? In this paper we first review the available data on environmental quality and natural resource degradation in the Philippines. We consider trends over time, and compare the Philippine case with those of its Asian regional neighbors. Second, we present a brief review of theoretical links between environmental quality, resource depletion, and development strategies and outcomes, and consider the Philippine data in light of this theory. Third, we discuss recent economic trends and policy initiatives having a bearing on environment and development, and present some simulation results indicating likely trends in economic and environmental variables under alternative policy regimes. Finally, we ask what past experience and current trends might indicate for the future of the Philippine environment.

The “environment" can only be meaningfully discussed in terms of its component parts. As identified in official Philippine documents, these include natural resource stocks such as forests, minerals, water, biodiversity and soils, as well as air and water quality in specific locations and times. Since these categories are sometimes difficult to identify separately it is convenient to group them as a set of *ecosystems*—forest and uplands, lowland agriculture, urban-industrial, coastal/marine, freshwater—and a set of *resources* (that are of course components of ecosystems): forests, fisheries, soils, minerals and biodiversity. We examine the data and some analytical evidence on each of these, but concentrate in the second half of the paper on some case studies of specific ecosystem and natural resource issues.

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2. The state of the Philippine environment

The Philippines' environment and natural resource sector is generally classified as comprising five major inter-linked, and sometimes overlapping, ecosystems: (i) the forest and uplands ecosystem; (ii) the agricultural/cropland ecosystem; (iii) the freshwater ecosystem; (iv) the coastal and marine ecosystem; and (v) the urban ecosystem.[1] Some of these ecosystems include significant mineral and other natural resources; others also host a rich variety of flora and fauna (Table 1). The country is home to 5 percent of the world's flora species, 6% of the birds, and 4% of the mammals; 67% of the species in the major groups of animals and plants are not found anywhere else in the world, its coral reefs are second only to Australia's Great Barrier Reef in terms of the diversity of coral and fish species, and the country has the second highest number of seagrass species in the world. However, each of the Philippine ecosystems faces significant, often severe, problems of environmental degradation, both from the depletion of resource stocks and from the production of polluting emissions.

Forests and uplands

The forest and upland ecosystem covers around 45 percent of total land area, and its resources directly support about 30 percent of the population, including some of the poorest in the country. It is experiencing severe pressures of a variety of kinds, of which the most prominent is rapid deforestation. Deforestation reduces biodiversity through its destructive impact on plant and animal habitats, alters hydrological properties of soils, and adversely affects watershed functions. Further, a large proportion of the uplands have steep slopes which, once cleared of their permanent cover, are prone to severe land degradation, particularly soil erosion, unless adequate conservation measures are implemented.[2]

Estimates of actual forested area and rates of 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), between 1900 and 1950 national forest cover fell from around 70 percent of total land to 50 percent, and by the end of the 1980s had further fallen to less than 25 percent. With deforestation proceeding at an annual average rate of 2.9 percent even according to Philippine government

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[1] This classification of the Philippine ecosystems is based on Chapter 4 of *The Philippine National Development Plan: Directions for the 21st Century* (Republic of the Philippines 1998), *Philippine Agenda 21: A National Agenda for Sustainable Development for the 21st Century (*Philippine Council for Sustainable Development 1997), and *Philippines: Environment and Natural Resource Management Study* (World Bank 1989). The latter, though published in 1989, remains a very useful source of material on several aspects environmental issues facing the Philippines. See also the review of issues as of the late 1980s in de los Angeles and Lasmarias (1990).

[2] About 45 percent of the 'uplands' have 18 – 30 percent slopes, while more than half of the land area in the country are over 18 percent in slope (World Bank 1989)

sources, by the late 1990s forest cover was less than 19 percent.[3] Table 2 provides a regional perspective, showing the Philippine deforestation rate to be well in excess of those in neighboring countries— even those which, like Vietnam, not do not have especially large initial forest stocks.

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 be primarily responsible for depletion of old-growth *dipterocarp* forests with valuable timber, with conversion to agricultural uses accounting for much of the deforestation of secondary or residual forest lands.[4]

In upland areas, increases in agricultural production have traditionally been come to a great extent from expansion at the cultivated margin rather than by improvements in the efficiency with which existing land resources are utilised. Between 1960 and 1987, the upland population more than doubled to an estimated 18 million, and the area devoted to upland agriculture increased sixfold, 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 to upland rice and corn, with lesser amounts planted to vegetables, tree crops, pasture and other uses. Since 1990 the national planted area of major upland and rainfed crops such as corn has declined somewhat, but this is due more to the conversion of land to other crops and to non-agriculture 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 a 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 percent 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).[5]

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[3] The 2.9 percent rate for the 1990-95 period is given in Republic of Philippines, 1998. According to the *World Development Report 1999/2000*, the annual average rate of deforestation during this period was 3.5 percent. Kummer (1992) presents a detailed discussion of data issues in the forestry sector. Fujisaka *et al.* (1986) also provides a useful overview of the nature and evolution of the upland ecosystem.

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

[5] 60 per cent of the endemic Philippine flora are considered to be already extinct, and a great many other species are endangered.

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 practised 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 3; and see David 1988; Cruz *et al.* 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 intensively pursued, pesticide runoff is also a problem (Deutsch *et al*. 2001). Watershed degradation as a consequence of deforestation has emerged as perhaps the most important environmental problem of the Philippines, given that its impacts are felt not only in the uplands but also very widely in the lowlands.[6]

Agriculture and croplands

Agriculture remains the largest single sector and employer in the Philippine economy. Well over half the population depends either directly or indirectly on income generated in 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 fertiliser use rates are among the lowest in tropical Asia (Table 4).

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) has become 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 long-term land productivity decline, a phenomenon sometimes disguised in recent years by technological progress (Cassman and Pingali 1995; Ali and Byerlee 1996). 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 areas of the country. Current estimates suggest that between 74 and 81 million tons of soil are lost annually, and that between 63% and

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[6] 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. In this source the annual value of on-site damage *only* from erosion was estimated to be about of 0.25% of GDP.

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 Philippine agricultural land base is a source of serious concern. The loss 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.

In cereal crops, agricultural development has been associated with increasingly intensive use of inorganic fertilisers and pesticides. Although 'environment-friendly' techniques such as integrated pest management (IPM) are increasingly popular, chemical control of pests remains the norm. Rice cultivation accounts for a large fraction of total agricultural chemical demand in the Philippines: in 1987, 47% of all insecticides and 82% of herbicides sold were for use in rice (Rola and Pingali 1993). Uncontrolled pesticide use and inappropriate application methods account for many deaths as well as eye, skin, respiratory, cardiovascular and neurological illnesses among farmers and their families. Such health problems have been documented by Rola and Pingali (1993), who note that the mean pesticide-related health cost to Central Luzon rice farmers in their data base far exceeded its net benefits in terms of improved crop yields. Offsite, inorganic fertilisers and agricultural chemicals further contribute to water pollution, loss of biological function in lakes, streams and estuaries, and downstream health and abatement costs.

Coastal and marine ecosystems

The Philippines has 7,107 islands and a total coastline of 17,460 km; its marine territorial waters cover nearly 2,000,000 km^2 of oceanic waters and 266,000 km^2 of coastal waters. The coastal and marine ecosystems are clearly major components of the country's environmental resources, performing critical ecological functions (e.g. breakwater and erosion control, nutrient recycling, beach sand deposition) and providing important resources such as mangroves, coral reefs and seagrass beds that nurture a rich variety of fish and other aquatic life and also providing facilities for recreation and tourism. These environmental resources are unique in many ways, and, being major repositories of biodiversity, have international significance in terms of their importance in the global ecology. As with other environmental resources of the country, these too have been significantly degraded. With more than half of the population residing in coastal areas, and most of the big cities located near the coast, these areas are subject to most of the environmental pressures emanating from population growth and the full range of human activities.[7]

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[7] For an excellent bibliographic survey of pre-1990 research on Philippine fisheries and aquatic resources see de los Angeles *et al.*, 1990.

The most tangible and direct economic impact of environmental degradation of marine ecosystems is reflected in the depletion of fish stocks (due primarily to over-fishing, often with destructive methods such as bottom trawling, explosives and harmful chemicals), the destruction of mangrove areas and corals, pollution of coastal waterways. But fish production levels have been maintained and even increased through greater fishing effort, further diminishing fish reproductive capacity.[8]

Mangrove swamps play a key role in the coastal ecosystems, forming the foundation of the coastal fisheries food chain and the breeding ground and nursery for many varieties of fish and crustaceans. They also provide timber, charcoal and other types of wood for coastal households. Of approximately 450,000 ha of mangroves that existed in 1918, more than two thirds had been destroyed by 1987/88, so that only 149,000 ha remained. With continuing conversion of mangrove land to fishponds and other forms of aquaculture, tourism development, and exploitation for wood and charcoal, mangrove area declined further to only 120,500 ha by 1994, with most located in isolated regions of Mindanao, Eastern Visayas, Bohol and Palawan. There is less quantitative information available on seagrass beds, whose importance in sustaining viable marine ecosystem is considered to be under-appreciated. However, they too are known to have experienced ongoing rapid degradation brought about by various forms of human activities such as coastal land development, mining, blast fishing, and runoff induced by deforestation and mining (Nickerson 1999).

The Philippines' coral reefs provide not only a habitat for fish and other forms of marine life contributing some 10-15 percent of total fish production, but are also a major tourist attraction. Most (nearly 95 percent) of the reefs have suffered some degree of degradation, with nearly a third being in poor condition. Though they make a major contribution, however, human activities are not solely responsible for coral reef degradation. Sediment deposit due to deforestation is considered a major source of coral damage, with other factors such as direct extraction, mine tailings, pollution, destructive fishing methods and coastal developments all contributing additional amounts.

Urban systems

Rapid population growth and urbanisation have contributed to urban population growth rates far in excess either of national or of regional averages in recent decades (Table 5). Industrial growth has also been highly concentrated in and around urban areas (see Pernia *et al* 1983). Urban pollution thus consists both of industrial effluents (emissions into air and water, as well as solid waste), and post-consumer effluents (vehicle emissions, sewage and solid waste). As a consequence, air and water pollution problems are most acute in urban regions and especially in Metro Manila, which has the largest concentration of population and industry.

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[8] "Philippine fishery resources… are being depleted at an alarming rate due to overfishing." (Republic of Philippines, 1998: p. 4-8).

Air pollution in Metro Manila is quite serious.[9] In 1992, in locations in Metro Manila where 80 percent of the people lived, annual average total suspended particulates (TSP) concentrations were found to be frequently more than five times higher than the World Health Organization Air Quality Guidelines (WHO AQG). Measures of PM_{10} (particulate matter less than 10 microns) were also two to three times higher than WHO AQG, and long-term measured lead levels exceeded both national and WHO guidelines.[10] Although these emissions levels are not very high by the standards of Southeast Asian cities (for comparative TSP and sulphur dioxide levels, see Table 6), their impact on health is nevertheless large. 1995 estimates indicated that PM_{10} alone may cause 1,300 deaths and respiratory diseases costing 4,594 million pesos (equivalent to 0.3% of 1995 GDP) per year. According to some official sources, TSP emissions are on an upward trend.[11] The primary source of air pollution has been increased fuel consumption, both by motor vehicles and for power generation. Bunker oil combustion in small to medium industrial and commercial enterprises was the major contributor to high TSP, followed by vehicle exhausts from diesel trucks, buses and jeepneys; vehicle exhausts contributed a greater share to PM_{10}. Gasoline contributed most lead; the introduction of low lead gasoline in the early 1990s appears to have reduced ambient lead levels in air.

