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Environmental Macroeconomics -- Basic Principles

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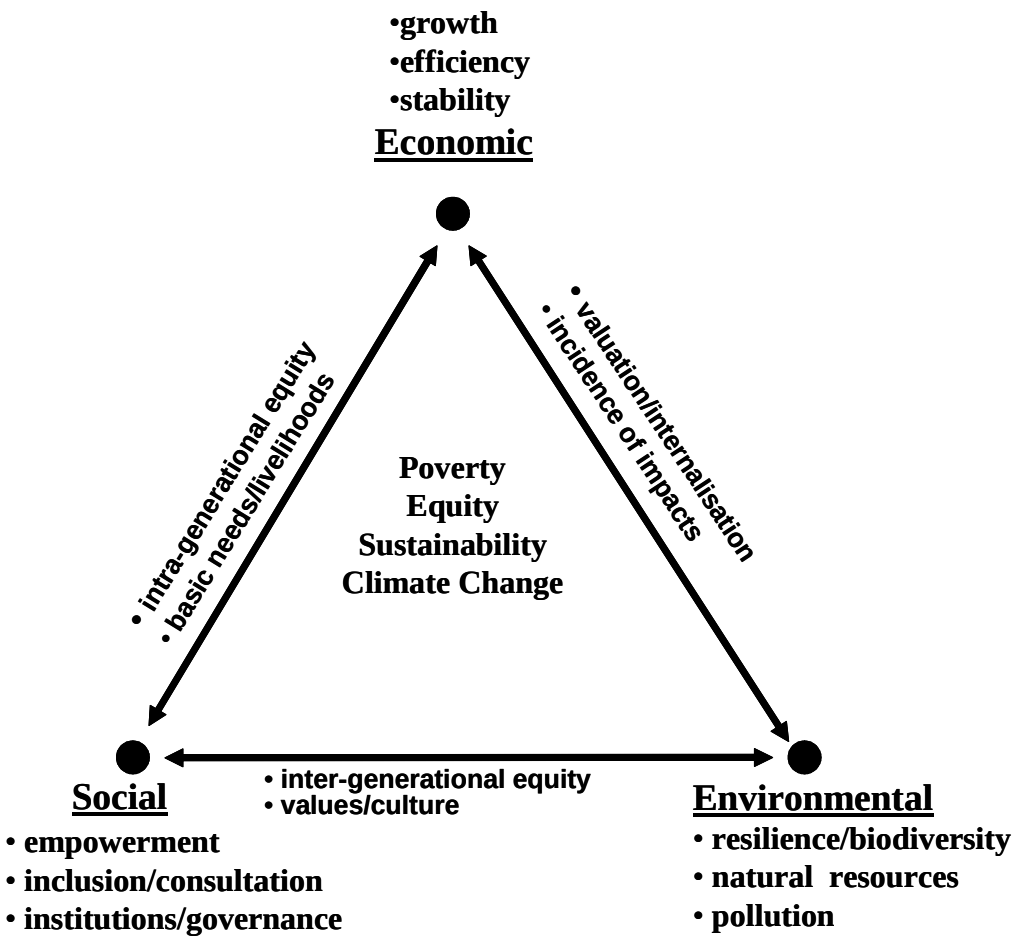
1. OVERVIEW

1.1 Introduction

The concept of sustainable development is receiving increasing attention from world decision makers, in their search for new solutions to many critical problems (WCED 1987, see entry on Sustainomics). In this context, the role of macroeconomic policies has come under increasing scrutiny, because of their powerful and widespread social and environmental impacts (Munasinghe and Cruz 1994, Reed 1996, Munasinghe 2002).

Sustainable development has economic, social and environmental dimensions -- Figure 1 (Munasinghe 1992). It may be defined as a process for improving the range of opportunities that will enable individual human beings and communities to meet their needs, as well as to achieve their aspirations and full potential over a sustained period of time, while maintaining the resilience of economic, social and environmental systems. Each such system has its own distinct driving forces and objectives. The economy is geared towards improving human welfare, primarily through increases in the consumption of goods and services. The environmental domain focuses on protection of the integrity and resilience of ecological systems. The social domain emphasizes the enrichment of human relationships and achievement of individual and group aspirations. The goal is to "***make development more sustainable***" with continuous improvements in the present quality of life at a lower intensity of resource use, thereby leaving behind for future generations an undiminished stock of productive assets (i.e., manufactured, natural and social capital) that will enhance opportunities for improving their quality of life (Munasinghe 1992, 2001). This wider perspective on human well-being is important, since most traditional economic policies focus on maximizing economic output, sometimes at significant environmental and social cost.

Figure 1. Key elements of sustainable development and interconnections



Source: Munasinghe (1992)

Macroeconomic strategies have widespread effects, ranging from exchange rate, interest rate, and wage policies, to trade liberalization, privatization, and similar programs. They are coupled with sectoral measures involving various economic instruments like pricing in key sectors (energy or agriculture) and broad sectorwide taxation or subsidy programs (agricultural subsidies, and industrial investment incentives). Such economywide policies are often packaged within programs of structural adjustment, stabilization, and sectoral reform, aimed at promoting economic stability, efficiency and growth, and ultimately improving human welfare. Although the emphasis is on economic policies, other non-economic measures (such as social, institutional and legal actions) are also relevant.

The next section of this overview contains a brief review of the historical evolution of ideas linking macroeconomic policies and the environment. Section 2 describes more recent empirical evidence, beginning with a discussion of the environmental impacts of structural adjustment programs since the 1980s, and followed by some stylised results. One important conclusion is that it is the combination of growth and economic imperfections that lead to environmental damage and unsustainable outcomes. Section 3 contains a discussion of some basic analytical frameworks for analysing the linkages between the macro-economy and the environment. Both micro- and macro-economic

models confirm the key conclusions of the previous section. Finally, Section 4 sets out the concluding remarks, including directions for future work.

1.2 Historical Evolution of Ideas

Many key ideas on macroeconomics and the environment have been developed within the last two decades, although some historical roots are discernible in several classical papers. We focus below on selected papers describing macroeconomy-environment interactions.

1.2.1 Tracing macroeconomy-environment linkages

Early work on such linkages pursued three interwoven lines of enquiry. First, economic activities require natural resources. The crucial role of land scarcities in limiting growth were recognised by Malthus (1798), who stressed impoverishment due to agricultural constraints and exponential population growth. Subsequently, Ricardo (1817) explained how diminishing returns to land would impose checks on wealth and population. Hotelling (1931) further developed the theory of exhaustible resources.

Koopmans (1973) paper combines exhaustible natural capital in Hotelling's simple "cake-eating" problem with accumulating manufactured capital, to optimize consumption within a Ramsey type growth model. The macroeconomic interest rate plays a significant role. Subsequent work (Withagen 1990) explored many ramifications of this approach, leading to recent work by Hartwick (1990) and others (see below). Stiglitz (1974) uses a model with capital, labour and natural resources as substitutes in production, to show that higher consumption levels are sustainable, provided increasing technological progress compensates for declining natural resource stocks.

