The World Bank



# WORLD WITHOUT END

## Economics, Environment, and Sustainable Development

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Economics, Environment, and
Sustainable Development

A Summary

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## A Note to the Reader

This booklet attempts to pick out some of the highlights of the book *World without End: Economics, Environment, and Sustainable Development.* As will be seen from the book's table of contents, which appears at the end of this booklet, the book's coverage is comprehensive. It details theoretical aspects of environmental economics, and it shows how these theories can be applied to developing countries, tropical forestry and agriculture, energy and industry, population and poverty, international trade, and the "global commons."

It is hoped that this summary provides a flavor of the many issues that are discussed at length, often at a more technical level, in the book.

The authors are grateful to Alfred Imhoff for his assistance in preparing not only this summary, but also the book itself.

# Sustainable Development

## *Moving toward Sustainable Development*

Environmental damage matters not just because it affects psychic or noneconomic welfare, but also because it translates into lost production. These costs can be large, and damage costs have been estimated to amount to 5 percent and more of gross national product (GNP). Given the scale and nature of environmental damage, sufficient evidence exists to support the view forwarded by advocates of sustainable development that a greater priority must be given to environment if economic policies are to be sustainable.

Insofar as past development policy has been influenced by the theory of optimal growth—and it clearly has—there is a critical need to analyze the conditions under which optimal growth is also sustainable growth. Since raising real income per capita must remain a major—but not the only—objective of development policy, growth with environmental quality can be achieved only by systematically considering and addressing the environmental effects of growth strategies. Where this cannot be achieved, it is essential to understand the nature of the tradeoffs between orthodox development goals and environmental deterioration. Better and more sophisticated attempts to value environmental functions are thus crucial.

Although the debate about sustainable development has not convinced some economists that the nature of the development process must be changed, it has encouraged others to give natural resources an even higher status in policymaking than that suggested by valuation studies. The latter stress several features of the workings of ecosystems: the extensive uncertainty surrounding the role of ecosystems in global and local life-support systems; the irreversibility of many of the effects in contrast to man-made capital, which can be increased or decreased at comparative will; and the values of environmental quality that are not related to use. The last feature explains much of the public concern over tropical deforestation and endangered species, which most people will never experience. Within traditional economic growth models, the amenity value of environmental assets acquires major significance, along with the environment as productive input. Combining these features of environmental assets with traditional concerns in order to secure optimal growth and intergenerational equity tends to support policies that conserve natural assets. Achieving sustainable development will continue to pose challenges for development economists and environmental economists alike in the future.

## *Measuring Sustainable Development*

A development path is sustainable if and only if the stock of overall capital assets remains constant or rises over time. The assets in question include manufactured capital (machines, roads, and factories), human capital (knowledge and skills), and environmental capital (forests, soil quality, and rangeland). To be on a sustainable development path, then, a nation must be living within its means, which, in this context, means not decreasing its overall capital assets. The proper measure of income corresponding to this idea of sustainability is widely accepted to be the amount that can be consumed without running the stock of capital down.

Manufactured capital assets depreciate over time. If the value of these assets at the beginning of a year is $X$ and the depreciation over the year is $d$, then the value of the assets at the end of the year is $X - d$. It follows that, to maintain capital, the amount $d$ has to be set aside in a depreciation fund rather than be consumed. If consumption is $C$, depreciation is $d$, and gross output is $Y$, sustainable consumption is $Y - d$. An indicator of sustainability, then, is a measure of sustainable income, defined here as the level of income that can be secured without decreasing the overall level of assets.

Measuring sustainable income would mean significantly adjusting the system of national accounts. In many countries the net national product (NNP) is computed. This is defined as the gross national product (GNP) minus the depreciation on manufactured capital, $Dm$, and, occasionally, minus the depreciation of stocks of natural assets such as forests or energy reserves. Therefore, NNP = GNP – $Dm$.

Assuming that GNP is correctly measured, an issue we return to below, a measure of sustainable income is NNP* = GNP – $Dm$ – $Dn$, where $Dn$ is now depreciation on environmental capital, which is measured by the monetary value of environmental degradation during the year. This environmental damage will show up in two ways: as losses of unrecorded GNP (for example, a loss of wildlife species or loss of a fine view) and as losses of GNP that would otherwise be recorded (for example, crop output foregone because of air pollution). Expressed another way, the level of sustainable consumption is equal to GNP minus the investment required to sustain the overall capital stock.

Measuring this concept of sustainable income would require major changes in national accounting procedures because of the effort needed to compute $Dn$. It involves, however, no fundamental modifications to the conceptual basis of the United Nations System of National Accounts.

To get a more accurate measure of GNP as an indicator of welfare, it is widely suggested that at least the following adjustments must be made: sustainable income = GNP – $Dm$ – $Dn$ – $R$ – $A$, where $Dm$ is depreciation

of man-made capital, $Dn$ is depreciation of natural capital, $R$ is restorative expenditure, and $A$ is aversive expenditure. In this equation, GNP is measured conventionally, including $A$ and $R$. Thus, sustainable income equals GNP $- (R + A + N) - (Dm + Dn)$, where $N$ is the overstatement due to nonoptimal use of natural resources.

### *Fairness and Time*

The environmental debate has undoubtedly devoted considerable soul-searching to the discussion of discounting. It has not, however, demonstrated the need to reject discounting as such. The arguments that environmentalists voice against the use of the opportunity cost of capital discount rates are, in general, not persuasive. To account for uncertainty in investment appraisal, it is better to adjust the cost and benefit streams for the uncertainty than to add a risk premium onto the discount rate. Finally, while analyzing the rationale for discounting, we examined the arguments for adjusting discount rates on various grounds of intergenerational justice. Although many of these arguments have merit, adjusting the discount rate to allow for them is generally not a practicable or efficient procedure. The need to protect the interests of future generations remains paramount in the environmental critique of discounting. Some alternative policy is therefore required if the discount rate is not going to be adjusted. One approach is to adopt a sustainability constraint.

Economic development requires a strong policy of protecting the natural resource base. The resource base—including all forms of capital—should perhaps be maintained intact or even enhanced. Some sustainability advocates go further and separate out natural capital for special attention. If conservation of natural environments is a condition of sustainability, and if sustainability addresses many of the valid criticisms of discounting, how might sustainability be built into project appraisal? Requiring that no project should contribute to environmental deterioration is absurd because it means rejecting all environmentally damaging projects, however small the damage. In fact, virtually all economic activity contributes to environmental damage in one way or another. An alternative would be to require that actual compensation be paid for environmental damage, as opposed to the hypothetical compensation implicit in the benefit-cost rule. Actual compensation could take the form of a monetary payment or a requirement that actual damage be repaired or offset in some way. An investment that destroys a wetland, say, might offset the damage by recreating the wetland elsewhere. Such requirements are, in fact, increasingly common in rich, industrial economies. Carried to an extreme, however, offsetting all environmental damage could be stultifying.

The alternative would be to impose the sustainability constraint in a more general fashion so that overall capital stocks are not reduced. A policy or project would not be sustainable if, for example, the proceeds of environmental destruction were simply consumed. Similarly, sustainability would be breached if critical environmental capital were destroyed. Of course, if the investment in question substituted environmental capital with superior (higher rate of return) man-made capital, the orthodox benefit-cost rule would apply provided the value of the lost environmental capital were properly taken into account. In short, the sustainability approach stresses

- The importance of valuing environmental assets and their services
- The need to ensure that investments truly build up the stock of man-made capital
- The need to think about safe minimum standards when environmental capital is critical.

The sustainability approach has some interesting implications for project appraisal. One of these is that the problem of which discount rate to choose largely disappears. The goal of adjusting discount rates to capture environmental effects is better served by the sustainability condition. Although it may have quite radical implications, a sustainability condition could avoid belaboring the tyranny of discounting and would remove the unrealistic requirement that all ethical and environmental concerns be accounted for by adjusting the discount rate. Nonetheless, the sustainability rule remains blurred and deserves more attention.

### *Evaluating Environmental Damage and Benefits: The Concept of Total Economic Value*

Value can be broadly categorized as either instrumental or intrinsic. Instrumental value refers to the capacity of something, when used, to satisfy a want or preference. Intrinsic value is regarded by ecological philosophers as being inherent to something. Opinions vary widely as to what possesses intrinsic value, in particular whether value can reside in both conscious and unconscious objects or whether only conscious objects can possess intrinsic value. Instrumental, or use value, can be divided into direct value, indirect value, and option value. Intrinsic, or nonuse, value is also referred to as existence value.

Direct use values are fairly straightforward in concept but not necessarily easy to measure in economic terms. Thus the output of minor forest products can be measured using market and survey data, but the value of medicinal plants is extremely difficult to measure. Indirect values corre-

spond to the ecologists' concept of ecological functions or services and are discussed in detail below.