The development of the Philippine energy sector, the largest single source of industrial emissions, reveals an industry-level trend that merits discussion. Prior to 1977, hydro power constituted more than 80% of total national electricity generating capacity. Major investments in oil-fired power generation during the late 1970s reduced this share to about one third. During 1992-98, a period in which electricity generating capacity increased by a factor of 1.76, hydro power capacity increased by a factor of only 1.04, and the share of this source in total electricity generation diminished from one third to less than one fifth, with oil-fired plants contributing another two-fifths to one half. The balance was made up primarily by increases in geothermal and coal-fired power generation; coal-fired generating capacity increased by a factor of 5, and its share in total power generation rose from 6% to more than 17% (NSO 1988; NSCB, various years). Over three decades there has been a substantial swing in the composition of electricity generation, with fossil fuels now contributing nearly two-thirds of total supply. Urban populations are by far the worst-affected by air pollution from power-generating plants (Hordijk *et al.* 1995).

Rapid growth of urban centers in the Philippines has not been matched by provision of infrastructure, including clean water, traffic control and mass transit systems, and problems of urban decay are mounting. The country's large cities do not have adequate sewage and waste disposal facilities. Again, the problems are most acute in Metro Manila. Only 13 percent of households in Metro Manila are linked to a sewage system. Forty percent of solid household wastes are dumped illegally, a part being burnt, adding to air pollution. Reporting these data, the

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[9] The data come from Shah and Nagpal (1997).

[10] SO_2 levels appear not be very serious in Metro Manila.

[11] See Republic of Philippines (1998). The figure given for 1995, however, is lower than the 1992 average.

1998 Philippine National Development Plan (Republic of Philippines 1998) summed up conditions in urban areas as follows:

> The absence of far reaching comprehensive land use and human settlement plans has resulted in the deterioration of the country's cities as human habitats beset with interrelated problems like inadequate mass transportation and road systems; pollution and inadequate and inappropriate waste disposal systems; flooding; water shortage; deterioration and lack of basic social services; and proliferation of crime and other social evils. (p. 4-9).

<u>Freshwater systems</u>

The Phippines freshwater ecosystem, comprising 384 major river systems and 54 lakes and covering an area of about 569,600 hectares, faces severe problems through pollution and watershed degradation. Many of the major rivers and lakes, particularly those passing through or close to urban centres, are heavily polluted. The main river systems in Metro Manila are biologically dead,[12] and siltation and chemical residues are serious problems for major lakes, including Laguna Lake, Lake Danao, Lake Lanao and Lake Leonard.

Urban water pollution is caused primarily by inappropriate disposal of household wastes. Much of the remainder is contributed by industrial enterprises, the majority of which do not comply with existing water pollution standards. As mentioned earlier, inadequate sewage and other failings of waste disposal systems leads to much illegal dumping; a considerable proportion of daily household waste ends up in waterways. Elsewhere, with few river or lake system management systems in place and little effective control over effluent discharges or runoff, agricultural chemical residues and, in some locations, effluents from mining operations also contribute to the build up of pollution.

The case of Laguna lake illustrates many of these problems.[13] It is the second largest inland water body in southeast Asia, covering a surface area of 90,000 hectares. Its drainage region includes Metro Manila as well as many other smaller cities, and 21 rivers and streams flow into it. In 1994, 1,481 factories were located in the catchment area, and the lake and its feeder rivers and streams were used as dumping grounds for industrial waste that contributed 30 percent of total lake pollution (agriculture and sewage respectively contributing 40 and 30 percent). Food processing, hog farms, slaughterhouses, beverage firms, and textile makers were the largest sources of industrial pollutants. Though 60 percent of the local factories had nominally adopted pollution control measures, only 6 percent complied with legislated standards, demonstrating the utter inadequacy and ineffectiveness of traditional regulatory methods. Although new measures and new approaches adopted in the late 1990s have had some apparent success in abating effluent discharges (see section 5), the Laguna lake ecosystem has already suffered long-term and possibly irreversible damage.

[12] The dissolved oxygen content is below the 5 mg/litre needed to sustain aquatic life.

[13] Data cited in this paragraph are from World Bank (1999).

Costs of environmental degradation

The foregoing review, though brief and necessarily somewhat cursory, vividly illustrates the scope and severity of challenges that human interventions now pose to the integrity of Philippine ecosystems. The postwar growth of the Philippine population and economy has been associated with decades of damage, both transitory and permanent, to these ecosystems and their component parts. In many cases the losses cannot easily be aggregated or even calculated, let alone valued. Nonetheless it is undeniable that environmental degradation has imposed costs on the Philippine economy, and it is conceivable that these have been quite large in relation to total income.

In the 1990s it became increasingly widespread practice for countries to augment standard measures of national income from the System of National Accounts with "satellite accounts" which compute net additions to or reductions in estimated income due to environmental damage and natural resource depletion. In developing countries, these exercises typically result in estimates of "adjusted" net domestic product (ANDP) that are substantially below the measured NDP (WRI 1988; TSC/WRI 1992). Our review of environmental developments in Philippine ecosystems suggests that past economic growth may have come at a significant cost in terms of environmental resources lost and amenities foregone. However, in the Philippines, a major natural resource accounting exercise completed in the early 1990s estimated that there was ‘no statistical difference’ between ANDP and unmodified GNP figures (ENRAP 1994). This seems to us to reflect limitations inherent in the methodological approach, rather than an accurate estimation of the real costs of long term environmental degradation. First, the methodology used values waste disposal services as contributing positively to GDP; while common practice, this is the same kind of procedure that gives rise to the statistical illusion that a plague among infants can increase a country’s GDP because it increases the value of health services.[14] Second, it adds the value of unmarketed natural resource services (not hitherto counted in GDP), which increases the value of adjusted GDP and thus largely offsets the negative effects of the depletion and degradation of the natural resource base. While this may produce a more statistically accurate one-off picture of national income (which measures the flow of goods and services over the year), it masks the long-term costs of environmental depletion and degradation. After all, recognition of previously unrecorded benefits of environmental resources should not be seen as somehow compensating for the long-term effects of the erosion of that very resource base that provides those benefits. Third, and related to the first point, the *net* costs detailed under specific items are rather small.[15] The authors attribute this to the high costs of importing pollution abatement equipment and materials.

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[14] The authors note that while their figure is similar to that for other countries using this approach to valuation of pollution abatement services, studies that use a different approach arrive at much higher differences between AGDP and GDP.

[15] For example, net environmental damages due to air pollution are estimated to be only 338 million pesos at 1988 prices, only 0.04% of GDP; a careful analysis of the health costs of air pollution in Metro Manila alone have been estimated to be 0.03% of GDP (Shah and Nagpal, 1997).

This assertion, if true, contradicts considerable evidence from other developing countries indicating that control costs are often well below the value of damages (see World Bank, 1999).

Finally, a more fundamental point should be noted. Estimates of environmental damage and abatement costs should recognise that the prevailing industry and price structure and associated levels and intensities of environmental degradation reflect the effects of distortionary policies. Ideally, environmental costs should be evaluated at shadow prices, rather than at distorted market prices. In principle, changes in policy may improve both efficiency and environmental outcomes. From this point of view, it is useful to have direct estimates of the social cost of environmental damages, so that alternative policies for abatement can be assessed.

Although an adjusted measure of GDP of the kind now popular in "satellite accounts" may be useful for some purposes, it disguises the full extent of environmental degradation taking place in an economy, and underestimates the environmental degradation costs that are being incurred. It follows that the goal of optimally utilising natural resources for economic growth and poverty alleviation while maintaining environmental quality poses a formidable challenge for the future. The first task is to understand the causes and consequences of unsustainable rates of environmental degradation and natural resource depletion.

3. Explaining the current situation and past trends

Economic growth and the environment

Nearly every form of economic activity is associated in some way with pollution or the depletion of natural resources. In production and trade, fossil fuels, timber, and minerals are consumed in the production and transport of goods and services using processes that that include waste emissions along with the desired output. Consumption by individuals and households also entails pollution in the form of solid waste, vehicle emissions, and sewage. While individuals or firms may correctly regard the environmental consequences of their actions as trivially small, in aggregate they contribute to a variety of social costs. These may include direct abatement or clean-up expenditures, loss of cultural and recreational amenities, and less direct and less easily quantified outcomes such as habitat and species extinction, biodiversity loss, and release of greenhouse gases. The fact that the full social cost of pollution and resource depletion is seldom internalised in private economic decisions lies at the core of virtually all economic analysis of environmental and resource problems.

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. 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 industrialised economies.

A variety of factors broadly associated with economic growth influence 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. [16] 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. At first glance it may appear that the scale effect—arising as it does from economic growth and increasing per capita incomes—will be the dominant determinant of long run environmental outcomes. But such outcomes are also strongly influenced by initial conditions, and the aggregate rate of economic growth is not a complete predictor of trends in environmental quality or resource depletion.

The *composition effect* is the environmental impact of changes in the structure of production and consumption. Economies at early stages of economic development are endowed only with "raw" factors of production, such as labour and a variety of natural resources including land and soils, water, minerals, and animal and plant populations. Early economic growth entails the use of these resources to produce both final goods for direct consumption as well as investment goods: physical capital, knowledge, technology, and the legal and financial institutions that underpin exchange. Economic growth thus leads inevitably to changes in economic structure, both 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. This structural shift has a scale effect (the decline of resource-based sectors is typically relative, not absolute, so there is more resource depletion overall), as well as a composition effect associated with the rise and decline of pollution-intensive industries.[17] 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.

In a typical example, a developing country in which the labour force is growing at 2% per year and net capital investment at 10% is one in which the most labour-intensive activities will decline over time, other things equal, as capital growth raises labour productivity faster in sectors

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

[17] The pollution-intensity of an industry can be defined in many ways; one is that an industry is pollution intensive if the total level of pollution in the economy increases when it expands (drawing resources from other industries in an economy thus contracting them) (Copeland, 1994). We introduce a quantitative measure of pollution intensity in Section 4.

that are more capital-intensive (the "Rybczinski effect"). By extension, more capital-intensive industries that were initially below break-even point may come into existence as the capital-labour ratio increases; others may disappear and others still may both rise and fall (Leamer 1987; Deardoff 1999). It follows from these supply-side shifts that patterns of resource exploitation and pollution will also change with unequal factor growth rates, even if production technologies and relative output prices are fixed. Moreover, the changes may be non-monotonic, as the late twentieth-century decline of traditional manufacturing and rise of human capital-intensive industries in the U.S. and other wealthy nations made clear. A similar process can now be observed in the Philippines, where long-term investments in education, English language training and computer skills are beginning to pay off in the growth of human capital-intensive industries such as computer programming, software creation, and support systems for high-tech service sector enterprises in the U.S. and elsewhere. Such processes are highly specific to the circumstances of an economy.