Daly (1991) points out that getting macroeconomic policies right may ensure optimal resource allocation, but does not address scale issues, as economies grow beyond the environmental carrying capacity. Solow (1993) defines net national product (NNP), adjusted to reflect both natural resource depletion and changes in environmental quality, as a measure of maximum consumption that can be sustained forever. These arguments link neoclassical economic theory with earlier work in environmental economics and environmental accounting. England's paper (2000) identifies three conditions which would curtail growth and lead to a steady state economy -- scarcity of natural capital; complementarity (non-substitutability) between manufactured and natural capital in production; and constraints on technological progress that raises productivity of natural capital use. Recent work has focused on the interactions between sustainable development and optimal growth in the long term (Munasinghe et al. 2001, Markandya et al. 2002).

The second historical approach draws on input-output (I-O) analysis developed during the 1930s. Leontieff (1970) describes a seminal framework to analyse polluting outputs from productive sectors, and the impact of policies to reduce such externalities in pollution abatement sectors. Many subsequent studies have elaborated on the basic I-O approach, by linking it with vintage models specifying labour demand and capital stock, as well as by endogenised consumer demand based on linear expenditure systems. More sophisticated models made the technical I-O coefficients endogenous and dependent on prices. Present state-of-the-art computable general equilibrium models used for macroeconomic-environmental analysis, as well as the integrated frameworks for environmental-economic accounting, use the I-O approach (see below).

Third, environmental considerations have been incorporated into more conventional macroeconomic models used in policymaking, ranging from extensions of the Keynesian IS-LM type used in analyses of comparative statics, to sophisticated computable general equilibrium (CGE) models that include environmental variables. Environmental considerations are increasingly examined in macroeconomic models, focusing on short run Keynesian issues such capacity utilization, unemployment, and cyclical movements in the economy. Girma (1992) starts from a conventional macreconomic modelling framework, and adds an environmental sector to examine key macropolicies and their impacts on the environment. Longer run environmental-macroeconomic models for both closed and open economies, are built around supply side issues like capital accumulation, natural resource depletion, long run labour supply, discount rate, and rate of technological progress.

1.2.2 Empirical surveys of macroeconomy-environment linkages

Grossman and Krueger (1995) analyze the empirical relationship between per capita income and several indicators of air and water pollution. An unresolved question is whether an inverted U-shaped 'environmental Kuznets curve' exists. There is agreement that environmental quality declines with increases in per capita income in the early stages of growth, but it is unclear whether continued growth reverses this trend, since the shape of the curve appears to vary widely by country and form of environmental degradation (Ecological Economics 1998, Environment and Development Economics 1997, and de Bruyn and Heintz 1999).

Opschoor and Jongma's (1996) paper is a comprehensive review of environmental impacts of World Bank and International Monetary Fund structural adjustment and stabilization programmes in developing countries. They argue for complementary environmental policies to counteract any adverse impacts of growth oriented macroeconomic policies as a short run remedy, but urge a more integrated approach in the long run.

Panayotou and Hupe (1996) point out that structural adjustment programs must pay as much attention to market and institutional failures as they pay to policy failures. Using environmental and social policies as parallel policies to cushion the environmental and social impacts of structural adjustment is second best, compared to full integration of these policies with the economic reforms. Partial reforms or incomplete implementation of reforms may do more harm than good if they are selectively applied without anticipating their social and environmental impacts.

Kessler and Van Dorp's (1998) paper draws attention to the unpredictable nature of impacts of structural adjustment programs, focusing on key indicators relating to soils, water resources and forests. The importance of remediation efforts is emphasized, through ex-ante assessment of the environmental impacts of adjustment policy packages.

1.2.3 Mathematical modeling

Jorgensen and Wilcoxon (1990) analyse the economic impact of environmental regulations on the US economy using a computable general equilibrium (CGE) approach that applies inter-temporal analysis to a complex disaggregate model of long term growth impacts. It focuses on critical energy-economy-environment linkages, and estimates the share of abatement costs in total costs for industry and transport.

Bergman's (1990) paper also uses a CGE model designed to simulate the effects of environmental regulation and energy policy on the Swedish economy. In this case, the environmental market failure is corrected by creating a market for emission permits, whose costs are incorporated in the cost functions.

Persson and Munasinghe (1995) examine deforestation in Costa Rica. Their CGE model confirms partial equilibrium analyses, showing that establishing property rights tends to decrease deforestation, whereas higher interest rates promote deforestation. Glomsrod et al. (1998) also use a CGE model to study the impacts of structural adjustment policies on deforestation in Nicaragua. Improving the fiscal balance by reducing public expenditure or through sales tax reform, promotes economic growth and conserves forests. Some polices increase deforestation in the near term, but ease pressure on forests in the longer term.

A paper by Holden et al. (1998) simulate six types of village economies in Zambia, to show that structural adjustment policies have significant adverse impacts on the environment. The removal of policy distortions does not necessarily lead to well functioning markets, because of high transactions costs and imperfect information in remote areas. The model results are consistent with empirical findings.

Useful qualitative insights about the environmental consequences of macropolicy reforms may be gained with CGE models (Devarajan 1990; Robinson 1990; Persson and Munasinghe 1995). Islam, Munasinghe and Clarke (2003) examines the sustainability of optimal growth. Their model analyses economic-ecological interactions, including resource depletion, pollution, irreversibility, and uncertainty. Key socioeconomic issues include savings, investment, technical progress, substitutability of productive factors, intergenerational efficiency, and equity. Many policy options emerge to make growth more sustainable.

1.2.4 Trade and environment

Steininger's (1999) paper provides a comprehensive review of trade-environment models, including Heckscher-Olin, statistical-econometric, and applied general equilibrium models, that can address a variety of issues such as leakage, distribution, policy feedback effects, interlinkages between production and markets, and specialization patterns.

Batyabal (1994) traces impacts of domestic environmental policies on international trade. His theoretical study shows that a large developing country might be worse off by pursuing environmental policies unilaterally. The government could use market power to set (second best) optimal pollution taxes to correct for domestic economic distortions, and thereby capture trade gains. Goldin and Roland-Host's (1997) paper examines the converse question – how growth in international trade might affect the local environment in Morocco. In their CGE simulation, trade liberalization alone promotes export-led growth, but also increases water stress. When complementary water price increases are simultaneously undertaken with trade liberalization, growth benefits are retained, while water stress improves.

Mani and Wheeler (1998) analyse data during 1960-95 for a variety of industrial sectors, in a wide range of countries, to determine whether pollution intensive industries seek havens in countries with lax environmental standards. They conclude that trade does not increases production of pollution-intensive goods, since production takes place primarily for domestic markets rather than exports.