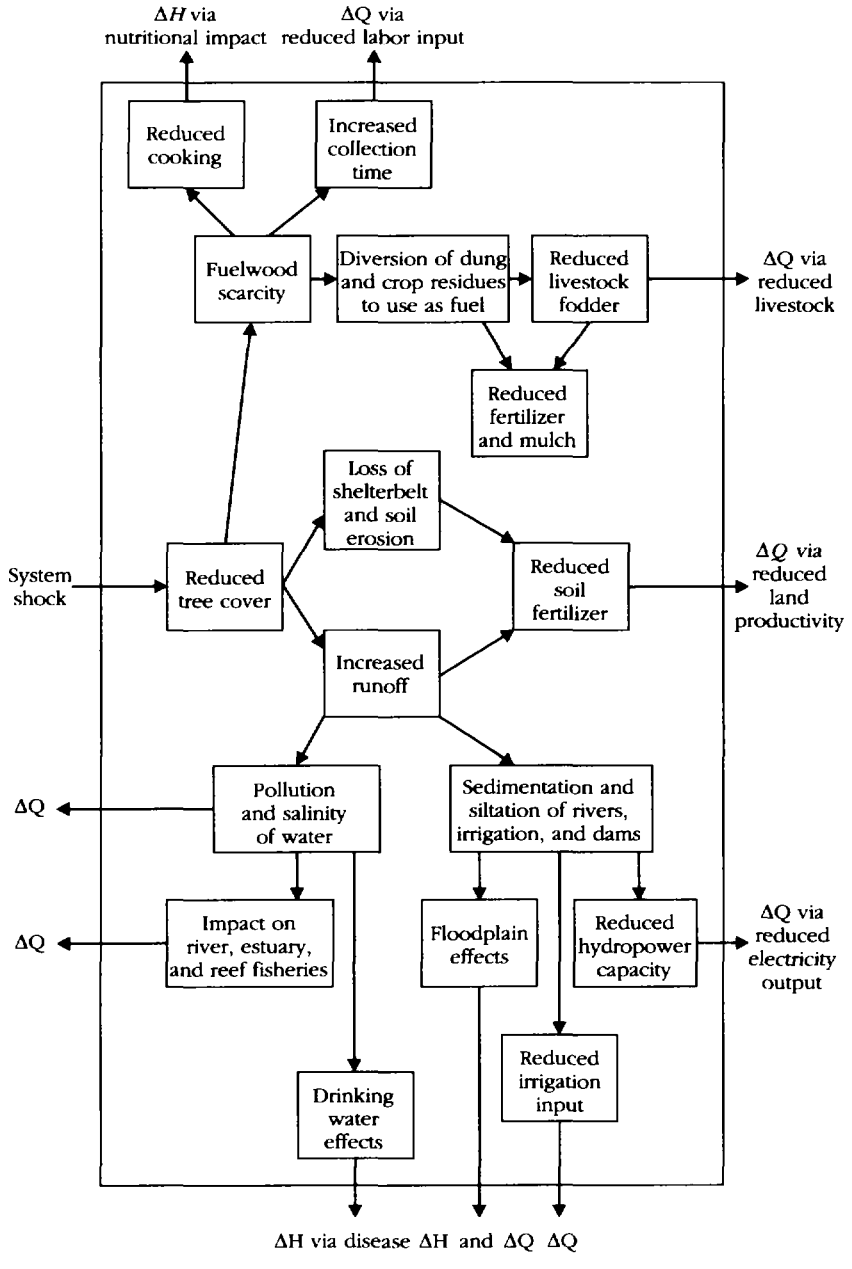
Option values relate to the amount that individuals are willing to pay to conserve a tropical forest for future use. That is, the forest is not used now but may be used in the future. Quasi-option value has also been identified in the literature. It is the value of information that arises after the choice has been made to conserve or develop now. Existence value relates to valuations of the environmental asset that are unrelated either to current or to optional use. Its intuitive basis is easy to understand because a great many people are willing to pay for the existence of environmental assets through wildlife and other environmental charities. Empirical measures of existence value have been obtained through questionnaires (the contingent valuation method).

Total economic value can be expressed as TEV equals direct use value plus indirect use value plus option value plus existence value. The components of TEV cannot, however, simply be aggregated: that is, before being added to the equation, components must be shown not to be mutually exclusive (for example, the benefits of clear-felling and the benefits of watershed protection). Tradeoffs exist between different types of use value and between direct and indirect use values. In practice, then, the TEV approach must be used with care. Nevertheless, exploring total economic value helps us investigate economic value.

The concept of total economic value offers a comprehensive framework within which to value environmental assets, and may be illustrated with regard to tropical forests. Total economic value comprises use values, option values, and existence values. Direct use values include timber and nontimber products and ecotourism. Indirect use values include the ecological functions of tropical forests: their watershed protection and mineral cycling functions. Existence value relates to the intrinsic value of the forest unrelated to its use. Since all these values are given by people, the total economic value approach is totally anthropomorphic. It does not deny other rationales, such as natural rights, for conserving tropical forests. Resorting to such moral arguments may not be necessary. Economic arguments alone could justify a dramatic reduction in deforestation. A major issue, however, is that any mobilization of existence value must result in flows of cash or technology targeted to the people who make the decisions about resource use. If those individuals are small colonist farmers, for example, this fact would have formidable implications for the way in which any transferred funds are used in the receiving country.

Use values alone may favor forest conservation. See figure 1, which illustrates the range of consequences of deforestation and by implication the use value of the forest. Clearing forests for livestock agriculture, in

*Figure 1. Ecological Effects of Deforestation*




*Note:* Δ*Q* refers to effects that show up in measured or measurable indicators of development. Δ*H* refers to effects on health.

particular, appears to have limited rationale. Doing so depends on substantial subsidies, which themselves introduce major economic distortions. Using forests as a source of products other than timber, such as minor forest products, appears to give higher financial rates of return than using them as a source of timber in some areas. Markets fail to allocate forests to their best uses because government intervention is inefficient, notably in the areas of subsidies and land tenure. The recreational use of tropical forests is only now beginning to be realized.

Indirect use values must be estimated. As yet, little effort has been made to do so. Existence values are much more difficult to estimate, although (as noted above) efforts using contingent valuation approaches have been made.

## Resource Degradation: Causes and Policy Response

### *Population and Environment*

Population growth has two broadly counteracting effects on environment and development. By forcing adaptive and technological change, population growth may actually increase the prospects for development in the traditional sense of rising GNP per capita. By contributing to the depletion of natural resources, primarily renewable and common property natural resources, population growth impedes development in the traditional sense and certainly reduces environmental quality. The balance of these two broad effects favors the view that population growth, certainly on the scale now being witnessed, is detrimental to future human welfare. Such growth threatens both the quantity and the quality of natural resources, including the capacity of the environment to assimilate waste. Moreover, to argue that population growth can be associated with advances in technology does not mean that technological advance will not occur without population change. Such a view overlooks the extent to which conscious decisions to invest in new technology can be made for reasons not associated with the need to feed, house, and supply with energy an increasing number of people.

Reducing population growth rates will contribute only partly to solving environmental problems. Many other factors generate resource degradation, especially misdirected policies concerning land tenure and prices. Major advances can be made by reforming government policy that directly or indirectly affects environmental quality. China, for example, has increased agricultural output dramatically by improving farmers' incentives and placing land under household management. Malawi has increased agricultural output 7 percent a year since 1973 despite having the third highest rural population density in Africa. The potential for energy conservation is substantial in the industrial and developing worlds alike.

Proper pricing and proper incentives offer the scope for substantial resource conservation.

To argue for the importance of policies other than those aimed at constraining population growth is not to downplay the importance of population control. Policies must be advanced on many fronts and should include major efforts to control birth rates, especially in Sub-Saharan Africa, where the traditional model of population control appears not to be working. Population policy requires not just investments in information about contraception and the benefits of reduced family size, but also a major effort to understand and modify the underlying economic and cultural factors that continue to favor large families. Ultimately, development will stabilize populations, but in many cases development itself is threatened by overly rapid population growth.

### *Policy Failure: Pricing below Private Cost*

Economists distinguish two broad types of inefficiency in the management of modern economies. The first is market failure—the failure of freely functioning markets to reflect the full social costs of production in the price of traded products and inputs and the failure of markets to exist for many inputs and outputs, especially environmental services. If input and output prices do not reflect full social costs, the economy cannot achieve maximum potential human welfare. Market failure has been widely used to justify government intervention in markets, not just intervention in external costs, such as pollution, but also in sectors that have widespread external benefits, such as education and health. Indeed, the argument of external economy has been used to justify the provision of free education and health care because the external benefits—better information, improved capability to make decisions, improved nutrition and productivity, and so on—are thought to be very large. It is important, however, to assess whether government intervention bears any costs, since governments are not necessarily more efficient than imperfect markets.