Changes in the composition of domestic consumer demand are captured in highly stylised form by Engel's law, which states that as per capita income expands, expenditures on food decline as a proportion of total consumer spending. This biased expansion of demand alters the relative weights of different goods in the consumption bundle over time as economic growth raises per capita income. In a closed economy, the Engel effect limits the growth rates of demand for food and other staples. Buoyant growth of spending out of new income on manufactures, personal services, education and recreation are the primary sources of changes in relative commodity prices that in turn produce shifts in the structure of production. Engel effects and other endogenous relative price changes are also readily observed in an open economy, however, through changes in domestic demand for *nontradables*—personal services, housing, education, health, recreational services and goods which, by virtue of transport costs or other impediments, cannot be exchanged with other countries (Anderson and Warr 1987). Rising per capita incomes may alter emissions through changes in the composition of demand, as a result, for example, of preference for private automobiles over public transport.

Finally, emissions and resource depletion associated with any given output level also depend 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. There may be exceptions, however, such as "smokestack chasing" competition in which sub-national or national governments relax environmental standards in order to attract investment.

In practice, the influence of composition and the technique effects on changes in emissions over time, and their relationship to the scale effect, are likely to depend very much on country-specific circumstances. There is, however, some reason to believe that the three effects make different relative and even absolute contributions to total emissions over the range of development experience. This line of thinking has been formalised in a body of literature on the so-called "environmental Kuznets curve" (Grossman and Kreuger 1993). 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, and 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 hypothesised, is an inverse-U shaped relationship between emissions and per capita income. As with the original Kuznets inverse-U hypothesis concerning the relationship between growth and income distribution, however, empirical tests of the environmental inverse-U hypothesis are largely inconclusive (Stern *et al.* 1996). Tests based on time-series data for single countries (Grossman and Kreuger 1995) appear to provide more robust support for the hypothesis than those based on cross-sectional or panel data (Cropper and Griffiths 1992; Selden and Song 1994; Hettige *et al.* 1997; World Bank 1999). What most tests do reveal, however, 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.

In open developing countries, trade policy (until very recently a major tool of industrialisation 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 hypothesised 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. Obviously, it would be desirable to deploy an analytical model in which aggregate welfare, environmental outcomes and the distributional effects of policy reforms are simultaneously determined. More generally still, which policy instruments are deployed and who bears the burden of pollution is determined in part by property rights (along with other political economy factors and the usual fiscal policy and efficiency considerations). Accordingly, in real world policy making, an institutional failure such as open access to natural resources or free disposal of emissions into air and water could in principle acquire great economic significance.

But a general point comes through in these normative models: trade policy is not a substitute for environmental policy. Where environmental externalities exist, they should be addressed at the source by specific environmental policies. In particular, trade restrictions are not an efficient instrument to address environmental problems. As Corden (1997) points out, in the presence of environmental externalities, the optimal policy for a ‘small country’ is not *laisser faire*, but free trade *together with* targeted policies that address environmental externalities.

In the remainder of this section we explore the Philippine experience of development, trade policy reform and environmental degradation, with emphasis on industrial emissions. In the subsequent section we make use of an applied general equilibrium model to provide some numerical results on the broader environmental implications of economic growth and policy reforms.

Industrialisation and industrial emissions

At the aggregate level, industrial emissions growth in the Philippines displays a pattern shared with other developing countries. A first glance at data relating emissions to the size of economies (Figure 1) or to increases in manufacturing output (Figure 2) suggests that the scale effect is the dominant manifestation of the environmental effects of economic growth. Toxic intensity (emissions per dollar of manufacturing output, discussed in more detail below) is positively related to growth of manufacturing output and GDP, and periods of rapid growth are associated with rapid increases in emissions, as well as in emissions per unit of income produced. Conversely, recessions or growth slowdowns such as occurred in the 1980s in each of the three countries shown in Figure 1 are associated with slower increases, or even declines, in emissions output.

Figure 2, which plots industrial emissions growth against manufacturing sector growth in the Philippines and other developing Asian countries, provides a clear indication of the strength of the scale effect. In general, increases in manufacturing output are accompanied by increases in industrial emissions, and the figure suggests that the ratio of these two broad indicators is similar across economies.

Although these aggregate data are suggestive of a strong relationship between economic growth (or industrialisation) and emissions growth, it should nevertheless be remembered that they reflect the joint impacts of scale, composition and technique effects. Changes in the composition of output, between manufacturing and other sectors as well as within the manufacturing sector, may account for much of the apparently exponential growth of emissions in developing economies, as well as for much of the observed decline in emissions growth rates in wealthy countries (Lucas, Wheeler and Hettige 1992). As seen in Figure 2, for example, the period from the late 1970s to the late 1980s saw a contraction of the Philippine manufacturing sector; nevertheless, aggregate industrial emissions still grew slightly. Variation in the relationship of emissions growth to manufacturing output growth thus has several sources, of which one is likely to be differences in the rate of change of the composition of industrial activity.

In the Philippines, the composition of manufacturing sector activity has altered over time, though not monotonically (Figure 3). Of course, at the level of aggregation shown in Figure 3 it is difficult to make clear inferences about the trend of industrial emissions; within each of the broad industry groups shown we find a mix of clean and dirty industries. However, the data fit a widely observed pattern in newly industrializing countries, i.e. that there is a compositional shift over time from heavy industries and industries engaged in basic processing—basic metals, textiles, paper, cement, fertiliser, which are highly emissions-intensive, towards assembly and light manufacturing (vehicles, electronics and garments) which are substantially cleaner. An indication of this can be gleaned from Figure 4, which shows data on a widely used measure of industrial emissions, the Acute Human Toxicity Index (AHTI), for manufacturing industries.[18] What cannot be discovered from Figure 3, however, is the extent to which changes in the composition of Philippine industrial production have occurred as the result of secular trends as opposed to policies—an analytical question to which we shall shortly return.

The spatial dimension

The breakdown of environmental changes by scale, composition and technique effects can usefully be taken several steps further. One way to do so is to recognise geography. The Philippines, as noted above, is geographically and climatically diverse, and poverty, growth and development are strongly spatially differentiated, perhaps to a greater degree than in countries with more uniform geographic conditions. As an example, the ratio of urban to rural populations, and especially the share of Metro Manila (the primate city) in total population have increased greatly in the postwar era, as has the percentage of the population in the forest/upland ecosystem. 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, and problems of post-consumer waste such as sewage, solid waste and vehicle emissions are more severe, even when adjusted for population, in urban ecosystems than elsewhere. Similarly, deforestation and the associated degradation of soils and watersheds in upland ecosystems impact rural (and within rural, upland) populations most directly. Assessing and aggregating such spatially distinct environmental problems is a major challenge for those who would evaluate the aggregate environmental benefits and costs of a given development strategy. We return to this point later, when we consider some possible tradeoffs between environmental conservation, poverty alleviation and the reduction of disparities in the real incomes of households.

Development strategy and the environment

Another valuable way in which to extend the scale, composition and technique effect analysis is to separate, where possible, the effects of economic policies from secular growth and economic change. This is especially important in a developing country like the Philippines, where (as is widely recognised) development strategies and the institutions and support them have had very significant impacts on the rate and nature of the growth and development of the economy. The

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[18] AHTI is the Acute Human Toxicity Index, an aggregate emissions score developed for developing countries by Hettige *et al*. (1995). The score is measured in risk-weighted pounds of Toxic Release Inventory (TRI) emissions per $1,000 of shipment value (the TRI aggregates 322 chemicals in an index developed by the U.S. Environmental Protection Authority). Higher AHTI scores indicate greater emissions intensity. These emissions measures are not based on Philippine data due to unavailability; however, "the present version [of the AHTI data] can be useful as a guide to probable pollution problems [in developing countries], even if exact estimates are not possible" (Hettige *et al*. 1995:7).

country's long adherence to ISI policies, its series of highly centralised and heavily corrupt administrations, and the boom-bust economic growth pattern that emerged partly as a result of both, have had both direct and indirect effects on resource use patterns and the growth of emissions. These effects are clearly seen in the pattern of industrial growth that took place behind protective trade barriers (Baldwin 1975; Bautista, Power and Associates 1979). Moreover, periodic economic crises and related political upheavals that eroded investor confidence and blurred rate of return "signals" were partly responsible for the failure of manufacturing sector to increase its share of GDP and total employment, and of the economy to diversify both sectorally and regionally until well into the 1990s.

Another indirect consequence of this pattern of growth is the spatial and sectoral distribution of increments to the Philippine population, as noted above. Philippine urbanisation, and especially the growth of Manila relative to other urban centers, is partly a consequence of secular economic growth and partly a function of the ISI strategy, since the latter tended to diminish profitability and dampen employment growth in agriculture and traditional, rural-based industries. With little substantive investment in urban infrastructure, rapid growth of urban populations both magnified and intensified the problems of water and air pollution and solid waste disposal. A low and uneven economic growth rate, meanwhile, as well as emphasis within ISI policies on capital-intensive industries, generated persistent high unemployment and underemployment rates in the labour force. With few new opportunities in traditional, lowland-based agriculture and rural industry, internal migration as well as a high rate of natural increase created a boom in upland populations, a point given empirical support in Cruz and Francisco (1993). Land colonisation, deforestation and agricultural intensification on sloping and marginally arable lands ensued.[19] In this section we present a framework for considering such indirect effects of the ISI industrialisation strategy and its attendant political economy features.

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, are not simply the inevitable consequences of rapid population growth and resulting pressures on the land frontier. They are to a considerable extent attributable to the effects of past policy decisions. Arguably, some deforestation was inevitable, and even optimal from a national viewpoint, given that forests represented a valuable natural resource that could be exploited to generate much needed capital for growth and provide agricultural land for a rapidly growing and predominantly rural population. Past Philippine policies promoted deforestation both directly and indirectly. Current forestry policy promotes conservation, but many indirect pro-deforestation policy influences remain.

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

Policies that directly impacted on the forestry sector can be categorised into three groups. First, there were government programmes that encouraged the conversion of forests to agricultural land uses, including state sponsored settlement schemes (as was the case until relatively recently, in parts of Palawan and Mindanao.[20] Second, the state did not always enforce regulations against conversion of forests to agricultural lands, and this was the case not only with respect to activities of large commercial interests but also 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 (Cavanagh and Broad 1993). In practice both legal and illegal logging facilitate land conversion to agriculture and hence play a critical role in this process even though in principle, selective logging need not cause deforestation.

Government programmes 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 programmes can be criticised on both economic and environmental grounds, but it cannot be denied that they reflected mainstream development policy thinking of the time. Their environmental costs were in general poorly understood, and in any case were assumed to be much lower than the expected benefits. In both economic and political terms forest conversion was an attractive policy: 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 leftwing insurgencies. But when it came to logging—the activity 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) concludes that population growth was not the primary cause of deforestation in recent time; 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 narrow private interests of the politically powerful; political power and the control of the state became a tool for the rapacious exploitation of national resources by privileged groups. Not only did the country lose economic rents from timber extraction; logging also served as a conduit for capital outflows. With judicious undervaluation of export receipts, it served as a mechanism for circumventing prevailing exchange controls in the context of overvalued exchange rates, so that large funds could be repatriated overseas.