1.2.5 Green national income accounting

Hartwick (1990) derives net national product (NNP) as the current value Hamiltonian for an optimal growth problem, including conventional economic inputs and natural resources. To derive NNP, drawdown of natural resource stocks should be netted out of gross national product (GNP), like depreciation of economic capital. Repetto et al. (1989) show how Indonesia's conventionally measured economic output could keep rising, while its natural resource base is being degraded, unless use of natural resource stocks is netted out. Hultkrantz (1992) provides monetary estimates of changes in timber stocks, production of non-marketed and non-timber products, and depletion of other natural assets in Sweden.

Bartelmus and colleagues integrated environmental and resource accounting into the standard system of national accounts (SNA) through the System of Environmental and Economic Accounting (SEEA) (UN 1993). Atkinson et al. (1997) describe methods of adjusting SNA to account for environmental effects, including social accounting matrices. The concept of green national product or GNP (i.e., conventional GNP revised to include changes in environmental services and resources) is extended, to develop the idea of 'genuine savings' (i.e., national savings that include environmental effects). Persistent negative genuine savings provides a danger signal.

Aronsson and Lofgren's (1998) paper reviews recent developments on the subject. Their theoretical framework summarizes the consensus concerning the current state of knowledge, and sets out some areas of uncertainty and key questions for further research.

2. EMPIRICAL EVIDENCE

2.1 Environmental Impacts of Structural Adjustment

During recent decades, structural adjustment programs (SAPs) have emerged as a powerful form of macroeconomic intervention in the developing world. Many developing countries experienced economic hardship during the 1980s. Domestic mismanagement and external economic factors caused the 'debt crisis.' The major oil price increases of 1974 and 1979 were a significant shock to oil-importing countries. Furthermore, restrictive monetary policies adopted by Western countries to curtail their own inflation, caused real interest rates to rise and made debt-service difficult for developing countries. Consequently, developing countries experienced balance of payment problems, which made them even more reliant on foreign donors. Economic growth rates declined and unemployment worsened.

The International Monetary Fund (IMF) and World Bank (WB) agreed to provide financial assistance to help countries service their debt, provided they adopted broad reforms called structural adjustment programs (SAP). These stringent economic and fiscal reform policies which were designed to restore growth, also had adverse environmental and social impacts.

Stabilization policies sought to reduce pressure on foreign reserves by reducing domestic demand. Balance of payment problems were addressed by controlling inflation and reducing imports with contractionary fiscal policies and tight money supply. Simultaneously, currency devaluation aimed to improve the terms of trade and make exports more competitive. Adjustment policies focused on the supply side and addressed inefficiencies of the internal economic structure, including public sector reforms, to

accelerate economic recovery and export growth. Parallel policies were adopted to improve the efficiency of resource allocation and competitiveness of markets at the sectoral level. Unfortunately, these reforms often had recessionary effects, resulting in significant loss of jobs and livelihoods -- before the promised export led growth could materialize. Furthermore, budget cutting pressures often forced governments to abandon social 'safety-net' programs, thereby causing further hardship to low income groups.

Reform programs have not always achieved even their economic goals. Furthermore, where macro-economic gains have been realised through adjustment, environmental and social problems have worsened. The sustainable development literature is seeking to identify and remedy development strategies that lead to the unsustainable use of natural resources. Often, the very economic policies aimed at alleviating economic problems may undermine the environmental resources and social fabric on which national long- term development will ultimately depend (Munasinghe 2001).

2.2 Some Stylized Results

Many case studies exist of environmental and social impacts of countrywide policies (Reed 1992; Munasinghe and Cruz 1994; Abaza 1995; Young and Bishop 1995; Munasinghe 1996; Reed 1996; Opschoor and Jongma 1996; Cruz, Munasinghe and Warford 1997; and Warford, Munasinghe and Cruz 1997, Environment and Development Economics 1999). However, generalizing about environmental and social impacts of economywide policies is difficult, because the linkages are complex and country specific. Even the purely economic impacts of structural adjustment programs are difficult to trace comprehensively (Tarp 1993). Nevertheless, we attempt to summarize the main lessons learned from recent studies, below.

Economywide policy reforms aim to achieve major economic objectives (e.g., macroeconomic stability, efficiency, growth and poverty alleviation). Their environmental and social consequences fall into three broad categories -- beneficial, harmful and unknown. First are the so-called "win-win" policies, where it is possible to achieve simultaneous gains in all three areas of sustainable development (i.e., economic, social and environmental). The second category recognises important exceptions where such potential gains cannot be realized unless the macro-reforms are complemented by additional measures which protect both the environment and the poor. The third group consists of impacts that are unpredictable, because of the complex linkages involved, and long-run time perspective.

2.2.1 Beneficial Impacts

Several studies indicate that liberalising reforms (like removing price distortions, promoting market incentives, and encouraging trade), often contribute to both economic and sustainability gains. For example, reforms that improve the efficiency of industrial or energy related activities could reduce economic waste, increase the efficiency of natural resource use and limit environmental pollution. Similarly, improving land tenure rights and access to financial and social services will yield economic gains, promote better environmental stewardship, and help the poor.

Analogously, shorter-run policy measures aimed at restoring macroeconomic stability will generally yield economic, social and environmental benefits. For example, price, wage and employment stability encourage firms and households to take a longer

term view, thereby encouraging environmentally sustainable activities. Lower inflation rates not only clarify price signals and enhance investment decisions, but also protect fixed income earners and the poor.

Studies of macroeconomic policies in Zimbabwe and Mexico (Munasinghe and Cruz 1994), and Thailand (Panayatou and Susangkarn 1991) illustrate win-win situations, with both economic and environmental gains. Birdsall and Wheeler (1992) argue that open trade policies in Latin America have promoted both economically productive and environmentally benign modern technologies. Other studies of environmental impacts of macroeconomic adjustment policies have been done for Sub-Saharan Africa (Stryker et al., 1989), Thailand, Ivory Coast, and Mexico (Reed 1992), and Philippines (Cruz and Repetto, 1992).

Country case studies involving win-win outcomes of sectoral policy reforms cover energy and industry in Mexico (Munasinghe and Cruz 1994), and Sri Lanka (Meier, Munasinghe and Siyambalapitiya 1995); water and sanitation in Brazil, China and India (World Bank 1992b, World Bank 1992c, World Bank 1993a); and land use in Tunisian rangelands (Munasinghe and Cruz 1994), Zambian farms (World Bank 1992d), Brazilian forests (Mahar 1988, Schneider 1993), Sudanese forests (Larson and Bromley 1991), and Botswana pastures (Perrings, 1993).

Macroeconomic stabilization policies to control inflation lead to more sustainable logging in Costa Rica (Persson and Munasinghe 1995), and sustainable farming in South America (Southgate and Pearce 1988, Schneider 1994).