The second kind of inefficiency arises from the failure of the government's policy or intervention. When governments intervene in the economy, they may produce less efficient outcomes than if they had allowed the market to allocate resources. Inefficient interventions may include subsidies, price controls, physical output targets, exchange controls, ownership controls, and so on. Even when intervention is justified, as it is in many contexts, the government should secure least-cost interventions, that is, use instruments of control that are not unnecessarily expensive or burdensome.

Price controls are common for two main reasons. First, the price of essential goods must be low to benefit the poorest members of society. This explains why food and energy are frequently subsidized. Second, keeping

the price of inputs low is thought to encourage industrial and agricultural activity. This explains why the price of fertilizers, irrigation water, and energy is generally controlled. Other policy considerations, such as protecting employment, also cause prices to diverge from efficiency prices. The costs of achieving these objectives can be very high since price controls mean that resources are used to subsidize the activities that produce the product whose price is controlled. These subsidies are often a serious drain on government revenues, and, of course, the revenue used for them could have been used for other purposes that also benefit the poor. The effect on the environment of expanding output is to increase the potential demand on environmental quality by increasing the level of wastes disposed in the natural environment. Frequently, as we shall see, subsidies are applied to products that are particularly damaging to the environment.

IRRIGATION WATER. Irrigation water is heavily subsidized throughout the developing world. This has a number of environmental implications. First, farmers give marginal valuations for irrigation water that are very high, several times higher than the charges actually imposed. Second, raising charges by small amounts will not affect demand because the marginal values are so high. Third, the benefits from irrigation water arise from its availability not its low price. Raising the price will not, therefore, reduce the social benefits of irrigation. Other implications follow from looking at how irrigation systems operate. Underpricing encourages a wasteful attitude so that systems are kept in poor repair. Inefficient irrigation negatively affects agricultural output. Because charges are low, demand is excessive, giving a premium to those who can secure water rights by, for example, being the first in line to receive water.

COMMERCIAL ENERGY. Commercial energy—coal, oil, gas, and electricity—is also widely subsidized in developing countries. As with irrigation water, these subsidies encourage wasteful uses of energy and add to the problems of air pollution and waste disposal. The economic effects of the subsidies tend to be more dramatic than the environmental effects: they drain government revenues and thereby divert valuable resources away from productive sectors. They also tend to reduce exports of any indigenous energy, thereby adding to external debt, and encourage energy-intensive industry at the expense of more efficient industry. Electricity supply is invariably subsidized: prices being well below long-run marginal cost in virtually all countries.

TROPICAL DEFORESTATION. Tropical deforestation arises because land is cleared for agriculture and road building, logged to satisfy the demand for timber, fuelwood, and fodder, and damaged by single events such as fire. The underlying reasons that deforestation occurs include the pressure

exerted by expanding and marginalized populations in search of land, the development process itself (logging and infrastructure), and government policy that deliberately or indirectly encourages deforestation. Determining the relative importance of each of the proximate causes is difficult because they tend to compound one another. Logging frequently opens inaccessible areas to agricultural colonizers. Forests regenerate if left alone, but the displaced primary forest is replaced with secondary forest that is not as rich. The regeneration process can be irreversibly destroyed if forest soils are used for inappropriate agriculture, such as cattle ranching. Government policy may unwittingly contribute to deforestation.

PESTICIDE SUBSIDIES. Subsidies range from 19 to 89 percent of the full cost of the pesticides, thus maintaining prices artificially low. Damage from excess use of pesticides shows up in several ways. For example, approximately 2 million cases of pesticide poisonings occur each year in the Asia and Pacific region, 40,000 of which probably result in death. Exposure is highest among men, and death rates rise significantly in communities where insecticides have been introduced on an intensive scale. There is also evidence of health risks from fish caught in pesticide-contaminated ponds, paddies, and irrigation channels. New pest biotypes have emerged in response to large applications of some pesticides, thus decreasing the stability of crop production. Subsidies are not the only factor causing excessive use of pesticides; ignorance of the risks as well as use of pesticides that are not permitted in the industrial world also contribute to excessive use.

### *Market Failure: Social Pricing Distortions*

POLLUTION AS EXTERNALITY. Environmental economics analyzes pollution as an externality. An externality is any impact on a third party's welfare that is brought about by the action of an individual and is neither compensated nor appropriated. Consider an upstream paper mill that discharges waste into a river, causing downstream pollution that damages fish stocks and reduces commercial and recreational fishing. The damage done is an external cost borne by the commercial and recreational fishermen. It shows up as reduced profits for the commercial fishermen and as a loss of welfare or utility for the recreational anglers. As long as the paper mill pays no compensation for the damage done, society suffers an overall loss of welfare compared with the desirable, or optimal, level of welfare. For an external cost to exist, then,

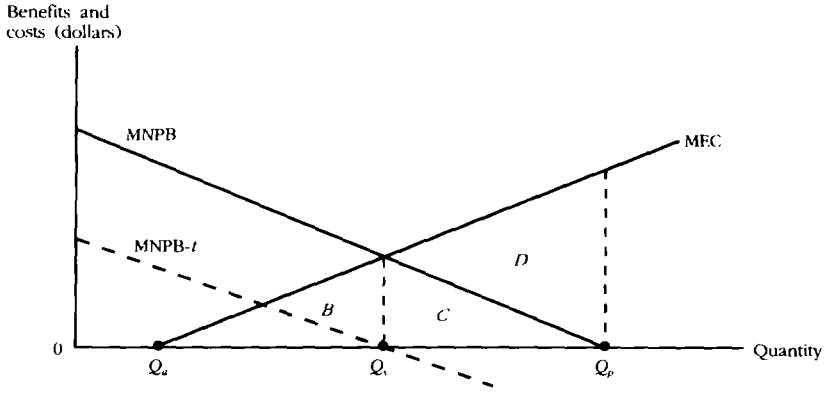
- The activity of one or more agents must cause a loss of welfare to other agents in the economy; and
- The loss of welfare must not be compensated.

A similar analysis also applies to external benefits. If an individual produces a product that benefits other people without exacting a price, a similar distortion arises in the economy. In this case, too little of the product is supplied, whereas in the case of external cost, too much is supplied. External benefits are not academic curiosities. A great many people obtain pleasure from knowing that a tropical forest is being preserved. They experience an external benefit from the preservation of the forest. Similarly, they experience an external cost if the forest is cut down. These observations have implications for how pollution and resource problems might be dealt with at the international level.

In theory, an optimal level of pollution can be determined in which the marginal cost of damage is equal to the marginal net private benefit of producing the polluting output (see figure 2).

To avoid creating an excessive amount of pollution, governments must intervene in a market-based economy. The extent to which governments should intervene is, however, very controversial. Individuals who favor free markets as part of a political ideology resist the idea that markets somehow fail to produce the right amount of environmental quality. Others argue that intervening to protect the environment places obstacles in the way of industrial progress and stagnates the standard of living. This argument is familiar in industrial economies. It is accorded even more

*Figure 2. Tax Solution to Pollution Externality*




*Note:* A pollution tax is set equal to MEC at the optimum $Q_t$. This shifts MNPB downward to MNPB -t. By Maximizing after-tax profits, the polluter automatically operates at $Q_p$, the optimum. To work ideally, the tax must equal MEC at the optimum, which means that we must have some idea of the monetary damage done by pollution in order to identify the optimum. This raises the issue of valuing environmental damage once again.

importance in poorer countries. Many people believe that free markets cannot deliver a long-run increase in the standard of living. They argue that free markets are, in effect, manipulated by industry and that a poor country is easily diverted into producing or importing consumer goods when it should be building up its capital base. Markets also tend to favor the rich. The poor may simply be unable to buy at the prices determined in the marketplace. Indeed, this is often the argument mounted in favor of energy and food subsidies. It is helpful to investigate these ideas a little further.

In principle it is possible to imagine a socially efficient solution obtained by bargaining between the party causing the damage and the party suffering it. Such an outcome suggests that, regardless of who owns the property rights, individuals will create markets in externality. However, in practice, this faces a great many difficulties. It does not work when conditions that are not competitive apply in the economy. It has little or no relevance to situations in which the sufferers are future generations, since they have no bargaining power. This is particularly relevant to global pollution such as the greenhouse effect. It is also at odds with observations that bargains are conspicuously difficult to find in practice. One response to this is that the absence of bargains is due to the costs of bargaining, the transaction costs of identifying polluters, organizing the suffering group, engaging in meetings and negotiations, obtaining legal surety for the bargain, and so forth. If bargaining is too costly, the benefits of the bargain must be less than the transaction costs plus the damage that would be avoided by securing the bargain.

Nonetheless, the bargaining approach does have relevance. In the international sphere, a great deal can be said for bargains concerning external effects. These might include bilateral deals where, for example, a country might receive aid in exchange for not reducing rain forest cover. Such negotiations do take place and, to some extent, are manifestations of the bargaining solution.