But these were not the only government policies and activities that impacted on deforestation and land degradation in the Philippines. Arguably at least as important were the

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

indirect effects of macroeconomic and ISI type trade policies, as well as sectoral policies targeting food crop agriculture such as the Green Revolution strategy in rice, and from the 1970s, high rates of protection for corn (Coxhead 2000). These impacts were transmitted through factor and product market linkages to the uplands, altering incentives for different forms of land use and inter-regional labour migration (Coxhead, Rola and Kim 2001; Coxhead, Shively and Shuai 2001). As their effects are not all immediately obvious, we identify them by considering a simple analytical model that captures some of the key stylised facts of the Philippines economy and the environmental issues of interest, the deforestation rate and patterns of upland land use.[21] This model serves to elucidate some of the main economic forces that drive changes in production, consumption and resource use in response to policy and other exogenous influences. In the next section we go on to demonstrate how these factors operate in a more richly specified applied general equilibrium model of the Philippine economy, and assess the quantitative importance of these forces in particular sets of circumstances.

Consider an economy that has two 'regions', upland and lowland; these are distinguished by land endowments of different quality (productivity). This captures in stylised form the key distinction between irrigated (lowland) and rainfed (upland) agricultural systems. Two goods are produced in each region. The lowland produces 'manufactures' and an agricultural crop, 'food'. The upland also produces 'food', along with a non-food crop, 'tree crops'. Food is thus produced in two spatially separate sectors, with distinct technologies based on land quality differences. Manufactures and tree crops are traded with the rest of the world at given world prices, with tariffs added on imports. Food, by contrast, is assumed to be non-traded. This assumption is made to capture in stylised form the effects of food policies, including quantitative restrictions on trade and monopoly trading by a non-profit state agency, that de-link domestic prices of staple cereals such as rice and corn from world market prices. Total food supply from lowlands and uplands is equal to total domestic demand, and its price adjusts relative to the prices of the traded goods to ensure that this market clearing condition is satisfied.[22] The lowland sectors each use labour and 'capital'.[23] The two upland sectors both use labour and land. Labour is assumed to be freely mobile among sectors and regions; labour 'migrates' across regions in response to changes in real wages. Labour supply grows at an exogenous rate, and wages adjust to clear the labour market. Land is region-specific; in uplands, land is mobile between the food and tree crops. Agricultural

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[21] A formal modelling exercise that describes the underlying assumptions and model limitations, together with analytical results for a range of different economic structures, and policy and exogenous changes, is in Coxhead and Jayasuriya (forthcoming). The basic model, an extended version of the specific factors (Ricardo-Viner-Jones model) in its main features, builds on earlier work by the authors (Coxhead and Jayasuriya, 1994, 1995; Coxhead, 2000; Coxhead and Shively, 1998; Jayasuriya (forthcoming)). (Where not specifically stated, the standard neo-classical assumptions are made.) This simple model is not, of course, meant to mimic the complexities of the Philippine economy, but rather to provide the flavour of the analytical insights that inform our basic arguments.

[22] From 1964-1988, rice imports constituted only 4.3% of total domestic supply (IRRI 1991).

[23] Implicitly, we can think of lowland agriculture using a specific factor, 'lowland', as well.

land in uplands can be created by clearing forest, an activity which requires labour inputs only; we assume open access to forest land, so there is no non-economic restraint on the amount of land that can be converted in this way.[24] The flow of services provided by standing forest is a public good; by assumption there is no market for these services, which are lost when forest is cleared to make land. In lowlands, the supply of land is fixed. Tree crops are normally much less soil erosive (land degrading) than annual crops (Table 3), so a land use switch between the two has environmental implications. In addition, the negative off-site impacts of erosion are considered to cause a (factor-specific) technical *regress* in lowland sectors, by reducing the productivity of irrigated land and hydro power generating facilities through siltation, diminished overall flow and greater seasonal variation, and turbidity.

The model as specified immediately implies that there is more deforestation than is socially optimal. Upland producers devote labour to the clearing of forest to create upland agricultural land until the marginal value product of land is just equal to the marginal cost of labour used to clear it, but they do not take into account the social gain from the existence of a standing forest. Hence the extent of forest conversion for agriculture that is optimal to upland producers will be too high from the point of view of society. It also follows that, in general, labour force growth will increase deforestation by lowering the economy-wide wage rate, and thereby reducing the cost of land conversion to both types of agriculture.

The impact of specific economic policies and exogenous factors ('shocks') on both environmental and other economic variables of interest depends on other structural features of the economy, including, for example, the relative factor intensities of the goods, whether manufacturing is an exportable or an importable, and the price and income elasticities of the non-traded food. Under ISI policy regimes, the manufacturing sector tends to be import competing and capital intensive, while under export oriented industrialisation (EOI) policies, it tends to be exportable and labour intensive. Upland food crops are assumed to be more labour intensive than tree crops.

Let us consider three cases of interest that can shed light on Philippine developments. These are the impacts of ISI and EOI policies on deforestation and soil erosion; the consequences of the Green Revolution in rice (primarily confined to lowlands); and the promotion of domestic self-sufficiency in corn through trade protection, subsidies on production, and the promotion of technological innovations.

<u>ISI and EOI policies</u>

ISI policies protected import-competing, capital intensive domestic industries, and also diverted investment funds through other means. Consider what happens if tariffs are increased in this model. Its direct impact is to increase the relative price (and profitability) of the capital intensive, import

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[24] In other words, one factor of production is endogenously supplied. This same specification may equivalently be interpreted as a four-good economy with one intermediate good, land in the upland region, produced using only labour.

competing manufacturing sector. This then leads to several product and factor market changes. Because manufacturing is capital-intensive, higher profitability of this sector tends to reduce the real wage (by the well known Stolper-Samuelson effect) as it draws capital away from lowland food. Lower wages mean lower labour costs in food crop sectors, but this is not sufficient to offset the effect of higher capital costs in lowland food, hence it contracts at the prevailing price. However, if food demand remains more or less constant,[25] reduced lowland supply will put upward pressure on food prices and the relative profitability of the more labour-intensive upland food will increase relative to tree crops. Further, lower wages will make land conversion to agriculture cheaper. Because its price is exogenously determined in world markets, profitability in the tree crop sector will diminish because both the protection of manufactures, and the consequent rise in food prices, reduce its relative price in the domestic market. Hence it will tend to contract. The overall effect will be to promote movement of labour to uplands, increase deforestation, and increase soil erosion as more erosive food crops expand in upland areas at the expense of tree crops. Thus, in addition to the negative effects of ISI policies on efficiency and the real wage, they exacerbate both deforestation and soil erosion. These in turn reduce productivity in lowland ecosystems, through off-site effects. The exact opposite happens in the case of open, EOI policies, as can be illustrated by considering the case of import tariff reduction in a model variant with a labour intensive export manufacturing good and a food crop sector that is a (protected) net importer.

<u>Green Revolution (productivity improvement) in lowland food</u>

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). Consider the impact of a Green Revolution-type productivity improvement in the context of our stylised model of an ISI economy.[26]

A productivity improvement in lowland rice pulls both capital and labour to that sector, increases lowland food supply and depresses food price, and increases the economy-wide wage rate. Higher wages tend to cause the import competing sector as well as both upland sectors to contract; the cost of land conversion rises and deforestation falls. The effect on upland food agriculture, such as corn, is more pronounced as it is labour intensive, and suffers more than do tree crops from an increase in wage costs.[27] Hence, there is a land use switch in uplands towards less

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[25] In principle, demand for food can go down because of reduced national income that may result from the efficiency cost of the tariff, but usually this income effect is expected to be dominated by price effects.

[26] This case is analysed in Coxhead and Jayasuriya (1994), in a model without a forest sector. The inclusion of a forest sector does not change the basic thrust of the results.

[27] Kikuchi and Hayami (1983) have documented the induced down-slope migration effect of the Green Revolution in Luzon. Shively (2001) quantifies the effects of irrigation development in a Palawan watershed on the demand for labour in lowland agriculture and through this on the diminution of upland activities that deplete forest resources.

erosive tree crops. Thus, even though the productivity impact of the Green Revolution is confined mainly to lowlands, its overall environmental effect is to reduce upland deforestation and soil erosion.[28] The combination of higher wages and lower food prices reduces incentives to open up forests and engage in low productivity, erosive upland food crop agriculture.

Corn policies

Corn has been increasingly protected in the Philippines, with effective protection rates rising from near zero in the late 1960s to at high as 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), and land area devoted to it has expanded significantly, often at the expense of forests, in the regions where deforestation continues. As earlier mentioned, Philippine agricltural policies have in essence converted corn into a nontraded good. Corn cultivation in sloping lands, particularly in steeply sloping lands, is highly erosive (Table 3). We can evaluate the impact of protection for corn in a variant of the model outlined earlier, by considering corn and rice to be substitutes in consumption, with corn cultivated as the upland food crop.

Higher protection for corn raises its relative price and profitability, and switches land use in uplands away from tree crops. To the extent that expansion of corn cultivation lowers food prices, it also tends to cause the lowland food sector to contract. Moreover, higher profitability in corn increases pressures for the conversion of forests into land for corn cultivation.[29] Thus it tends to increase the labour pull towards uplands, increase deforestation and aggravate soil erosion. The policy of high protection for corn has clear negative environmental outcomes.

After a long period of near-stagnation in productivity, corn has been experiencing significant yield increases in recent years, partly as the result of public sector investments in adaptive research and extension (Philippine Department of Agriculture 1990). What is the likely impact of such change? Productivity improvement generates two opposing forces impacting on corn profitability. First, at prevailing prices, it increases profitability. But, because trade restrictions break the link between domestic and world corn markets, the price of corn depends on domestic supply and demand. Productivity gains that increase supply have a depressing effect on price, and their effects are greater, the lower is the demand elasticity for corn.[30] Policy experiments with an applied general equilibrium model of the Philippine economy have shown that because corn demand is very inelastic, productivity improvements in corn can dampen prices to the point where land area may actually go down, and reduce land degradation (Coxhead and Shively, 1998).

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[28] Of course, the actual environmental impact of the Green Revolution has not been all positive; pesticide use that in reality had little productivity impact had costly health and environmental effects, as noted in section 2.

[29] In principle, higher wages that may accompany corn production expansion can dampen this effect. But, because the labour supply to uplands is probably quite elastic because it can draw on the larger population in the lowlands, this wage effect is unlikely to be strong.

[30] We ignore income effects, which in principle could partially offset this result, on the grounds that they are likely to be very small in this case.

But this result holds only when the trade regime completely insulates the sector from imports; under a more open policy regime, domestic prices will reflect (tariff-adjusted) world prices, and domestic supply increases will not have such a large dampening effect on domestic prices. In such circumstances, productivity increases will increase land area under corn—which of course will tend to be lower than at present—and increase deforestation and erosion. In the Philippines, public sector interventions in defense of the producer prices of corn and rice had analogous, though much more limited, dampening effects during periods of rapid supply growth in relation to demand (Coxhead 2000).