2.2.2 Avoiding Harmful Impacts

Typical economywide reform programs are implemented in stages, with the initial adjustment package targeting the most important macroeconomic issues. Often, some unaddressed distortions (policy, market or institutional imperfections), will combine with an adjustment program to cause environmental or social harm (Munasinghe and Cruz 1994, Abaza 1995). Adverse social and environmental impacts may be avoided by implementing additional complementary measures that remove such distortions, without necessarily reversing the original reforms. Examples include:

***Policy distortions*:** Promotional measures that increase profitability of exports might encourage excessive extraction of an underpriced natural resource (e.g., deforestation of open access areas due to subsidised timber stumpage fees). Similarly, trade liberalization could lead to expansion of wasteful energy-intensive activities, in a country where subsidised energy prices persisted.

***Market failures*:** Successful adjustment may be associated with severe environmental damage – e.g., if external environmental effects of economic expansion (like air or water pollution), are not adequately reflected in market prices. In Indonesia, liberalization policies and industrial promotion accelerated growth in the modern sector, and reduced pollution. However, the scale of expansion increased pollution externalities, requiring complementary pollution taxes and environmental regulations (Munasinghe and Cruz 1994).

***Institutional constraints*:** Unaddressed institutional problems (like poor accountability of indebted state-owned enterprises, weak financial intermediation, or inadequately defined property rights), undermine incentives for sustainable resource management and worsen

equity. Thus, reform of regulations and institutions should not lag behind economic restructuring, as shown in the case of energy pricing and institutional reforms in Poland (Bates et al. 1995). In Peru, economywide reforms could have potentially increased harvesting pressures on over-exploited fisheries, without complementary regulations to protect various fishing grounds included within the adjustment program (World Bank, 1993b).

Short Term Stabilisation: Unless government budget cuts to bring inflation under control are carefully targeted, they may disproportionately penalize critical expenditures on environmental protection or poverty safety nets (ECLAC 1989, Miranda and Muzondo 1991, Cornia et al., 1992). Other examples include increases in air pollution in Thailand and Mexico due to reduced infrastructure expenditures (Reed 1992), adverse impacts on low income groups in Africa (especially women and children) caused by lowered government spending in areas like health (Nzomo 1992), and underfunding of forest protection activities (World Bank, 1994). Another adverse linkage is the possible short-term recessionary impact of adjustment on poverty and unemployment, whereby the migratory poor are forced to increase their pressures on fragile lands and "open access" natural resources. The remedy would be to expand economic opportunities elsewhere.

2.2.3 Longer Term and Less Predictable Effects

Finally, economywide policies may have unpredictable and counter-intuitive longer term effects on sustainability. Some of these effects may be traced through a general equilibrium framework that captures both direct and indirect links. The Costa Rica CGE model captures indirect effects on deforestation, to show that economic and environmental implications of wage restraints in structural adjustment are different from the results of partial equilibrium analyses (Persson and Munasinghe 1995).

Adjustment often succeeds in generating new economic opportunities and livelihoods, thereby alleviating poverty and breaking the vicious cycle of environmental degradation and poverty (World Bank, 1992a). Higher incomes increase the willingness-to-pay for better environmental protection. However, while such growth is important for poor nations, it will increase overall pressures on environmental resources. At the same time, properly valuing resources, increasing efficiency and reducing waste, will reshape the structure of economic growth and limit undesirable environmental impacts. The long-run economic and environmental consequences of adjustment programs depend on the mobility of capital and labour. Finally, environmental policies themselves could have impacts on income distribution and employment.

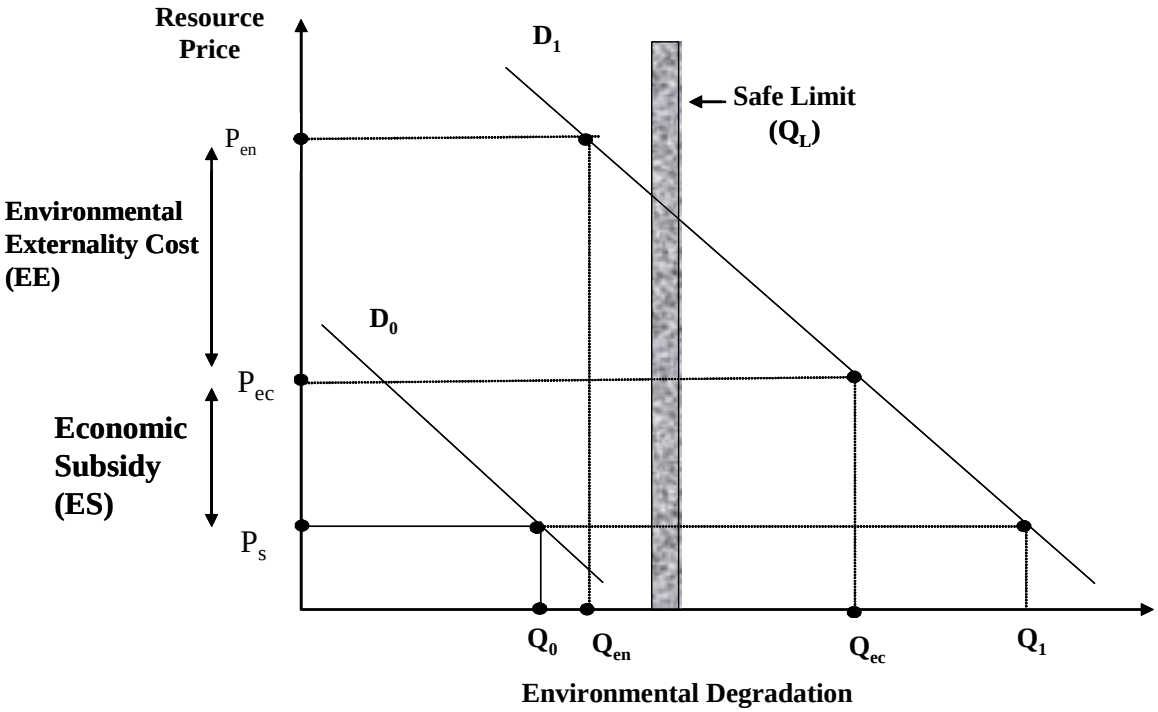
Inequitable access to land and rapid population growth exacerbate rural unemployment and income inequality, thereby forcing the poor to depend increasingly on marginal resources for their livelihood (Feder et al., 1988; Cruz and Gibbs, 1990; Lele and Stone, 1989, Environment and Development Economics 2004). The result is more pressure on fragile environments. A Philippines case study (Munasinghe and Cruz 1994) evaluates the policy determinants of long-term changes in rural poverty and unemployment that have worsened lowland to upland migration, and conversion of forest lands to unsustainable agriculture. Shifting cultivation and grazing could worsen land degradation, where capital and technical change are limited, and population growth is rapid (Cleaver and Schreiber, 1991). Important long term links between adjustment programs, trade and agriculture have been analysed by Goldin and Winters (1992).