MARKET-BASED INSTRUMENTS VERSUS COMMAND AND CONTROL. Once some form of regulation to maintain and improve environmental quality is acknowledged as essential, the issue devolves into one of how best to secure the regulation. Broadly, there are two alternatives: command and control versus market-based incentives.

The central government can set environmental standards and design regulations to ensure that those standards are honored. The form of regulation contains a command, which says that polluters must not exceed a predetermined level of environmental quality, and a control, which monitors and enforces the standard.

Typically, polluters prefer this approach: the standards are usually in place for a determined period of time, and, depending on the degree of control, polluters can usually negotiate with the regulator to resolve special difficulties. Something can be said for a system that reduces the uncertainty associated with regulation. Regulation is, however, also more expensive than other means of control and therefore offends the principle of minimum cost. Regulation is more expensive for two reasons. First, the regulator must acquire information from the polluter, for example, about the costs of abatement technology. Second, the polluter has no flexibility. He must abide by the standard even when his costs of abating pollution are much higher than those of another polluter. Because both polluters face the same standard, the polluter with the lower costs of abatement cannot take a larger share of the control.

Market-based incentive systems simulate market conditions using two basic mechanisms. The first alters the price of the polluting input or technology, the polluting product, or all of them. If coal combustion causes acid rain and greenhouse effects, the price of coal in the free market clearly does not reflect the use that coal combustion makes of environmental services supplied by the atmosphere. The price can be altered by imposing a tax or charge on the coal according to its sulfur and carbon content..

The second mechanism that simulates the market is the marketable permit, also known as the tradable permit. All command-and-control regulations set some sort of standard, either for allowable emissions or allowable concentrations of pollutants. The marketable permit uses this fact by issuing permits that allow firms to pollute up to the level of the standard. The point of departure is, however, that the permits can then be traded between polluters. This requirement may seem, at first sight, to be redundant, but it enables polluters facing high abatement costs to bid in the marketplace for the permits. This gives polluters whose abatement costs are relatively low an incentive to sell the permits. Permit buyers therefore tend to pollute more than permit sellers, yet the overall environmental standard remains unaltered because just enough permits have been issued to achieve the standard quality in aggregate. Reallocating permits between polluters thus minimizes the costs of complying with the standard. This is true because it concentrates the costs of control on the polluters who can best afford to adopt abatement measures.

Objections to marketable permits tend to focus specifically on how they might work. Some objections are simply misinformed. The most frequent objection is that issuing a permit allows polluters to pollute, which is ethically undesirable. The problem, of course, is that all regulatory approaches allow pollution up to the level of the standard. Marketable permits are no different. If intended to mean that there should be no

pollution, this criticism would have to be justified by an objective other than efficiency. But even if this were the case, marketable permits would still be a cheaper way to achieve a given target than a command-and-control approach. If intended to mean that there should be no waste, rather than no pollution, this criticism is an impossibility according to the laws of thermodynamics.

Overall, then, market-based incentives are an attractive approach to controlling environmental pollution. Not least among these attractions is the likelihood that it will cost industry less to comply with standards backed by market-based incentives than to comply with command-and-control approaches. Moreover, since industry can always pass on some of the costs of controlling pollution to the consumer, the costs to the consumer are also lower under the market-based incentives approach. Keeping the costs of compliance down without sacrificing environmental standards is critical if, as seems likely, environmental costs will grow as global pollution worsens.

MARKET-BASED INCENTIVES AND DEVELOPING COUNTRIES. The idea of implementing pollution control measures through mechanisms such as charges and marketable permits is attracting attention in developing countries. Past neglect is hardly surprising given the limited attention afforded these techniques in the industrial world and the newness of environmental policy itself in many developing countries. Nevertheless, many developing countries have environmental agencies, and others are seeking advice on how to establish them. It is not too early to urge developing countries to begin considering a broad set of policy instruments. Many countries should perhaps establish their own instruments instead of simply borrowing the institutional structures already in place in the OECD nations. It seems likely, however, that they must gain far more experience before such instruments can be transferred as part of environmental policy in the developing world.

Attempting to adjust the price mechanism through effluent taxes may also be premature in other senses. The developing world often lacks the institutional basis for implementing such taxes. They may lack experience in environmental monitoring in general, have an inadequate legal system to back up a regime of fines, have problems collecting taxes, and so on. More important, pricing in developing countries rarely reflects the purely financial costs of production. In terms of the formula for social cost pricing introduced earlier ($P = MC + MEC = MSC$), the problem is that $P < MC$. Considerable environmental gains may be achieved by simply ensuring that prices reflect the financial costs of production. Setting $P$ below MC produces several effects. First, it implies a financial subsidy, which drains

central government resources. Second, it encourages excessive consumption, resulting in both financial waste and environmental degradation. Third, it creates rent, that is, large differences between the economic benefit obtained and the apparent cost of consumption. The existence of such rents encourages rent seeking—the creation of additional opportunities to create rent and therefore expand activity in the subsidized area.

Nonetheless, in many instances, charges could be implemented in a simple rule-of-thumb fashion, and the weapon of charging or taxing should not be overlooked. As traffic increases in the cities of many developing countries, so does the importance of the role that rising gasoline and diesel taxes can play in controlling the externalities associated with traffic, noise, congestion, and air pollution. Externality taxes are not intended to raise revenue. They are designed to offer incentives and work best when the demand for the product in question is fairly responsive to price, that is, when it is elastic. If demand is not responsive to price, taxes must be very large—which is not politically feasible—to have any effect. At the same time, modest environmental taxes on commodities with inelastic demand can be justified as a means of raising revenue in developing countries, whose tax base is often difficult to implement. Taxing a polluting product such as gasoline can be and is, however, done with comparative administrative ease. If doing so does not alter behavior much, it does, nonetheless, raise revenues that can either be used to supplement other sources of general government revenue or be directed to specific environmental purposes.

### *Planning Failure: Socialist Planning and the Environment*

The major contribution to the damaging particulate air pollution in Central and Eastern European (CEE) countries does not come from tall stacks of industries and power plants, which disperse their emissions over a considerable area. Instead, they come from low-stack households and the service sector, which use more coal than is common in Western Europe. Except in Poland and Czechoslovakia, the share that coal has in generating electricity and industry in CEE countries is similar to its share in Western Europe.

The damaging pollution effects from low stacks show that the ambient level of exposure, not the total level of emissions, is important, since emissions and ambient air quality are not linked directly. Moreover, particulates (especially in conjunction with sulfur) are more damaging to human health than gaseous pollutants. Given the nature of the sources, relatively simple and inexpensive measures, such as switching residences and small boilers from coal to gas, would largely solve most of the severe

problems of air quality throughout Central and Eastern Europe. This is essentially what occurred in the heavily industrial regions of Western Europe and North America twenty years ago.

Controlling water pollution would be far more costly than controlling air pollution, and such investments are given lower priority, since water pollution generally involves few health costs except in limited geographical areas. In most CEE countries, the high levels of water pollution increase, above all, the capital and recurrent costs for infrastructure. Moreover, as in the West, nonpoint sources contribute a major portion of water pollution. Wastewater and nonpoint source pollution can be mitigated in large part through inexpensive, low-technology methods that increase the oxygen content of water and improve its self-purification properties (weirs, aeration equipment, and constructed wetlands); the typical high-cost western model for intensive wastewater treatment is not a good example.

Changing the industrial structure of the CEE countries—above all, reducing the share of heavy industry—would solve many environmental problems but could increase others if the relative price of energy and natural resources is not systematically adjusted. In the OECD economies, the two oil price shocks of the 1970s made a significant fraction of the total capital stock obsolescent because it was poorly adapted to the new relative price of factors and resources. This capital was gradually replaced by new equipment that was more energy efficient and designed to meet much higher environmental standards. In contrast, CEE countries were largely insulated from the energy price increases in the West. Energy prices (combined with incentives to ensure a rapid response to higher energy prices, especially a hard budget constraint) are expected to be the single most important factor reducing the main diffuse air pollutants in CEE countries until the end of the century. Unfortunately, no similar instruments exist to reduce wastewater discharges. In the longer term, controlling water pollution will therefore require much larger investments than controlling air pollution.

Environmental performance in the West did not improve purely as a result of economic changes. In the United States alone, for example, some $640 billion have been spent on environmental investments, although much has not been spent efficiently. CEE countries strapped for resources would benefit if the effectiveness of the factors contributing to environmental improvements were better understood.

Any environmental action program must be based on a clear understanding of what would be achieved through price adjustments, industrial restructuring, and privatization, on the one hand, and explicit environmental policies and investments, on the other. This task is complicated by the rapid changes and great uncertainty in the new democracies of Central

and Eastern Europe. The analysis must therefore evaluate different scenarios of economic and technological development and the impact that the stabilization and adjustment programs now under way to varying degrees in the CEE countries are likely to have on the environment.