Of course, in the real-world Philippine economy many of these effects are modified by market rigidities, a much more diversified economic structure, and other real-world complexities. Some of these are explicitly incorporated in the more detailed applied general equilibrium model discussed in the next section. Nevertheless, the overall picture and insights that emerge from this simple model are useful for understanding the effects of the broad policy regime and some of the important policies pursued in the food agriculture area. The ISI policy regime not only slowed aggregate economic growth, but also had a harmful environmental impact—directly, by promoting the growth of generally emissions-intensive, capital-intensive industries, and indirectly, by promoting changes that accelerated resource depletion and environmental degradation in forest/upland ecosystems. The Green Revolution in rice (the negative effects of overuse of harmful pesticides and other chemicals notwithstanding) also had a positive environmental impact on deforestation and upland land degradation. Protectionist policies in corn, on the other hand, had an offsetting negative effect to that of the Green Revolution in lowland rice.

In this model, we do not analyse the direct impact of trade liberalisation on commercial logging activities. But from standard analytical models the nature of the impact is clear: because logs are exportables, trade liberalisation will tend to increase their relative prices and the profitability of their production. Higher log prices imply higher stumpage values. But in the absence of well specified and enforced property rights (such as in an open access regime) the increase in stumpage values will accelerate deforestation. On the other hand, with secure long term property rights, more liberal trade policies will have the same impact on commercial forests as on other export sectors. Protectionist trade policies, absence of policies to ensure that environmental externalities are internalised by private agents, and the direct complicity of government officials in deforestation for private gain have all combined to give the Philippines its present problems of deforestation and land degradation. They have also contributed to the pattern of population movements: though the mega-city bias in development, and the pattern of migration to crowded cities and forested uplands that have characterised Philippines in recent decades may not be solely due to impact of policy regimes, they have certainly played an important role.[31]

[31] The urban bias in industrialisation, particularly Metro Manila bias, is often blamed on ISI policies. While ISI policies have clearly contributed to this phenomenon, it must be noted that there are powerful economic forces of

4. Policy reforms, environment, and economic welfare

In the 1990s, the Philippine government has been taking some major legislative steps to address environmental problems. The Philippine Council on Sustainable Development, a multi-agency task force established in the wake of the 1992 Rio Conference, prepared *Philippine Agenda 21*, a document containing a comprehensive assessment of environmental problems and many proposals for regulatory and legislative reforms to address them. [32] Bills have been passed addressing property rights in forests and uplands, and others have been formulated to protect forests, fisheries and other natural resources. Conversion of mangrove lands has been banned. Low-leaded and unleaded gasoline were introduced in 1993 and 1994 respectively and it is planned that leaded gasoline will be completely phased out by 2001. The 1999 Clean Air Act laid out, for the first time in legislative form, guidelines for the control and reduction of emissions into air.

What are the likely environmental impacts of these policy and legislative initiatives? What economic tradeoffs might be involved? The success or otherwise of explicitly environment-oriented measures in reducing deforestation and other forms of environmental degradation can be assessed only in the long run. In some cases, increased environmental protection may come at some cost in terms of foregone output; on the other hand, implementation may reduce abatement expenditures, thus delivering a benefit in the form of resources released for use in other activities.

At the same time, other legislative and policy changes are taking place which, although they do not specifically target environmental variables, can nevertheless be expected to have potentially large environmental effects. During the 1990s the Philippines embarked on significant steps in the area of trade policy reform, liberalisation of foreign investment regulations, and the relaxation of some food and agriculture sector policies including the long-standing quantitative restrictions on rice and corn importation. Significant reforms in each of these prominent areas of the economy can be expected to impact not only on the sectors or regions most directly affected but also, through the kinds of general equilibrium linkages explored in section 3, on many other sectors and regions as well. Given the strength of factor and product market linkages, it may even be that the environmental implications of major economic reforms are more significant than those of any single environmental protection measure. There is, accordingly, a risk that the effects of environmental protection policy could be diminished or even negated by composition and technique effects induced by economic policy reforms.

These questions are exceptionally difficult to answer in a rigorous manner. Good-quality data are scarce; moreover, the answers in some cases must be traced through economic relationships that are quite indirect. Given these difficulties, one strategy is to simulate the effects of possible past or future changes on variables that are likely to provide indicators of environmental

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agglomeration that would have operated even under a more open trade regime (see Fujita, Krugman and Venables, 1999).

[32] See the list of legislative acts and policy initiatives in the *Philippine Agenda21: A National Plan for Sustainable Development for the 21st Century (republic of the Philippines, 1997).*

change, in a model that captures the main intersectoral and macroeconomic linkages through which the indirect effects of changes are transmitted.[33] In the remainder of this section we present the results of simulations using such a model, the APEX computable general equilibrium model of the Philippine economy (Clarete and Warr 1991). The APEX model, which originated in a joint Australian-Philippine research project, does not contain explicit environmental accounting; however, the results of policy simulations can readily be interpreted in terms of broad environmental outcomes by observing industry-level changes in output, input use, and prices, as explained below.[34] This enables intersectoral effects of the kind outlined in the previous discussion to be explicitly accounted for, and their quantitative effects gauged—at least in terms of signs and orders of magnitude. Another advantage is that the model provides the means to calculate changes in important macroeconomic aggregates such as trade and fiscal deficits, measures of economic welfare, and indicators of distributional change simultaneously with information on production, input use, consumer demand, trade and price formation. The general equilibrium structure thus permits evaluation of tradeoffs, where they arise, between economic and environmental outcomes for a given set of policy changes.

As noted, 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 (the model contains 38 manufacturing and service sectors, and 12 agricultural sectors divided into three geographic regions). These results can be used in conjunction with external information on the sectoral distribution of emissions, estimates of soil erosion rates under different crops, and so on, to calculate the likely effects of a given change on industrial pollution, deforestation and agricultural expansion, as well as other outcomes of interest.[35]

To illustrate the possible environmental effects of a broad-based policy reform, we use the APEX model to examine the predicted outcomes of an across-the-board tariff reduction. As mentioned earlier, ISI has been a very prominent feature of Philippine development policy, and its effects have lingered in trade policy settings even until very recently. By asking what would happen if protection policies were relaxed, we obtain *ex post* insights into the effects of past protection policies on economic activity, and by extrapolation with additional information, on environmental phenomena such as industrial emissions.[36] Recognizing that trade policy reform is highly complex and that any such reform involves altering a range of different measures in

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[33] Ideally this approach should supplement detailed, data-driven analyses of individual environmental problems and sectoral economic experiences.

[34] Coxhead (2000) uses the APEX model to examine the economic and environmental consequences of technical progress and food policy in Philippine agriculture.

[35] There have been a number of earlier experiments along these lines, both using APEX for the Philippines (Coxhead and Shively 1998; Coxhead 2000) and other applied GE models, for example for Indonesia (Anderson and Strutt 1996) and Sri Lanka (Bandara and Coxhead 1999).

[36] 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.

different ways, we do not attempt to replicate any specific set of reforms. Rather, we simulate a uniform proportional tariff reduction of 25%. Tables 7a and 7b show, for the 50 APEX sectors, some basic information from the APEX data base on sectoral size and labour-intensity, and approximate protection levels. Table 7b also shows the AHTI emissions intensity data and rankings for manufacturing industries.

The trade reform simulation 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. Product differentiation means that the prices of imported tradeables and those produced in the domestic economy do not necessarily move together. Supplies of some primary factors (land, skilled labour, and capital) are assumed to be fixed; the markets for these inputs clear through factor price adjustments. We assume, however, that there is initial slack in the market for unskilled labour, particularly in the lowest income groups, so aggregate employment can rise or fall as the result of a shock, with no change in the nominal wage. The remaining details of the macroeconomic closure are chosen to ensure that the burden of adjustment to a shock falls entirely on households. The model thus yields a measure of welfare change based on increases or declines in real household consumption expenditures.

Sectoral results of the trade policy reform experiment are shown in Table 8 (more detail on changes in macroeconomic variables is found in Appendix Table A-1; the appendix also provides a description of APEX and solution procedures). It can be seen in Table 8 that broadly speaking, trade liberalisation reduces activity in manufacturing sectors, which are mainly import-competing and receive the highest initial protection, and increases it in food processing and in primary industries, including forestry and mining. Aggregate agricultural output changes little, although it does exhibit considerable regional and sectoral variation, as discussed below. Within manufacturing, where there is a general correspondence between capital-intensity, protection rates and emissions-intensity, some heavily emissions-intensive sectors contract. Declines in the prices of competing imports reduce domestic producer prices, although by less since domestic and imported goods are imperfect substitutes. Conversely, many labour-intensive export-oriented industries, which expand as a result of liberalisation, are not especially emissions-intensive; the net result could be argued to be a composition effect that is positive for manufacturing.

In the forestry sector, the reforms bring about a rise in the producer price and output expands. If property rights in forestry are well-defined and enforced, as is assumed in the model, then an increase in the relative price of forestry should promote an expansion based on the planting of production forests, presumably at the expense of upland agriculture. On the other hand, if property rights are missing or not enforced, then the model result will not be the actual outcome: as discussed earlier, by raising the stumpage value of existing trees, it enhances the incentive for logging of existing forests rather than for a longer term increase in the forest sector. In this case trade liberalisation is likely to 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 industries 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 9). 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 lowland and upland/forestry ecosystems, provided institutional failures (such as open access in forestry) are not severe.

That some agricultural sectors and some exportable manufacturing sectors should contract as the result of trade liberalisation requires an 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. In the simple model of Section 3, there was only one exportable and one importable, and the impact of liberalisation was clear-cut. But when there are many goods in each category, 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. The trade reform reduces 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 labour-intensive sectors. Unskilled labour demand rises by 3.4% in semiconductors; by 4.4% in wood products; by 2.6% in 'other foods' processing, 1.9% in mining, 2.5% in forestry, and 1.4% in construction. Although unskilled labour supply also increases (by 0.3%), agricultural profitability rises by less than in other exportable sectors, especially those that are relatively labour-intensive.

Table A-1 shows some macroeconomic and distributional results of the trade policy experiment. The reforms have a very small positive effect on aggregate welfare, measured as the weighted sum of real household consumption expenditures. Because unskilled labour supply is elastic and because consumer prices fall in general, the reform has a slight positive effect on income distribution.

The trade policy reform simulation provides predictions about composition effects and, in 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 results in 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.

5. Issues and Prospects

It is clear that the Philippines faces several major environmental problems—deforestation, fisheries depletion, land and water system degradation, and urban pollution—that directly reduce the health and well being of the population as well as the performance and growth potential of the economy. To some extent, these problems are almost inevitable outcomes of high population growth and changes in economic structure associated with early stages of economic growth. But they have been aggravated, quite severely in some cases, by the direct and indirect impact of government policies. The past era of inward looking protectionist policies, and the quite blatant use of state power to help favoured elite groups to exploit national resources, did more than simply constrain economic growth. By perpetuating poverty in rural areas these policies and practices encouraged population movement to crowded cities and to ecologically fragile uplands. By causing underinvestment in essential infrastructure for waste disposal, mass transport, and provision of clean water, they intensified urban environmental degradation. By undermining respect for property rights in nationally owned natural resources, they promoted deforestation. These legacies now weigh heavily on the Philippines.