3. FRAMEWORK FOR ANALYSIS

3.1 Microeconomic View of Environmental Harm -- Magnitude and Structure of Growth

The ***magnitude of growth*** which may cause environmental damage, could be moderated by policy measures that ***restructure growth*** -- to make it less resource intensive and polluting (see also, Section 3.5). Munasinghe (1995) analyses the interplay of price and income effects in an initially stagnant economy which has open access forests, to clarify how economic reforms could combine with neglected economic distortions, to cause environmental harm.. The downward sloping curve D_o in Figure 2, depicts demand for timber, which is assumed to depend on both price p and income Y [i.e., D = D(p,Y)]. At the effective (subsidized) price p_S representing the marginal cost of logging, the initial deforestation rate is Q_o. Suppose Q_L is the safe limiting rate of deforestation beyond which serious ecological damage occurs. If $Q_o < Q_L$, the situation may continue undetected and uncorrected.

Figure 2. Restructuring growth to reduce environmental degradation



Source: Munasinghe (1995)

Next, suppose economic reforms stimulate growth and shift the timber demand curve outward to D_1. This "income effect" may result from increased domestic demand (e.g., timber for construction) or higher timber exports (e.g., trade liberalization and devaluation make exports more profitable). Now, the deforestation rate could shift to $Q_1 > Q_L$ -- causing serious environmental harm.

Clearly, the remedy is not to stop growth, but rather to introduce complementary measures that establish proper timber prices. First, property rights could be re-established in open access areas and "efficient" stumpage fees imposed -- to eliminate

the economic subsidy (ES) and correctly reflect the opportunity cost of the timber. The resulting efficient price (p_{ec}) would reduce the logging rate to Q_{ec}, which still exceeds Q_L. Second, an additional environmental externality cost (EE) may be charged, to reflect loss of biodiversity or damage to watersheds, and thereby establish the full environmentally adjusted price (p_{en}). The deforestation rate now falls to $Q_{en} < Q_L$.

Exactly analogous reasoning would apply if we considered fuel prices and polluting emissions from urban transport or industry. In this case, p_S might be a subsidized diesel price, p_{ec} the equivalent trading opportunity cost, p_{en} the full price including taxes to cover air pollution externality costs, and Q_L the health-determined safety standard.

3.2 A Macroeconomic View of Environmental Harm

In this section, we examine whether macroeconomic policies might be directly tailored to satisfy environmental considerations, without using addititonal complementary measures.

3.2.1 The Role of Second Best Policies

Maler and Munasinghe (1996) developed a theoretical model, showing that first-best macroeconomic policies which seek a Pareto optimum will not maximize welfare, if an environmental externality exists. Here, second-best macroeconomic policies ought to be pursued, to trade-off broad macroeconomic goals against environmental damage. Their model confirms both empirical evidence and microeconomic analysis presented earlier, that environmental damage is indeed caused by the interaction of growth inducing economywide policies with residual imperfections. Therefore, the first best solution would be to correct the imperfections using complementary policies while pursuing the original macroeconomic reforms. However, if political or other constraints prevent or delay introduction of complimentary measures, then second-best macroeconomic policies may be justified -- especially in cases where environmental harm could be significant.

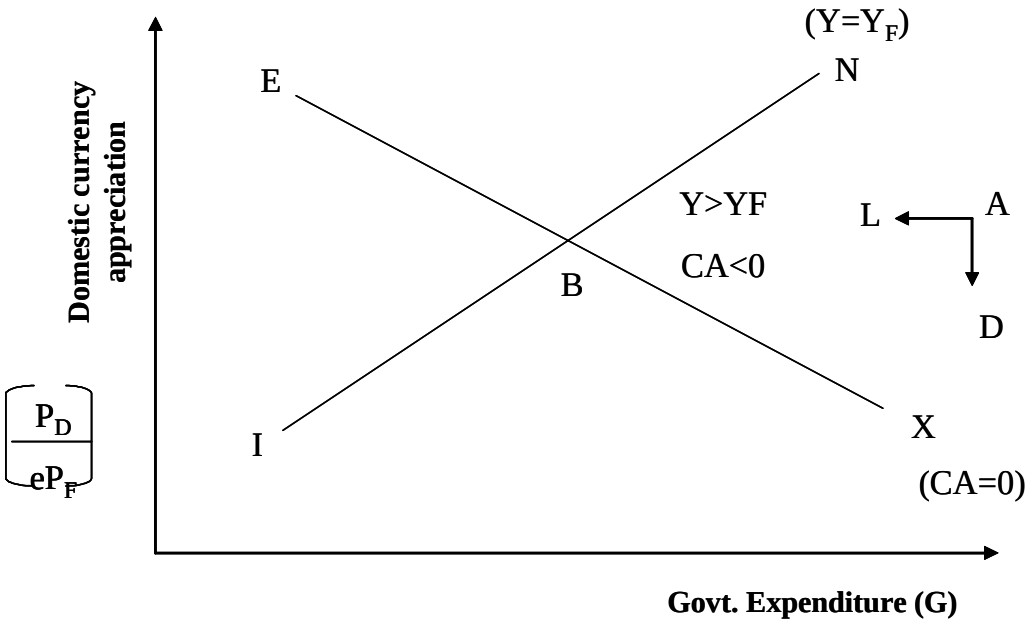
Second best options also cover the dynamics of policy reform processes. For example, reforms might be gradually intensified (instead of being suddenly imposed), thereby allowing further time to phase out residual imperfections that degrade the environment.

3.2.2 The Timing and Sequencing of Policy Reforms

Could the timing and sequencing of economic reforms affect the extent of environmental damage? Some insights emerge from recent literature on the timing and sequencing of adjustment measures to achieve economic goals (Edwards 1992).

In Figure 3, the X-axis indicates aggregate expenditure in a national economy (e.g., government expenditure) and the Y axis reflects the effects of domestic currency appreciation (e.g., ratio of domestic goods prices to foreign goods prices weighted by exchange rate). Point A represents the initial state of the economy -- below the line of internal balance IN (representing an economy producing at the full employment level Y_F), and above the line of external balance EX (representing a zero current account, CA). Typically, macro-policymakers would seek to move the economy towards equilibrium point B by reducing both the current account deficit (since CA < O) and excess demand (since $Y > Y_F$).

Figure 3. Timing and sequencing of economic policies to make development more sustainable



P_D = price of domestic goods
P_F = price of foreign goods
e = exchange rate
IN = internal balance equilibrium
EX = external balance equilibrium
AL = reduce govt. subsidies
Y = income
Y_F = full employment income
CA = current account
G = government expenditure
AD = depreciate currency/liberalise trade

A downward movement AD is achieved by currency devaluation and removal of trade barriers, while a leftward shift AL occurs if government subsidies were eliminated (e.g., raising subsidized energy prices). Suppose that reforms affecting AD could be achieved first and AL somewhat later (e.g., delayed by powerful transport or industrial lobbies). Then, economic liberalisation represented by AD alone might lead to greater foreign investment and expansion of energy intensive industries which were attracted by low energy prices. However, this apparent gain would also result in wasteful use of (subsidized) energy and more environmental pollution.