CEE countries have paid little attention to their weak institutions, limited absorptive capacity, and inability of their local currency resources to match the limited hard currencies available even today. Throughout Central and Eastern Europe, quite high standards of technical expertise can be found, but decisionmaking and management capability are sorely lacking, as is knowledge of how to design and implement sound projects.

Most CEE countries have a fairly comprehensive system of permits, fines, and fees. In practice, these systems do not work because enterprises are more concerned about meeting their production targets than about improving their financial performance. Indeed, the price-setting regime allows them to build the cost of fees into the cost base used to determine the prices they charge for domestic sales. These prices are subsidized (by means of a so-called soft budget), and part of the subsidies actually support pollution. Further, the fees and fines are consistently well below the average cost of reducing emissions and are not systematically adjusted for inflation. They are trivial in real terms. This does not necessarily imply that environmental charges do not work in CEE countries nor that they should be abandoned. Where fees and fines are sufficiently high, pollution has apparently been reduced, although this is hard to disentangle from the general process of economic downturn. Clearly, given the widespread tradition in CEE countries, further efforts to make the system workable are warranted.

Privatization and industrial restructuring are being promoted with relatively little awareness of the potentially critical role that environmental factors play in the process. Thus investors shy away from committing themselves (a) because they are afraid of being held liable for past environmental damage, (b) because the regulatory framework (including standards) is unclear, and they may be forced to change practices after making major investments in equipment, (c) because national or local authorities have established specific investment constraints based on a misguided ordering of economic and environmental priorities, and (d) because the environmental infrastructure makes meeting high production standards and attracting skilled labor impossible.

### *Property Rights Failure and Renewable Resources*

Natural resources may be divided broadly into renewable and nonrenewable resources. Nonrenewable resources, as the name implies, are

finite, so that using them at all depletes the stock over time. The economic issue with nonrenewable resources is the rate at which the stock should be run down over time. Renewable resources are capable of regeneration. Examples would be fisheries and forests. Their capacity for self-renewal does not, however, mean that they will, in fact, renew themselves. This depends on the management regime. A forest that is clear-felled and then used for livestock, say, does not typically renew itself. Even if the agricultural use is temporary, renewal may be impaired because the soil is eroded and nutrients are lost. A management regime that involves sustainable use allows the resource to renew itself and takes the sustainable yield of the resource. Thus, a fish stock can be fished by harvesting only the mature fish and leaving younger fish to age and breed and grow until they are ready for the next catch. If more than the sustainable yield is taken on a regular basis, the remaining stock has no chance to regenerate. The result is overuse, which threatens the resource with extinction. Extinction may be optimal in some circumstances, but extinguishing a renewable resource conflicts, at least potentially, with the philosophy of sustainable development. The economic issue with renewable resources, then, is the rate at which they should be used so that their stocks are maintained.

Game theory can be used to assess the risk of a renewable resource held under common property or open access becoming extinct or degraded. Game theory analyzes the behavior of individuals or groups contingent on the reactions of other individuals or groups. What A does, for example, depends on how he thinks B, C, and D will react. Two models are particularly relevant to the problems associated with renewable resources; these are the prisoners' dilemma and the assurance game. An analogous presentation is also provided using a basic public goods model. Once a public good is provided to one person, it is automatically provided to others and no one can be excluded from receiving the benefits of access to it. In such circumstances, one would expect to find free riders—individuals who aim to secure the benefit without meeting the cost of providing the good.

Evidence from a variety of sources relating to fisheries, the Pacific seal, the blue whale, and forest resources indicate that any open-access regime, in which no property rights are defined for named individuals or communities, risks extinction of the resource. Nonetheless, in theory, open-access equilibria can be stable, that is, consistent with sustainable use. In practice, open-access contexts reveal the serious risks facing resources such as blue whales, elephants, and many tropical forests. Private ownership should maximize profits, which, in turn, should lead to restrictions on rates of exploitation and conservation of the resource. In practice, various factors, such as the uncertainty surrounding ownership rights, may lead to the

overly rapid exploitation of the resource. Common property regimes are likely to produce resource use rates somewhere between the solution of private ownership and that of open access. Common property carries much lower risks of resource degradation than open access, and the two should not be confused. Although intuitively attractive, maximum sustainable yield is unlikely to be a rational management solution for renewable resources.

Privatization is a frequent policy prescription for solving the problems caused by overusing resources under open access and common property. Lack of formal title to land, in combination with factors such as the lack of transfer rights, the weakening of indigenous institutions, or the increasing scarcity of land, may result in various forms of uncertainty that could contribute to resource degradation. At the same time, the absence of title to land does not necessarily mean that landholders lack security.

At first glance, state ownership of land and natural resources would address the tragedy of the commons since the externalities ingrained in the overuse of common resources become internalized to a single owner, the state. For state ownership to work efficiently, however, the state must be able to monitor the use of resources, establish acceptable rules of use by individuals and communities, and enforce those rules. Typically, this has not been the experience with state ownership.

Anthropologists and sociologists presume that local communities best understand their own environments and hence are best capable of managing natural resources in a sustainable way. Certainly tribal and peasant societies have formidable knowledge of soils, natural medicines, risk-minimizing cropping strategies, and so on. Similarly, these communities have elaborate rules and regulations to ensure sustainable use of natural resources. Mutual support within the community and storing produce for hungry days are but two examples. Although all this is true, such communities do not necessarily take care of nature. Many examples of successful communal management systems, where success is measured by survival, occur in communities that have no need to destroy their relatively abundant resources; because resources are abundant, the element of resource management per se never arises. Communal systems vary substantially within broad types of land users—agriculturists and transhumants—so that generalizations are far from easy. Similar environments do not even correspond to similar social and political structures.

However, population growth obviously pressures communal systems as existing land is divided between an increasing number of people or is used by increasing herds of livestock. Moreover, technology can induce the overuse of resources, as with the introduction of motorized fishing boats in San Miguel Bay in the Philippines, chain saw technology in the Amazon forest, and high-velocity rifles for poaching elephants in Africa.

The following conclusions emerge for the management of renewable resources in the realms of open access and common property.

- Open-access regimes contain high risks of resource degradation even though, technically, an equilibrium should exist at which average profits are zero and the resource is used sustainably. The risk arises because the resource stock may not be known with accuracy and because the minimum viable size of the stock is frequently quite high.
- Open access must be distinguished from common property, in which sets of rules typically exist for the management and sustainable use of the resource. Even common property has built-in risks of overexploitation because the private good diverges from the collective good. If common property regimes break down, it cannot be assumed that they do so because of the internal contradiction between social and private benefit. Many other factors contribute to the destruction of common property systems: the insertion of alien values by colonialists, exogenous technological change, and population growth.
- Privatization, the right of individuals to use or own resources, is attractive because it provides incentives for individuals to develop resources. Even if common property regimes are stable and sustainable, they may not cause incomes to rise over time. Privatization can provide dynamic incentives to improve land and resources but is also consistent with optimal resource degradation and the continued existence of externalities among owners.
- Common property management regimes do work, especially when the incentives for communality are high. This is typically the case when the collective benefit is high, for example, the need to avoid the risk of total collapse.

## *Poverty, Income Distribution, and Environment*

INEQUALITY AND SUSTAINABLE DEVELOPMENT. Three types of inequality or inequity may be distinguished.

- Inequality through time: intergenerational equity
- Inequality between nations at a given point in time: intragenerational equity between nations
- Inequality within a nation at a given point in time: intragenerational equity within a nation.

Sustainable development has clear implications for intergenerational equity; in fact, sustainability has been defined as some sort of intergenerational equity. Sustainability involves holding total capital stocks at least

constant to ensure that future generations have the same capability to develop as current generations. Environmental capital is a vital part of that stock since it renders the life-support functions that make a reasonable quality of life feasible and, in some people's view, make existence possible.

But is sustainable development relevant to inequality now? Some authors distrust the emphasis that sustainability approaches give to environmental quality. This emphasis appears to some, for example, to be a conspiracy of the rich nations to conserve natural assets in the poor nations simply because those assets yield utility to the rich countries. On this view, not only does the asset generate benefits mainly outside poor countries, but conservation precludes poor countries from using the asset for development. Thus tropical forests yield the benefits of existence value and option value to rich countries, but these values do not translate into flows of cash for the poor, whereas development options might. This view contains a clear element of truth but misses much of the thrust of the sustainability approach.

First, sustainable development is concerned with inequality between countries. If the pattern of demand for traded natural resources in rich countries encourages unsustainable management of those resources in poor countries, that pattern of demand may threaten development prospects in the future. Those prospects are based on the comparative advantage that natural resources confer on the developing world. Hence, inequality between nations (intragenerational inequality) is relevant to the sustainable development of the developing world. On this hypothesis, inequality between nations may, in certain policy environments, foster unsustainable development. In other words, not only does sustainability affect equity, but inequality also affects sustainability.