Policy changes during the decade of the 1990s signalled a movement, broadly speaking, towards dismantling of protection and liberalisation of other markets. This trend appears set to continue (though if history is any guide, the path may not be smooth). For the foreseeable future, environmental outcomes are likely to reflect the interaction of structural changes and patterns of growth in a more open policy context, along with such specific environmental policy and investment initiatives as might emerge in response to national and international environmental concerns. We have already outlined the structural impacts that seem likely in an open policy regime. They highlight that liberalisation tends to improve overall export performance, while previously highly protected import-competing sectors contract. The environmental impact is not necessarily negative; indeed, there are some indications that land degradation and deforestation, and the intensity (if not the volume) of industrial emissions may be lower under a more liberal trade regime. Such scale effects as are induced may thus be diminished by composition effects, shifting the country onto a "cleaner" growth path. Further, for a labour-rich country such as the Philippines, trade reforms have both distributional as well as growth benefits.

In a more open and liberal policy context, there appear to be several areas where government action seems essential, involving policies as well as resource expenditures. While policy liberalisation may be benign for the environment, specific environmental externalities need to be addressed with targeted environmental policies. Indeed, the cost of market failures may be higher under open trade and investment regimes. For example, given an open access regime, more liberal trade and investment policies can raise the incentives for ecologically sensitive natural resources to be even more intensively exploited, with no regard for sustainability concerns.[37]

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[37] Empirically, raising upland incomes through means that do not depend on resource exploitation has been demonstrated to diminish pressures on forest and wildlife stocks (Shively 1997).

Finally, massive investment in essential infrastructure for waste disposal, and clean water, particularly in crowded and fast growing urban areas, is essential. These pose major challenges for Philippine administrations.

Considerable progress was made in the 1990s with development of policies and programmes specifically targeting the environment. But both international and Philippine experience demonstrates that enforcement of environmental legislation is not easy, and requires not only government will, but also community support and action to overcome enforcement problems that are particularly serious in a low-income country. Enforcement problems can be overcome to a considerable extent if implementation of environmental programs is combined with institutional innovations that foster community mobilisation and participation in environmental conservation. A number of recent dcvelopments are encouraging. The shift away from leaded gasoline has reduced atmospheric lead levels, and harmful effluents from industrial plants dropped significantly following a pilot scheme that implemented environmental user fees on plants operating near the Laguna Lake. *EcoWatch*, a program that combined standards based ratings of the pollution-performance of plants with public disclosure of non-compliant firms, has achieved remarkable success in reducing non-compliance in a group of selected factories in Manila. In upland ecosystems, several community based programmes have made progress with soil and forestry conservation through agroforestry, modified agricultural land management practices, and reforestation. These achievements all show that there is much untapped potential to utilise environment-friendly techniques without significant costs in output, and that considerable growth may be feasible with minimum damage to the environment.

These signs of progress, however, will only signal a new chapter in the Philippine environmental story if economic growth is sufficiently rapid and equitable to generate both the resources and the political support for preservation of environmental quality. Achieving growth at no environmental cost whatsoever seems unrealistic, and some difficult trade-offs will be unavoidable. As growth takes place, despite the demonstrated potential for technique changes to reduce or minimise environmental harm, the absolute levels of some environmental ‘bads'—such as certain types of industrial emissions—are likely to increase; in other words, the scale effect may overwhelm technique and composition effects. On the other hand, with proper policies to address externalities and market failures, growth can be compatible with maintenance, or even improvement, of a range of other environmental variables. With the right combination of policies and community action, the country should be able to minimise environmental costs along the growth path, and ultimately deliver sustainable and equitable development. For the Philippines, in the environmental arena, as in many other aspects of economic development, the past century has been rich in experiences in what to avoid. It is to be hoped that the new millennium will be one that will be rich in positive lessons and satisfying achievements.

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Appendix: An Overview of the APEX Model of the Philippine Economy[38]

APEX (Agricultural Policy Experiments) is an applied general equilibrium model of the Philippine economy developed in a collabourative venture by researchers at the Australian National University and the Philippine Department of Agriculture. 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. Such models are very well suited to the kind of comparative statics exercise we report in this paper. APEX shares many features with the well-known ORANI model of the Australian economy (Dixon *et al.* 1982), but these features have been amended to fit Philippine realities. Input-output data in APEX are drawn from the Philippine Social Accounting Matrix. Unlike any other AGE model of comparable size, however, in APEX all parameters describing technology and preferences are constructed from original econometric estimates.

The model contains 50 producer goods and services produced in 41 industries. These are aggregated into seven consumer goods. The model consists of five households, each representing a quintile of the income distribution and having unique income and consumption characteristics. Factor demands, aggregation of factors of different types, and consumer demands are all described by flexible functional forms. 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 (1996). Further description and some illustrative experiments may be found in Warr and Coxhead (1993).

In APEX, agricultural production takes place in three regions (Luzon, Visayas and Mindanao). The agricultural sector produces a vector of intermediate and final consumption goods using land, unskilled labour and fertiliser inputs. Land is specific to agricultural uses, while the other inputs are not. Due to data constraints, agricultural inputs are assumed to be non-allocable; the model does not identify the quantity of each input used in the production of any individual agricultural output.

Some groups of agricultural goods are presumed to be jointly produced. One such group is the category "rainfed crops", which includes rainfed rice, corn, and root crops. We identify this sub-aggregate as the set of agricultural crops in which there is potential for measurable soil quality depletion through erosion. According to the APEX data base, value-added in the rainfed crops sector is dominated by corn (60%), with root crops accounting for 28%, and rainfed rice 12%.

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 can be 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

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[38] Material in this section is drawn largely from Coxhead and Shively (1998).

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.

The APEX model is constructed and solved using GEMPACK simulation software (Pearson 1988). The complete model in GEMPACK code can be found at http://www.aae.wisc.edu/coxhead/apex.

Table 1: Flora and Fauna in the Philippines

Species	Approximate Number
	13,500
Plants	
Animals	**170,000**
Pteridopytes, broyophytes, fungi, algae and lichens	**4,000**
Terrestial vertebrate	**1,090**
Birds	558
Mammals	185
Amphibians	95
Reptiles	252
	3,088
Marine	
Corals	488
Fish	2,400
Algae	69
Protozoans	125
Seagrasses	6

Source: Republic of the Philippines (1998), *The Philippine National Development Plan: Directions for the 21st Century*, Manila

Table 2: Forest cover and deforestation rates in developing Asian economies

Country	Total Forest (mn. ha)			Ave Annual % Change		Natural Forest (mn. ha)		Ave Annual % Change		Plant-ation	Av. Ann. %
	1980	1990	1995	1980 -90	1990 -95	1990	1995	1980 -90	1990 -95	1990	1980-90
China	126,398	133,756	133,323	-0.6	-0.1	101,925	99,523	04	-0.5	31,831	4
Indonesia	124,476	115,213	109,791	-0.8	-1.0	109,088	103,666	-1.1	-1.0	6,125	8
India	58,259	64,969	65,005	-1.1	-0.0	51,739	50,385	-0.6	-0.5	13,230	14
Myanmar	32,091	29,088	27,151	-1.2	-1.4	28,853	26,875	-1.3	-1.4	235	18
Malaysia	21,564	17,472	15,471	-2.1	-2.4	17,391	15,371	-2.1	-2.5	81	15
Thailand	18,123	13,277	11,630	-3.1	-2.6	12,748	11,101	-3.4	-2.8	529	8
Lao PDR	14,470	13,177	12,435	-0.9	-1.2	13,173	12,431	-0.9	-1.2	4	4
Cambodia	13,484	10,649	9,830	-2.4	-1.6	10,642	9,823	-2.4	-1.6	7	0
Philippines	**11,194**	**8,078**	**6,766**	**-3.3**	**-2.9**	**7,875**	**6,563**	**-3.3**	**-3.6**	**203**	**0**
Vietnam	10,663	9,793	9,117	-0.9	-1.4	8,323	7,647	-1.5	-1.7	1,470	4
Nepal	5,580	5,096	4,822	-0.9	-1.1	5,040	4,766	-1.0	-1.1	56	14
Pakistan	2,749	2,023	1,748	-3.1	-2.9	1,855	1,580	-3.5	-3.2	168	3
Sri Lanka	2,094	1,897	1,796	-1.0	-1.1	1,758	1,657	-1.4	-1.2	139	6
Bangladesh	1,258	1,504	1,010	-1.8	-0.9	819	700	-3.3	-3.1	235	7

Source: WRI, *World Resources 2000*, Table 11.1

Table 3: 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
Kaingin areas (no conservation measures)	90-240
Annual cash crops (uplands)	30-180

Source of basic data: NRAP (1991)

Table 4: Asian agriculture: fertilizer, irrigation and crop yields

	Crop Land 1992-94	Irrigated Land as % of crop land		Fertlizer Use (kg/ha)		Av. crop yields (kg/ha, 1994-96)	
	Ha	1982-84	1992-94	1984	1994	Cereals	Roots & Tubers
Bangladesh	8,849	20	37	65	120	2,602	10,635
Cambodia	3,832	5	4	1	3	1,638	6,076
China	95,145	45	52	200	309	4,673	16,583
India	169,569	24	29	49	80	2,136	16,936
Indonesia	31,146	17	15	72	80	3,895	11,647
Lao PDR	900	16	16	0	2	2,561	9,005
Malaysia	7,536	6	5	105	159	3,052	9,701
Myanmar	10,067	10	11	19	12	3,015	8,995
Nepal	2,556	29	35	18	33	1,819	7,704
Pakistan	21,323	76	80	62	98	1,943	14,233
Philippines	9,320	16	17	29	64	2,283	6,880
Sri Lanka	1,889	29	29	102	113	2,568	8,903
Thailand	20,488	18	22	23	64	2,434	13,671
Vietnam	6,739	26	28	57	192	3,504	6,883

Source: WRI: *World Resources2000-2001*

Table 5: Asian developing economies: population and urbanization

	Population 1998 (000)[1]	Urban (%)	Urban pop growth rate (%) 1980-85	Rural pop. growth rate (%) 1980-85
Bangladesh	124,043	21	5.7	1.9
Cambodia	10,751	23	6.2	2.1
China	1,255,091	34	4.2	0.6
India	975,772	28	3.2	1.8
Indonesia	206,522	40	5.3	1.0
Lao PDR	5,358	23	5.4	1.8
Malaysia	21,450	57	1.5	-4.9
Myanmar	47,625	28	2.1	2.1
Nepal	23,168	12	6.0	2.3
Pakistan	147,811	37	4.6	2.9
Philippines	72,164	59	5.2	0.6
Sri Lanka	18,450	24	1.2	1.7
Thailand	59,612	22	2.8	1.6
Vietnam	77,896	20	2.5	2.1

Source: WRI *World Resources*

Table 6: Air Pollution in Selected Asian Cities (1995)

		Total Suspended Particulates (TSP): micrograms/m^3	Sulphur Dioxide (SO_2) micrograms/m^3
China			
	Shanghai	246	53
	Beijing	377	90
	Tianjin	306	82
India			
	Bombay	240	33
	Calcutta	375	49
	Delhi	415	24
Indonesia			
	Jakarta	271	..
Malaysia			
	Kuala Lumpur	85	24
Thailand			
	Bangkok	223	11
Philippines			
	Manila	200	33

Note: WHO annual mean guidelines for air quality standards for TSP are 90 micrograms/m^3. For SO_2, the guideline is 50 micrograms/m^3.
Source: *World Development Indicators, 1998*

Table 7A: Agricultural, Natural Resource and Service Sectors

	GDP share	Lab. 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	NA
Fruits	0.11	0.51	40.0
Vegetables	0.06	0.54	21.66
Rootcrops	0.02	0.55	NA
Other Comml Crops	0.10	0.56	4.34
Hogs	0.16	0.38	NA
Chicken and Poultry	0.03	0.49	NA
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
VA shares and labor shares are calculated from 1989 data in APEX database.