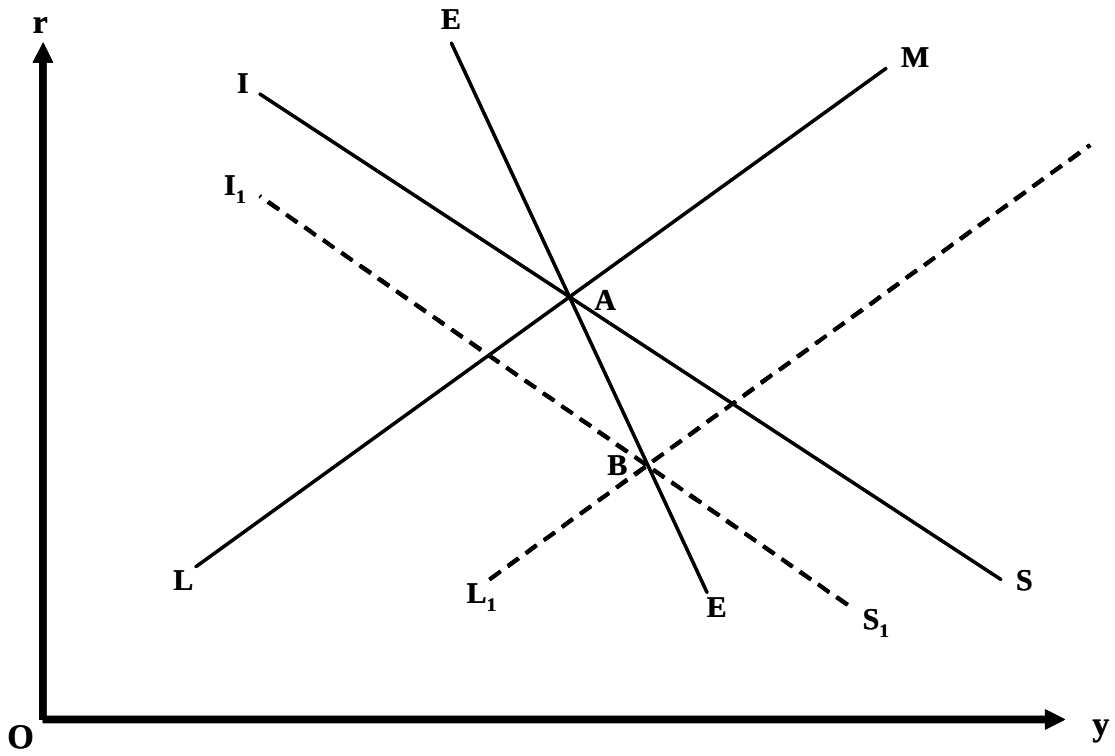
This simple, static provides useful insights, although restraint and good judgment are required to resist making major changes in economywide policies merely to achieve minor environmental (and social) gains. Once again, policy options that achieved "win-win" gains would be the most desirable.

3.3 Extending the Conventional IS-LM Macro-economic Analysis

Next, we examine environmental concerns, based on the well-known IS-LM framework used in comparative static analysis of macro-economic policies (Heyes 2000).

In Figure 4, the familiar IS-LM curves are plotted in (r,y) space, where r is the interest (discount) rate and y is aggregate demand.

Figure 4. Extending conventional IS-LM Analysis to include the environment



The IS curve is derived from aggregate demand and supply identity, representing equilibrium in the goods market:

$$y = [c(y) + i(r) + g] = [c(y) + s(y) + t.y] \; ; \quad \text{or equivalently} \quad [i + g] = [s + t] \; ;$$

where c is consumption, i is investment, g is government spending, s is saving, and t is the tax rate. Simple calculus yields the basic IS curve:

$$[dr/dy]_{IS} = [t + ds/dy] / [di/dy] \; ; \text{ which is downward sloping.}$$

The LM curve is derived from the corresponding money market equilibrium:

$$M/p = L(r,y) \; ;$$

where M is (fixed) money supply, p is the price level, L is money demand. Simple differentiation yields the basic LM curve:

$$[dr/dy]_{LM} = - [dL/dy] / [dL/dr] \; ; \text{ which is upward sloping.}$$

Environmental variables could be introduced into the familiar (r,y) space, by examinign the variation of environmental capital over time:

$$[d(KE)/dt] = [e(r).y + k.KE] \; ;$$

where KE is the stock of environmental assets, t is time, e is the environmental intensity of economic activity (or pollutants emitted per unit of economic output), and k is

the rate of environmental self-renewal in the natural state. In a steady state economy, d(KE)/dt is zero, and implicit differentiation yields:

$$[dr/dy]_{EE} = - [e] / [y.(de/dr)] .$$

Assume that environmental intensity increases with capital cost, i.e., (de/dr) > 0. Therefore, $[dr/dy]_{EE}$ is downward sloping. The EE curve is drawn steeper than the IS curve, assuming that e is relatively insensitive to r. Suppose that e is also a function of some regulatory framework parameter Z, which determines how effectively polluters are obliged to pay for environmental externalities. If (de/dZ) < 0 , then EE would shift leftward as regulatory enforcement improves.

To demonstrate the pedagogic value of this approach, consider an economy initially at equilibrium, with the IS, LM and EE curves intersecting at point A. Expansionary monetary policies would cause a shift from LM to L_1M_1 . Restoring the tripartite equilibrium at point B, would now require contractionary fiscal policies that yields the countervailing shift IS to I_1S_1 (assuming the EE curve is stable). Many similar policy exercises may be conducted, involving changes in various parameters and curves.

3.4 Action Impact Matrix (AIM): A Tool for Policy Analysis, Formulation and Coordination

An Action Impact Matrix (AIM) portrays an integrated viewpoint, meshing development decisions with priority economic, environmental and social impacts. Table 1 shows a simple AM, although an actual one would be larger and more detailed (Munasinghe and Cruz 1994). The far left column lists key development interventions (both policies and projects), while the top row indicates major sustainable development issues. Thus the matrix cells: (a) explicitly identify critical linkages; (b) focus attention on valuation and other methods of analysing the most important impacts; and (c) suggest action priorities. The organization of matrix also facilitates the tracing of impacts, as well as coherent articulation of links among various development actions – i.e., policies and projects. This AIM-building process has helped to harmonize views among economists, environmentalists and others in several countries, thereby improving prospects for successful implementation.