Second, inequality within a nation may foster unsustainability because the poor, who rely on natural resources more heavily than the rich, would perhaps deplete natural resources faster if they had no real prospects of gaining access to other types of resources. This is the poverty-environment hypothesis. Moreover, degraded environments can accelerate the process of impoverishment, again because the poor depend directly on natural assets. As we shall see, this circular link between poverty, environment, and poverty is both far more complex and far more common than generally imagined.

The poorest of the poor thus occupy the least resilient, most threatened environmental areas of the world. The very fact of low resilience to stress and shock means that an exogenous event, such as a change in climate, could induce the poor to take actions that further degrade the environment. This happens when the poor are in some way confined to an ecologically fragile area and react to stress by intensifying their use of limited resources,

that is, by deforestation and overgrazing. The stress in question could include population growth and economic signals from policymakers that diminish the incentives to maintain a stable equilibrium between the local economy and its environment.

On this analysis, poverty is not so much a cause, in the narrow sense, of environmental degradation, as a mechanism by which the true underlying causes are transformed into actions that degrade the environment. Put another way, poverty does not necessarily in and of itself lead to environmental degradation. That depends on the options available to the poor and on their responses to outside stimuli and pressures. Poverty, however, removes their ability to respond and adapt because the time horizon is typically short and few feasible options are available. This leaves only two types of reaction: they can attempt to supplement scarce assets by using free common property or open-access resources, or they can leave the land altogether and move to urban areas. The result of using up resources is to degrade the rural environment. The result of moving to urban areas is to swap one form of degradation for another, that is, rural for urban. Because poverty is also associated with poor health, the capability of responding to exogenous factors is further reduced by the physical effort involved. The association of poverty with illiteracy compounds the issue, since illiteracy also reduces the ability of individuals to respond to pressures. Poverty in all its manifestations keeps the poor from being able to respond to environmental degradation arising from other underlying causes; it thus becomes a disabling factor.

This idea of poverty as a disabling factor rather than an underlying cause of environmental degradation permits us to take into account other compounding issues. Population growth acts as both an underlying cause and a compounding factor. In Bangladesh, for example, population growth is reducing the average farm size, thus lowering productivity and deepening poverty. As poverty increases, the ability to escape environmental degradation is reduced even further. In Nepal, the same phenomenon leads farmers to clear and crop hillsides in an effort to maintain their income. Expanding agricultural area is associated with deforestation and with increased soil erosion.

The generalized picture of the links between poverty and environment must not be exaggerated. The existence of poverty does not mean that environmental degradation will necessarily follow. As the model suggests, if the underlying causes or shocks are absent, the state of poverty is likely to persist, but without environmental degradation. Comparatively few attempts have been made to trace the responses of the poor to stress and shocks over time. Other factors cause environmental degradation, notably new roads that open up virgin territory and lead to agricultural coloniza-

tion, misguided price and other incentives, and population growth. Illiteracy compounds the disabling effects of poverty. Instead of stimulating entrepreneurial activity and investment in rural areas, increasing literacy may quicken the exodus of the poor. It is sometimes argued that biasing public investments toward urban areas reinforces the trend of rural-urban migration by creating a large informal sector that acts as a magnet. In many ways, then, individuals in rural areas react to environmental stress by migrating to urban areas. As we saw, this shifts the type of poverty from rural to urban. This is particularly true if the informal sector cannot assimilate the flow, but has real prospects for improving welfare if it can. Certainly, a bias may exist where cost recovery is not practiced and subsidies are not targeted. On the other hand, public investments in urban infrastructure are necessary if cities are to be a positive force in the national economy and provide jobs and income for "excess" rural labor. The important issue is to ensure that the beneficiaries of urban investments pay their fair share for those benefits and that indiscriminate subsidies do not end up in the pockets of the urban well-to-do.

Faced with declining real income because of, say, an exogenously determined decline in crop output, the poor may react in a number of ways.

- They may seek marginal lands on which to expand output—a direct link between poverty and environmental degradation if the marginal lands are ecologically fragile, as is likely.
- They may also seek ecologically sound ways of expanding output in ecologically sensitive areas, for example, by adopting terracing techniques or agroforestry on steeply sloped land. In Kano, Nigeria, for example, the pressure of famine did not seem to affect the preference of smallholders for tree conservation.
- They may also seek income security rather than food security by obtaining employment off the farm or undertaking other activities that generate income. If so, they may well choose not to undertake activities that damage the environment.

Therefore, impoverishment by itself does not necessarily cause environmental degradation. Much depends on the coping strategies of the poor, and these depend, in turn, on the availability of options, cultural factors, and policies of local and national governments.

Just as significant, the factors giving rise to impoverishment may, however, be the underlying cause of actions that do degrade the environment. As economies grow and monetization is extended, the poor may become marginalized by changes in the structure of property rights. Common property, for example, may be privatized. This trend may be encouraged by the growing scarcity of land and water resources caused by

population growth, as the poor are excluded from access to the privately owned land and forced onto marginal lands. This process has been observed in parts of India, for example. Poverty in the sense of powerlessness then becomes the means by which a more fundamental cause—centrally directed changes in property rights—gives rise to environmental degradation. From this point of view, the poor create degradation through misdirected public policies.

The general theory of poverty and environment outlined above suggests that the link is not always straightforward. Often it can be direct and simple—reductions in real incomes do cause activities to expand into marginal areas, giving rise to environmental degradation. Disentangling this effect from population change and the influence of public policies is not easy. Frequently, however, policy measures and general population pressure dominate the processes that generate environmental loss. If this is correct, the policy response must, first, raise agricultural productivity in the most resilient and potentially productive areas, thereby improving the well-being of 250 million of the most impoverished poor and reducing the pressure exerted on marginal lands by populations who would otherwise be displaced from resilient areas. Second, the policy response must decrease the fragility of marginal areas through schemes of water conservation, agricultural extension, afforestation, and agroforestry. As with resilient areas, the policy mix must consist of investment, incentives schemes, infrastructure, credit, extension information, and institution building, including in many cases establishing or reinforcing resource rights through land and resource tenure.

The first type of policy is likely to be more technological in character than schemes of the second type, which are likely to concentrate on institutions and incentives. The efforts to meet the poverty challenge have, in fact, witnessed just this kind of policy shift toward designing policies that are aimed at households and farms, communities, and local governments and that pay due attention to the centralized economic signals affecting choice of crops and type of economic activity. At the investment level, considerable gains can be achieved by efforts to conserve the already fragile resource base, as with water harvesting techniques that conserve even low amounts of rainfall. It is important to recognize that urbanization is an important, positive force in reducing the pressure on rural lands. A link that should be stressed is the relatively low population growth rates associated with urban areas (which are related perhaps to such factors as improved social security and the existence of educational and job opportunities for women). Care must be taken, however, to keep urban centers from becoming pockets of future poverty. Appropriate urban policy is

needed that promotes productivity, reduces poverty, and encourages environmental management.

## International Environmental Issues

### *World Markets and Natural Resource Degradation*

It is perfectly possible for a single nation to secure sustainable development—in the sense of not depleting its own stock of capital assets—at the cost of procuring unsustainable development in another country. An example might be when industrial economies import products from tropical forests in quantities that encourage deforestation in the exporting country without building up other forms of capital. The importing country effectively imports sustainability, while the exporting country exports it. The import and export of sustainability are partly an issue of international inequality. The traditional theory of comparative advantage, which says that countries export goods in which they have a comparative advantage and import goods in which they have a comparative disadvantage, must take into account the external effects and user costs of trading in natural resources.

How far this trade in sustainability is a matter of concern depends on (a) the balance between the trade and the resource endowments of the countries involved, (b) the extent to which revenues from exported resources are converted into other forms of capital, and (c) the extent to which the trade takes place at international prices that reflect the true social costs of resource depletion in the exporting country. Even when trade is in some sense responsible for environmental degradation, the appropriate policy may not be to restrict it. Trade accompanied by environmental policy is better than increased protection without appropriate environmental policies.

TERMS OF TRADE. Given the dependence of the developing countries in general on exports of natural resources or commodities based on natural resources, the prices at which those resources and commodities are traded is clearly of major significance. Changes in relative prices tend to change production and consumption patterns and, hence, may affect the environment. Changes in the terms of trade are an important example of changes in relative prices; by extension, therefore, changes in the terms of trade will probably affect the environment. Nevertheless, there is little empirical evidence linking changes in the terms of trade to changes in the quality or availability of natural resources in the developing world. Primarily this is because specific hypotheses are difficult to test.

The so-called Brundtland hypothesis about the link between the terms of trade and the environment is as follows. If the terms of trade decline, exporting countries must export more and more just to maintain foreign exchange earnings constant. In the specific case of crop exports, then, emphasis is placed on expanding acreage in order to increase exports. If the affected crops are environmentally hazardous—for example, groundnuts or maize—soils in land that is not marginal may be directly damaged. Damage to marginal soils would be even higher. Even if the crops are environmentally benign, efforts might be made to expand cultivation onto marginal lands by clearing shrub and forest land and adding to potential erosion through deforestation.