Table 7B: Agricultural Processing and Manufacturing

Sector	GDP share	Lab. cost share %	Implicit tariff 1994	AHTI score	AHTI Rank
Agric. Processing	**0.07**				
Rice and Corn Milling	0.35	0.47	51.58	n.a.	
Sugar Milling/Refining	0.07	0.31	59.21	1.121	18
Milk and Dairy	0.06	0.28	29.23	2.251	15
Oils and Fats	0.22	0.39	16.12	3.721	13
Meat & Meat Prod.	0.21	0.36	82.21	0.431	21
Feed Milling	0.02	0.37	26.49	0.281	22
Animal Feeds	0.05	0.44	72.69	0.701	19
Other Foods	0.03	0.40	29.52	2.021	17
Manufacturing	**0.15**				
Beverages and Tobacco	0.07	0.37	41.99	0.5921 *0.272	20
Textile & Knitting	0.08	0.49	14.5	6.071 *1.312	12
Other Textiles	0.02	0.47	19.69	7.21 *6.042	8
Garments*	0.16	0.65	24.69	12.351 *12.762	5
Wood Products	0.05	0.53	13.31	9.91 *0.642	6
Paper Products	0.05	0.46	19.97	16.111 *4.232	3
Fertilizer	0.01	0.38	4.07	105.31	1
Rubber/Plastic/Chem Prod.	0.11	0.42	28.59	17.41 *15.692	2
Coal & Petroleum Prod.	0.04	0.12	28.88	6.231 *1.442	10
Non-Ferr. Basic Metals	0.09	0.19	6.19	13.231	4
Cement & Non-Metallic	0.10	0.28	16.51	7.31 *4.172	7
Semi-conductors	0.06	0.55	7.70	n.a.	.
Metal Products	0.07	0.49	17.24	6.081 *3.382	11
Electrical Machinery	0.05	0.47	18.78	3.291 *1.252	14
Transport Equipment	0.01	0.54	23.75	2.181 *.96	16
Misc. Manufacturing	0.04	0.56	18.83	6.71 *2.962	9

Note: Value-added shares shown for each sector are within-group shares
VA shares and labor shares are calculated from 1989 data in APEX database.
* CV of AHTI scores, when calculated as weighted average from several subsector values

Table 8: Results of a 25% tariff reduction (percentage changes)

	Producer price	Domestic output		Producer price	Domestic output
Agr. Commodities			**Manufacturing**		
Irrigated Rice	-.80	-.56	Beverages and Tobacco	-1.06	.25
Rainfed Rice	-.80	-.46	Textile	-.65	-.84
Corn	-.50	-.26	Other Textile	-.11	.24
Coconut	-.02	.29	Garments	.09	-.62
Sugar	-.15	.04	*Wood Products*	*-.35*	*2.16*
Fruits	-.04	.16	*Paper Products*	*-.46*	*-.41*
Vegetables	.12	.25	*Fertilizer*	*-.07*	*-.09*
Rootcrops	.11	.24	*Other Rubber Products*	*-.94*	*-.05*
Other Comml Crops	.11	.12	Coal & Petroleum Prod.	-.13	-.11
Hogs	-.05	.05	*Basic/Non-ferr Metals*	*.08*	*-.50*
Poultry	-.28	.02	Cement	-.81	-.44
Other Livestock	-.24	-.02	Semiconductors	-.29	1.83
			Metal Products	*-2.68*	*-.24*
Natural Resources			Electrical Machinery	-.97	-.40
Marine Fisheries	.20	-.07	Transport Equipment	-1.18	-.48
Inland Fisheries	.35	.08	Misc. Manufacturing	-.69	-.80
Forestry	.90	.88			
Crude Oil	-.48	-.04	**Services**		
Other Mining	-.19	.63	Agricultural Services	.13	-.16
			Construction	-.60	.24
Ag. Processing			Elect, Gas and Water	.24	.05
Rice and Corn Milling	-.07	.13	Tc Services	.50	.08
Sugar Milling	.05	.04	Transpt/Storage/W'sale	.56	.08
Dairy	-1.55	.01	Banks	.66	-.03
Oils	-.09	.40	Insurance	.70	.05
Meat	.14	.07	Government Services	1.34	.02
Feed Milling	-1.81	.32	Other Services	.01	-.12
Animal Feeds	-.67	-1.52			
Other Foods	-.65	1.24			

Note: *Sector name* denotes manufacturing sectors with highest emissions intensity scores (see Table 7b).

Table 9: Agricultural land use changes due to 25% tariff reduction (percent changes)

Agricultural activity	Luzon	Visayas	Mindanao
Irrigated rice	-.29	-.49	-.37
Rainfed rice	-.21	-.23	-.31
Corn	-.07	-.06	-.13
Coconut	.51	.20	.54
Sugar	.34	.06	.25
Fruits	.42	.11	.34
Vegetables	.53	.31	.48
Root crops	-1.62	1.03	-3.51
Other commercial crops	.55	.03	.30
Hogs	.37	.00	.23
Poultry	.35	-.03	.17
Other livestock	.36	-.17	.07

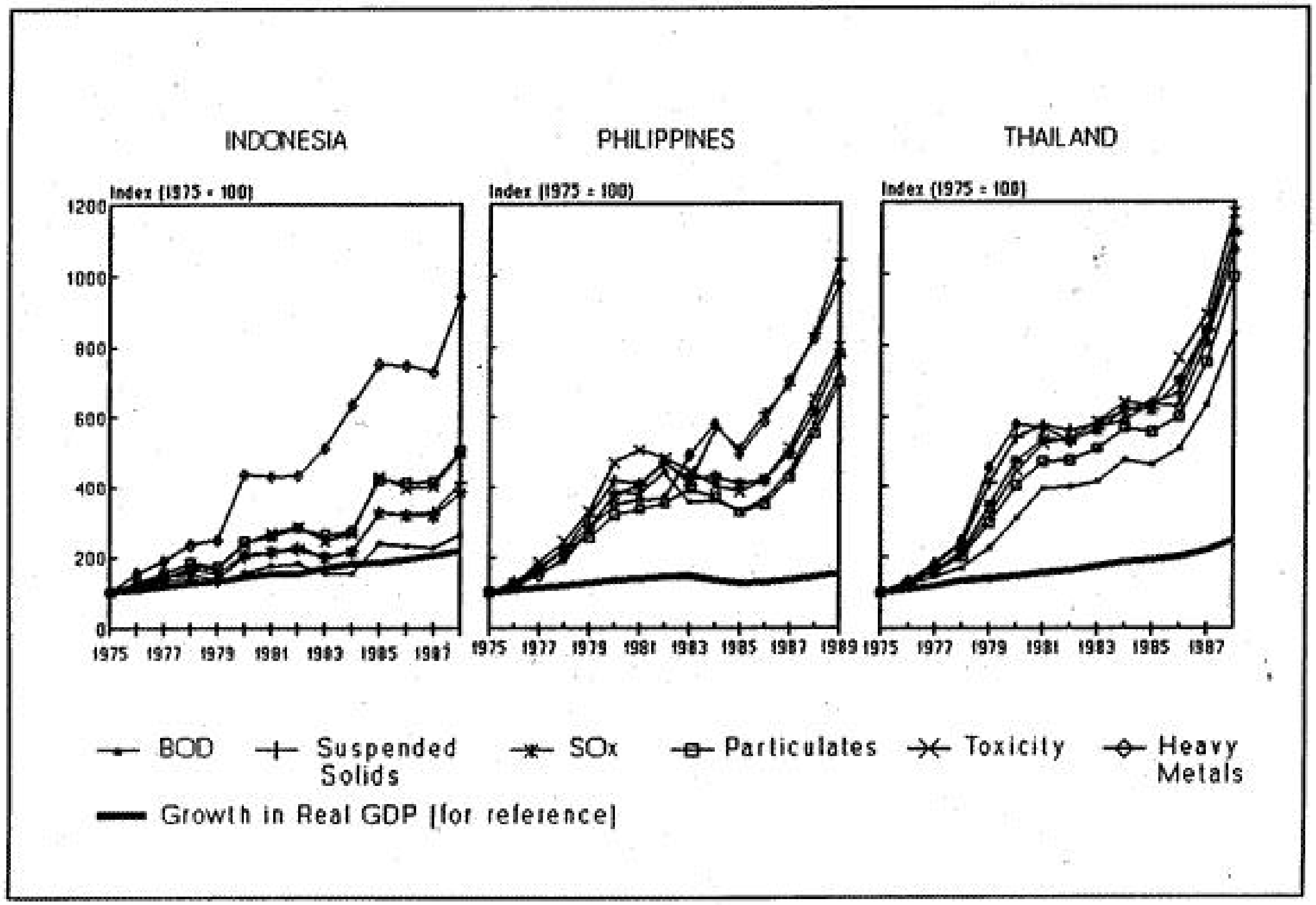
Source: APEX simulation results

Appendix Table A-1: 25% tariff reduction: summary of macroeconomic results

	Percent change
A.1 Overall Economy	
Gross Domestic Product	
Nominal (local currency)	-.14
Real	.08
Consumer Price Index	-.11
GDP Deflator	-.22
A.2 External Sector	
Export Revenue (foreign currency)	.56
Import Bill (foreign currency)	.54
Trade Deficit (in levels, foreign currency)	0*
A.3 Government Budget	
Revenue	
Tariff revenue	-23.95
Aggregate revenue	.62
(nominal, local currency)	
Real	
Expenditures	
Nominal (local currency)	.47
Real	.58
Budget Deficit (in levels, local currency)	0*
A.4 Household Sector	
Consumption	
Nominal (local currency)	-.03
Real	.08
Savings (in levels, local currency)	
A.5 Labor market: change in unskilled labor supply	0.32

Source: APEX simulation results

Figure 1: Estimated total industrial pollution in selected Asian countries



Source: Brandon and Ramankutty (1992)