3.4.1 Screening and Problem Identification

The AIM-based process facilitates early *screening and problem identification* -- by preparing a preliminary matrix that identifies broad relationships, and providing a qualitative idea of policy impacts. Thus, the preliminary AIM helps to prioritise key linkages between policies and their sustainability impacts. For example, in the top row of Table 1, a currency devaluation aimed at improving the trade balance, may make timber exports more profitable but lead to deforestation of open access forests. The remedy involves complementary measures to strengthen property rights and restrict access to forest areas.

Another example involves increasing energy prices closer to marginal costs -- to improve energy efficiency and decrease pollution (second row of Table 1). Adding pollution taxes to marginal energy costs (to further reduce pollution), is the complementary measure. Increasing public sector accountability will reinforce favourable responses to these price incentives, by reducing the ability of inefficient firms to pass on cost increases to consumers or to transfer their losses to government.

Table 1. Simplified Preliminary Action Impact Matrix[1].

ACTIVITY/POLICY	MAIN OBJECTIVE	IMPACTS ON KEY SUSTAINABLE DEVELOPMENT ISSUES			
		Land Degradation	*Air Pollution*	*Resettlement*	*Others*
Macro-economic & Sectoral Policies	Macroeconomic and sectoral improvements	Positive impacts due to removal of distortions Negative impacts mainly due to remaining constraints			
· *Exchange Rate*	· Improve trade balance and economic growth	(-H) (deforest open-access areas)			
· *Energy Pricing*	· Improve economic and energy use efficiency		(+M) (energy efficiency)		
· *Others*					
Complementary Measures	Specific/local social and environmental gains	Enhance positive impacts and mitigate negative impacts (above) of Broader macroeconomic and sectoral policies			
· *Market Based*	· Reverse negative impacts of market failures, policy distortions and institutional constraints		(+M) (pollution tax)		
· *Non-Market Based*		(+H) (property rights)	(+M) (public sector accountability)		
Investment Projects	Improve efficiency of investments	Investment decisions made more consistent with broader policy and institutional framework			
· Project 1 *(Hydro Dam)*	· Use of project Evaluation (cost Benefit analysis, Environmental Assessment, Multi-criteria Analysis, etc.)	(-H) (inundate forests)	(+M) (displace fossil fuel use)	(-M) (displace people)	
· Project 2 *(Re-afforest and relocate)*		(+H) (replant forests)		(+M) (relocate people)	
· Project n					

Source: Munasinghe and Cruz 1994

Notes

[1] A few examples of typical policies and projects as well as key environmental and social issues are shown. + and - signify beneficial and harmful impacts, while H and M indicate high and moderate intensity.

In the third example, a major hydroelectric project (shown lower down in the table), has two adverse impacts -- inundation of forested areas and villages, and one positive impact -- replacement of thermal power generation (thereby reducing air pollution). A re-afforestation project coupled with adequate resettlement efforts will address both negative impacts.

The AIM therefore encourages systematic articulation and coordination of policies and projects to achieve sustainable development goals, using readily available data. Social impacts, especially those affecting the poor, need to be incorporated into the AIM, using the same approach.

3.4.2 Analysis and Remediation

Analysis and *remediation* is the next stage, where more detailed analyses are carried out for matrix elements representing high priority linkage between economywide policies and environmental impacts. Such analyses, range from simple methods to fairly comprehensive system or multisector modelling efforts (e.g., CGE models including environmental and social variables) -- depending on planning goals and available data and resources. Economic valuation of environmental and social impacts is a key (and often difficult) step, in integrating these concerns into conventional economic cost-benefit analysis (Munasinghe 1992, Freeman 1993). When such valuation is problematic, other techniques like multi-criteria analysis may need to be used.

Sectoral and partial equilibrium analyses are more useful to identify direct impacts, whereas CGE modeling provide a more comprehensive but aggregate view with insights into indirect linkages. This process would lead to a more detailed AIM, which helps quantify impacts and formulate additional policy measures to enhance positive linkages and mitigate negative ones.

3.5 Environmental Kuznets Curve (EKC)

The structure of economic growth is an important determinant of environmental degradation. Figure 5 shows an ‘environmental Kuznets curve’ or EKC, representing the relationship between economic progress (e.g., GNP per capita) and environmental risk (e.g., CO2 emissions per capita) (Munasinghe 1995). Point C might represent an industrial country, whereas a developing country would be at point B. Ideally, the industrial countries (exceeding safe limits) should increase environmental protection efforts and follow the future growth path CE. Developing countries which learn from past experiences of the industrialized world, could adopt measures permitting them to “tunnel” through BDE -- preferably below the safe limit indicating where environmental damage (like climate change or biodiversity loss) could become irreversible.

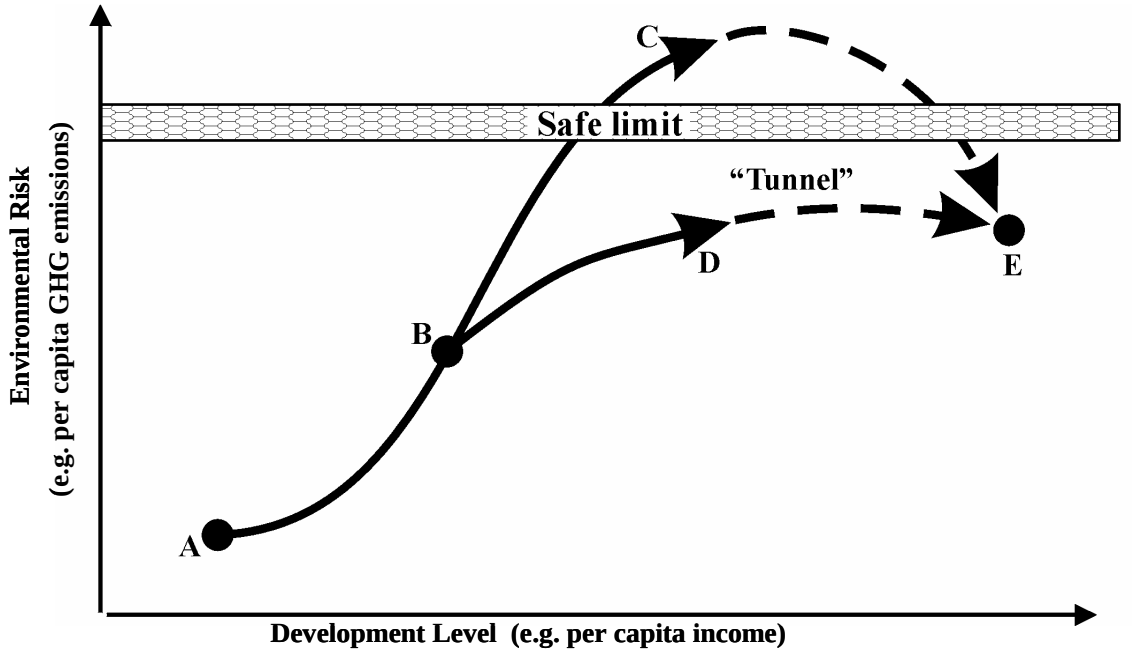
Such a tunnel also corresponds to a more economically optimal path, and resembles “turnpike” growth paths which appeared in past literature (Burmeister and Dobell 1971). The highly peaked path ABCE could result from economic imperfections that make private decisions deviate from socially optimal ones. Corrective policies would help to reduce such divergences and permit movement through the tunnel BDE. Developing countries could thereby avoid severe environmental degradation along conventional development paths of industrial economies (ABCE). This approach is not

concerned with empirically estimating the EKCs for any single country. Instead, it focuses on identifying policies to delink environmental degradation and growth.