IVORY, CASSAVA, AND HAMBURGERS. The conservation community has been mainly, though not exclusively, concerned with imposing a total ban on the ivory trade, which would require the compliance of all importing and exporting countries. Are such bans economically justified? Economists have long doubted the viability of bans on trade; in practice bans rarely work, and there are compelling theoretical reasons for why they do not. The essence of the ivory trade is that some has been legal (sanctioned by the Convention on International Trade in Endangered Species [CITES]) and some has not. A ban affects the legal trade but leaves the illegal trade largely untouched. Some of the demand that was legal before the ban will even become illegal after it. Although overall demand will fall, the price of ivory may actually rise because the inflated illegal demand faces a smaller supply. Higher prices may induce smugglers to find more effective means of continuing their trade, notably the use of entrepôt countries outside the CITES system.

Because cassava tolerates widely varying conditions, but prefers poor soils, small farmers in Thailand grow it as a commercial crop on previously forested land. Some authorities cite cassava production as a significant cause of deforestation, soil erosion, and soil nutrient reduction in Thailand.

The reality is more complex. Cassava does not deplete the soil more than most other crops: it is usually planted ahead of the main rains and thus does not contribute to erosion from that source, but it does remove nutrients from the soil. When farming technology does not include artificial fertilizers, as is generally the case in northeast Thailand, cassava production depletes nutrients from the soil. Although cassava production was secured in Thailand by clearing forests, the reasons for doing so were complex. Building new roads for military purposes opened up the northeast uplands, and farmers began to grow cassava to meet the demand in the European Community. If they had not grown cassava, they would have grown another crop in an effort to escape considerable poverty. In short,

deforestation would have occurred anyway. Cassava production takes place on some 25 percent of deforested land; most deforestation is the result of logging, followed by clearance for other crops, livestock, and so forth.

Part of the mythology of the so-called hamburger connection is that U.S. imports are satisfied at the expense of per capita consumption of beef within Central America; however, domestic consumption accounted for some 80 percent of production in the 1980s, compared with 60–70 percent in the 1960s and 1970s. Indeed, per capita consumption within Central America is growing. The hamburger connection seems to be limited to a number of large ranches that supply the export trade. Legal Amazonia supplied the United States with only 0.007 percent of its consumption of beef in 1982. In addition, U.S. health regulations prohibit the importation of fresh, uncooked beef from that source.

EUROPEAN COMMUNITY BEEF AND RANGE DEGRADATION IN SOUTHERN AFRICA. The European Community (EC) imports a guaranteed quantity of beef from Botswana each year through the various rounds of the Lome Convention, which govern EC's relations with the developing world. It has similar agreements with other countries such as Kenya and Swaziland. High agricultural support prices in the EC mean that Botswana secures more revenue from this arrangement than if the beef were sold at world prices. About 85 percent of Botswana's beef production is exported, half to EC countries (mainly Germany, the Netherlands, and the United Kingdom), 33 percent to South Africa, and 13 percent to other African countries. Botswana beef is grass-fed and therefore leaner than the grain-fed beef typically consumed in the EC. This explains Botswana's ability to secure an export agreement with the EC, which otherwise produces a surplus of beef.

Botswana ranching has expanded considerably in recent years, frequently into relatively marginal savannah lands, where cattle compete with indigenous wildlife. The national herd probably doubled in size between 1964 and 1984; overgrazing is widespread, and range degradation is common. Much of the overgrazing is encouraged by fiscal incentives and subsidized services. Livestock owners receive various benefits from the government: animal health, extension, and research services; veterinary cordon fences; subsidies for slaughterhouses; and tax write-offs whereby agricultural investments and running losses can be offset against income from other sources. Having the EC as a guaranteed market simply adds to the list of existing domestic policy distortions that encourage increased stocking rates and more range degradation. That is, the price guaranteed for the EC acts as a further subsidy to livestock producers.

DOES FREE TRADE CAUSE ENVIRONMENTAL DEGRADATION? The gains from trade are not without costs, and the environment might suffer as the result of liberalized trade in several ways. First, free trade tends to increase economic activity, which tends to drag more materials and energy through the economic system (the materials balance principle). This is the growth effect of trade liberalization. Such an increase is likely but not necessary since it depends on what happens to the technical coefficients between economic activity and inputs. If energy inputs per unit of economic activity decline over time, as they have in industrial countries, expanding output need not increase energy consumption. Economic expansion is also likely to involve changes in land use that threaten natural environments. Sites that were once green will be converted to housing, factories, roads, and other developments. The EC Single Market, for example, has the potential to worsen environmental quality. As an example, the internal market is expected to increase transfrontier lorry traffic 30–50 percent.

Second, free trade may result in industrial and agricultural reorganization to capture the economies of scale made possible by larger markets. This might involve larger productive units: factories that are aesthetically unpleasing and farms that remove hedgerows and use intensive agricultural techniques. Third, free international trade neglects the environment in the same way that domestic free markets fail to account for environmental losses. In other words, trade liberalization can be expected to increase market failure. Fourth, freer trade removes subsidy systems since subsidies are barriers to free trade. This offsets the previous effects to some extent. Where subsidies take the form of price supports, overproduction tends to decrease, which may benefit the environment. The Common Agricultural Policy is a case in point, depending on how the use of land changes as the system of support is reduced over time.

Overall, then, trade liberalization is likely to produce negative environmental externalities, but also some environmental gains. The negative association between freer trade and environmental degradation does not imply that freer trade should be halted. It does suggest that the most cost-effective policies should be adopted to optimize the externality. Restricting trade is unlikely to be the most efficient way of controlling the problem, especially if trade retaliation may occur. The losses can best be minimized by firm domestic environmental policy designed to uncouple the environmental effects from the economic activity. This firm environmental policy may itself have international trade effects. The best way to correct externalities is to tackle them directly by implementing the principle of the polluter pays, not restricting the level of trade. Where having the polluter pay is itself not feasible (when, for example, the exporter is a poor developing country), adopting cooperative policies—such as transferring

clean technology or assisting with cleanup policies—will likely be preferable to adopting import restrictions.

Clearly, countries vary in the extent and speed with which they embrace environmental policy. The growing use of environmental standards, regulations, taxes; the perception or reality of subsidies—or failure to control—environmentally degrading activity; import restrictions based upon environmental standards: all these spell potential problems with the GATT, in that they many be thought of as interference with the principle of free trade. Since environment was not a major international issue in 1947 when the GATT was signed, its relevance for environment is subject to interpretation on a case by case basis. At the time of writing, controversy and ambiguity dominate the scene. International consensus on how environment should be treated under GATT rules is still far away.

USING ECONOMIC POLICY TO MANAGE THE ENVIRONMENT: STRUCTURAL ADJUSTMENT LENDING. Until fairly recently, environmental impact has rarely been considered in adjustment lending operation, but when it is, environmental policy is generally determined on a project by project basis. An investment in a particular area is checked for its environmental impact and may be modified to minimize environmental damage, or projects may be specifically designed to improve the environment. This approach is inadequate. First, projects often do not achieve their intended results since they depend on a mixture of good design, careful management, and continued management after teams from the donor agency cease to participate. Second, projects tend to be specific to a sector or a location; although they can affect the entire economy, that is not usually the case. Environmental degradation tends to be pervasive and therefore requires pervasive policies that reach throughout the economy. The most powerful tools for doing so are price controls and regulations. Projects exert an important influence but must be combined with macroeconomic policy reforms.

The idea that structural adjustment should focus more on environmental conservation is of recent origin and contrasts with the criticism that structural adjustment loans (SALs) are an instrument of environmental destruction. Because they shift economic activity within the borrowing country, SALs may, it is argued, cause environmental degradation. The evidence does not however support the view that SALs have been environmentally destructive. Adjustment policies often raise agricultural prices. The impact of increased farmgate prices is not always clear, but in the countries in question, the increase tended to be for perennial crops that provide a continuous root structure and canopy cover. Such crops assist soil stability on sloping land and include bananas, cocoa, coffee, palm oil,

rubber, and tea. Food crops not intended for export—for example, cassava, maize, millet, and sorghum—are often erosive. In general, SALs encourage environmentally benign crops more than erosive ones. Potentially damaging crops, such as cotton and tobacco, tend to be produced under sustainable conditions by commercially oriented organizations. SALs also lowered the price of some food crops that are environmentally damaging: maize, rice, and sorghum in Panama, and cotton, foodgrains, and tobacco in Turkey, for example. Although the motive for these price reductions was not environmental—their principal aim being to reduce public expenditure caused by high support prices—their effects were probably environmentally beneficial.