Figure 2: Growth of manufacturing output and emissions, Asian LDCs

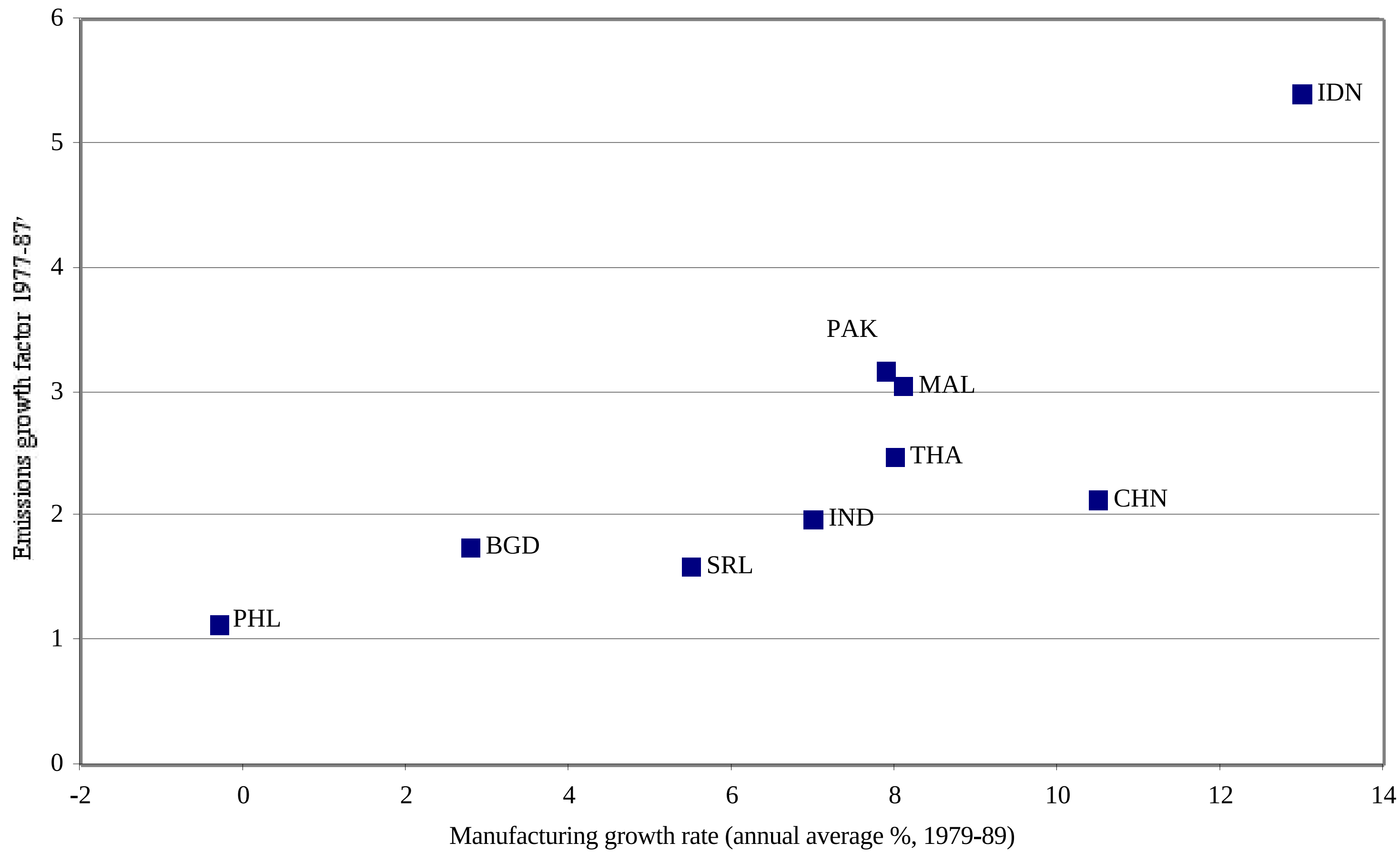


Figure 3: Gross Value Added in Manufacturing (in billions of pesos at constant 1985 prices)

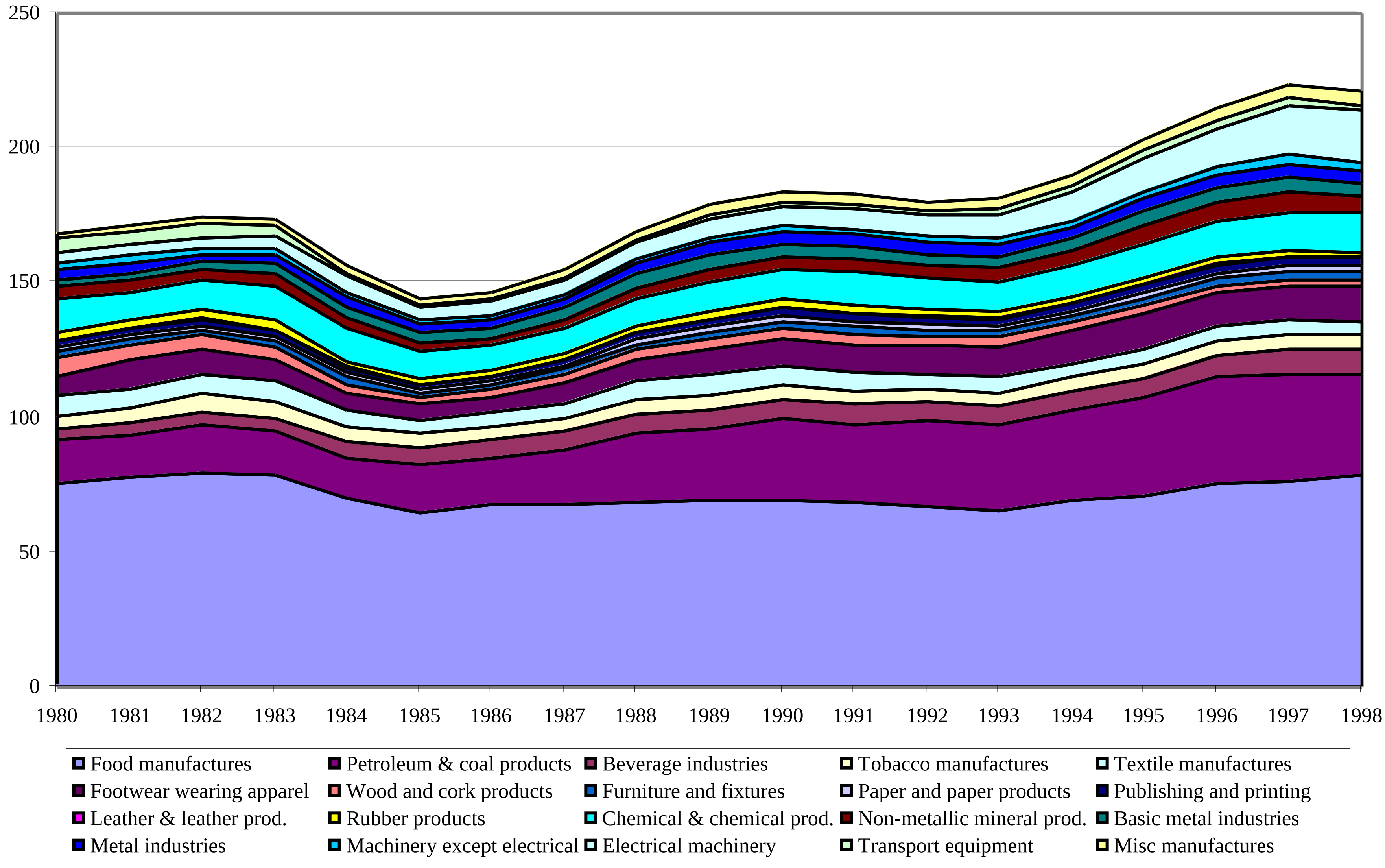
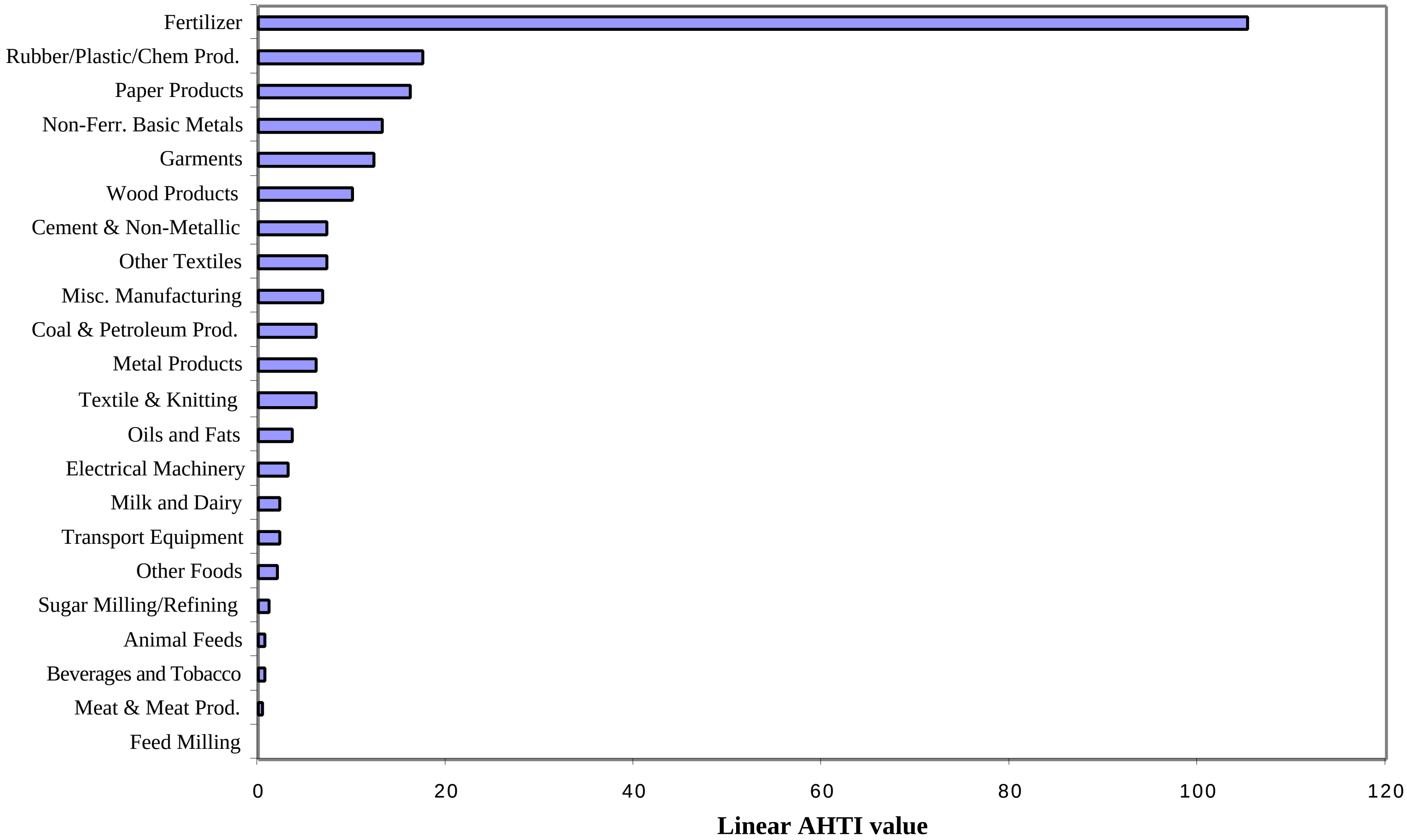


Figure 4: Acute Human Toxicity Indices for Manufacturing Industries



Source: Hettige et al. 1995.