The following actions might help decisionmakers in finding such a "tunnel":

1. Actively seeking 'win-win' policies that simultaneously yield both economically and environmentally (and socially) sustainable paths.
2. Pre-empting excessive environmental (and social) harm through ex-ante environmental (and social) assessment of projects and policies, introducing remedies that eliminate imperfections (like policy distortions, market failures and institutional constraints), and strengthening capacity for environmental protection.
3. Considering the fine-tuning of growth inducing economywide policies (e.g., altering their timing and sequencing), especially where severe environmental (and social) damage could occur.

Figure 5. Tunneling through to Reduce Environmental Risk



Source: adapted from Munasinghe [1995].

3.6 Macroeconomic Performance Measurement Issues

To better include sustainability concerns in macroeconomic analyses, the conventional system of national accounts (SNA) must be improved, and new measures of environmental and social progress developed. Gross domestic product (GDP) is the common market-based measure which influences macroeconomic policy. Its shortcomings include neglect of income distributional concerns, non-market activities, and environmental effects. Current SNA measures do not adequately reflect either the depletion of natural resource stocks (like deforestation), or environmental damage (due to pollution) (USBEA 1995).

Several countries have explored different environmental adjustments to the SNA. Various measures of national product and wealth are under consideration, including *natural resource (stock) accounts*, *resource and pollutant flow accounts*, *environmental expenditure accounts*, and *alternative national accounts aggregates* (Atkinson et al. 1997). However, no countries have formally altered their SNA to reflect environmental concerns, beyond the 1993 revision to the SNA (UNSO 1993).

The United Nations Integrated System of Environmental and Economic Accounting (SEEA) is a pioneering step towards standardizing various accounting approaches (UN 1993). It adds *satellite* accounts to the conventional SNA (without modifying the core accounts), involving disaggregation of the standard accounts to highlight environmental relationships, linked physical and monetary accounting, imputations of environmental costs, and extensions of the SNA production boundary.

The SEEA framework may be used to estimate various national accounts aggregates such as 'green GNP' -- which are adjusted downward to reflect the costs of net resource depletion and environmental pollution. Green NNP is a Hicks-Lindahl measure of *potentially* sustainable income (Hicks 1946). However, it cannot indicate whether the rate of saving is sufficient to maintain this income indefinitely, and typically does not measure potential consumption if the economy were actually on a constant-utility path. 'Genuine savings' is a better measure of macro-sustainability (Atkinson et al. 1997).

Total wealth per capita is a useful indicator of sustainability, if the SNA measures total national wealth including the value of stocks of manufactured capital, as well as living and non-living resources. For total wealth *W* and population *P,* development is (weakly) sustainable, when:

$$S = [d(W/P)/dt]/[W/P] \geq 0$$

This index has several desirable properties -- e.g., separately accounting for changes in natural assets having low substitution possibilities.

Some researchers have computed composite indices of human welfare to show that the relationship between 'true' welfare and conventional income per capita is positive in the early stages of development, but becomes negative later on -- in contrast to the EKC effect (Daly and Cobb 1989, Max-Neef 1995). One such measure called Index of Sustainable Economic Welfare (ISEW), has already peaked in the 1970s or 1980s and is now declining for the US, UK, Germany, Austria and Netherlands. Poverty alleviation remains a dominant social objective (Sen 1984). Thus, recent work is seeking to expand the social accounting matrix (SAM) to include the distributional impacts of environmental damage across income groups (Munasinghe 2002)

4. CONCLUDING REMARKS

4.1 Review

Macroeconomic reforms could make development more sustainable through simultaneous economic, social and environmental gains. However, unintended adverse environmental and social impacts may occur when such reforms are undertaken while other policy, market or institutional imperfections persist. The remedy involves additional complementary measures that remove such imperfections, while maintaining the original economywide reforms. While growth is essential in poor countries, the ***magnitude of growth*** will intensify pressures on environmental resources. Increasing efficiency,

reducing waste, and properly valuing resources, will ***re-structure growth*** and reduce environmental damage. Strategies to ***"make development more sustainable"*** must be devised on a country-specific basis, based on local conditions, resource endowments, and social needs.

The Action Impact Matrix (AIM) provides a systematic framework for identifying and addressing the most important environmental and social impacts of economywide policy reforms. The process for avoiding environmental (and social) damage includes:

1. AIM-based analysis to identify, prioritize and analyze the most serious economic-sustainability linkages;
2. Specific *ex-ante* complementary measures to limit environmental and social harm, before economywide reforms are implemented;
3. Contingency plans and carefully monitoring of sustainability issues, to deal with them *ex post;*
4. Reviewing the timing and sequencing of economywide policies and complementary measures, to minimize environmental and social damage.

Developing countries seeking sustainable development paths, could learn from the experience of the industrialised countries and avoid making the same mistakes. Economic imperfections that make private decisions deviate from socially optimal ones, exacerbate environmental damage along EKC growth paths. Tunneling through the EKC is possible, by:

(1) adopting "win-win" policies that provide simultaneous economic, environmental and social gains;
(2) using complementary measure to address harmful impacts on sustainability; and
(3) reshaping economywide policies in cases where environmental and social damage was serious enough.

Better sustainable development indicators, including environmentally adjusted national accounts, will improve macroeconomic decision making.

4.2 Areas for Further Work

More country-specific case studies are required in tracing the environmental and social implications of economywide policies, especially in areas like trade and privatization. Exploring the sustainability of long run growth is important, especially in the context of worsening natural resource scarcities, including degradation of the global environment. Better practical models and analytical tools are required, based on approaches familiar to practicing macroeconomists (e.g., extended IS-LM framework).

Distributional, political economy, and institutional issues also need to be addressed in future work. The cross-linkages between environmental and social impacts of economywide policies needs to be further explored. Better environmental and social indicators should be developed, including environmentally adjusted national accounts, and improved techniques for valuing environmental impacts. Where economic valuation of environmental and social impacts is difficult, techniques like multicriteria analysis (MCA) can usefully supplement conventional cost-benefit analysis (CBA).

Further details concerning the subject matter of this article may be found in: Munasinghe, M. (ed). 2002. *Macroeconomics and the Environment*, International Library of Critical Writings in Economics, Edward Elgar Publ., Cheltenham, UK.

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