SALs often adjust agricultural export taxes. An export tax is equivalent to lowering farmgate prices since if the tax did not exist, farmers would receive higher prices. In Haiti, SALs attempted to remove export taxes on coffee and to reduce incentives to grow erosive grain crops on hillsides. In Malawi, by contrast, export taxes on tea increased under SALs. Although tea is a perennial beneficial for protecting the soil, in Malawi tea is cured using fuelwood obtained through deforestation. The increased taxes, designed to generate higher public revenues, probably benefitted the environment overall. However, many SALs have reduced export taxes on erosive crops such as maize, sorghum, and tobacco. The overall effects depend on the mix of policies. Increased foodgrain production need not be environmentally damaging if production methods are managed carefully. In other cases, incentives to produce foodgrains reduced price supports for crops, such as sugarcane, that are erosive.

When environmental policy is in place, SALs generally improve the environment. Put another way, SALs produce significant benefits. When the environmental consequences are negative, policymakers should not abandon structural adjustment but should encourage positive environmental policy. In sum, the effect of SALs on the environment is mixed. On balance, the environment has probably gained from SALs, although improving environmental conditions is not their aim. As such, there is a real risk that SALs will be designed in such a way that they inadvertently damage environmental quality. This risk can readily be reduced by ensuring that all SALs are monitored and evaluated for their environmental effects and that they are designed specifically to enhance environmental quality. It is clear, however, that SALs, even as they are designed at present, do not necessarily damage the environment.

Recognizing the necessary interaction between macroeconomic policy and environment is the first step toward achieving an environmentally sensitive economics in the developing world. Once this recognition has been achieved, there are no easy answers or prescriptions. In some cases,

the positive or negative environmental effects of policies are reasonably clear. In other cases, the analyst and policy advisor must expect the effects to be specific to the location, which means that generalizations are unlikely to be fruitful. In still others, economists simply do not understand the implications of policies. Finally, we know too little about the character and volume of physical effects.

### *Transfrontier Environmental Issues*

Waste emissions in one country can affect other countries. Known as transfrontier pollution, examples include acid rain, pollution of a sea or international lake, and pollution of a river that flows through several countries. In the same way, resource degradation in one country can affect well-being in another. Such transfrontier problems require at least bilateral negotiation and often multilateral cooperation.

A feature of international environmental problems is that degradation in any one country may affect the well-being of another. This transboundary effect sets the stage for resolving environmental problems through mutual cooperation. Without that cooperation, countries tend to use more of the resource in question than they do with it. The result is overuse. The main issue, then, is to devise an efficient system of incentives that will induce cooperation between the relevant parties. Clearly, international environmental problems require international environmental policy and incentives.

At the early stages of development, the perceived value of natural environments frequently appears to be low. Priority is given to industrialization and development programs, which often damage the environment. In contrast, environmental values in the richer, industrial countries appear to be high. Environmental concerns are often high on the political agenda of all political parties. The higher the level of real income per person, the more willing are individuals to act. This discrepancy between the perceived value that industrial and developing countries give to the environment raises the issue of transfers to finance action on international environmental issues.

An illustration can be made using the example of tropical deforestation. A poor deforesting country, $P$, may judge the benefits of deforesting, $B^{DP}$, to be greater than the costs it bears, $C^{DP}$. A richer country, $R$, secures little or no benefit from deforestation in $P$, but may well suffer costs in the form of effects on climate, concern over loss of biological diversity, and so on. The richer country then suffers costs, $C^{DR}$. If decisions regarding deforestation are made within $P$, deforestation will occur as long as

$B^{DP} > C^{DP}$.

But if global well-being is to be maximized—and the world is made up of countries $R$ and $P$—deforestation is not justified unless

$B^{DP} > (C^{DP} + C^{DR})$.

Not surprisingly, the poorer nations seeking the benefits of rapid industrialization may well resent the implication that they need to take into account the costs to wealthier countries of environmental degradation. This raises the issue of transfer payments for international environmental degradation.

The direction of the transfer, however, is not a straightforward issue. For example, country $P$ imposes an external cost on country $R$ by deforestation. Application of the principle of the polluter pays suggests that $P$ should pay $R$ for the damage caused. But since the forests belong to $P$, property rights are vested in $P$, which suggests that $R$ should pay $P$ not to deforest. This is an example of the principle of the victim pays and illustrates Coase's theorem, in which the loser compensates the gainer. This principle tends to apply when there is no supranational body to determine property rights: national sovereignties turn the issue into a bargaining context.

The application of both principles to unidirectional externalities is fairly clear. When the damage is reciprocal, or is a mix of reciprocal and unidirectional externality, the principles are more difficult to derive. Nevertheless, bargaining offers both countries opportunities to gain. The assumption that all parties, or at least the main or dominant parties, can gain by bargaining is at the heart of international environmental cooperation.

The international transfers necessary for mutual gain can be made in many ways:

- Lump sum payments can be transferred directly to compensate a country for not developing a resource.
- Compensatory resources can be transferred to a country that avoids degrading a resource by developing along some other, environmentally less destructive route. The transfer may take the form of technical assistance and loans that are specific to environmentally benign projects.
- Industrial countries can make transfers to developing countries that reduce some of their debt obligations in return for an agreement to reduce their environmental destruction and manage natural resources sustainably.

As yet, pure side payments—the transfer of resources without specifying how they might be used—have not occurred. Examples of the second and third types of international transfers are many. The most notable among

them are the international funds to assist environmentally benign development (the Global Environmental Facility) and debt for nature swaps.

## *Managing Global Resources*

THE GREENHOUSE EFFECT. The effects of global warming may be classified in the following terms: changes in average regional temperature and rainfall, average rise in sea level, and frequency and severity of weather events. The impact of climatic change on developing countries could be substantial. First, developing economies tend to be more dependent than industrial economies on natural resources, which themselves are sensitive to fairly moderate changes in climate: soil quality, woody biomass, and water for drinking and as a habitat for fish. Second, the agricultural systems of many developing countries are based on low-lying deltaic land fed by rich silt from river systems. These lands will be prone to flooding and the intrusion of saltwater. Third, many agricultural systems rely on natural rainfall rather than irrigation systems. Not only does the amount of rain matter, but so do the timing and distribution of rain across the growing season. Third, many small developing countries are island communities at special risk from severe weather events such as hurricanes and cyclones. Fourth, the very poverty of many developing countries will preclude them from undertaking the kinds of adaptive policies, such as sea defenses, that may be needed.

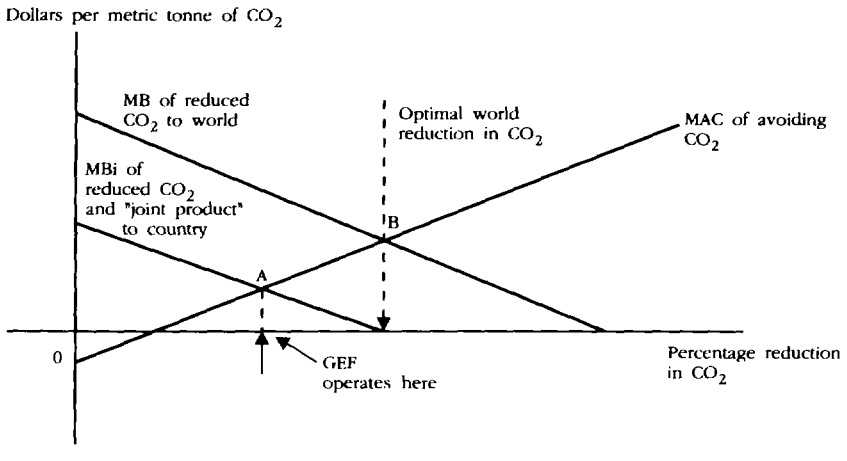
Inadequate though it is, the use of cost benefit analysis should be pursued vigorously as a check on the economic implications of global emission reduction targets. If the two approaches result in very different outcomes, attention should focus on why this is so. Moreover, existing negotiations focus on reducing emissions as the appropriate response to global warming. But it is very unlikely that formulating policies that only reduce emissions will be efficient. Adapting to global warming, through economic adjustment and defenses against rises in sea level, will surely play a part. The ecological limits approach tells us nothing about the optimal combination of prevention and adaptation. Cost-benefit analysis is expressly formulated for just such a purpose. What a more detailed analysis will show, however, remains open to question.

The major issue is how to achieve whatever target is eventually set for an acceptable level of global warming. An obvious point is that the targets must be internationally agreed, initially through a framework convention. This would produce a statement recognizing the problem and showing intent to take action. The task of setting quantified targets would be a matter for one or more protocols. The convention should target aggregate emissions of greenhouse gases rather than carbon dioxide alone. Individual

countries should be free to adjust their mix of emissions to meet the target because this would reduce the costs of complying with the target. For example, if it is cheaper—per radiative effect—to cut CFCs, that should be the first step taken. If energy conservation is cheapest, that should be pursued early on. Figure 3 illlustrates this with regard to the working of the Global Environment Facility. At the heart of the analysis is the concept of marginal abatement costs (MAC) and corresponding marginal benefits. Economic theory indicates that an efficient solution will be found where marginal benefits equal marginal costs.

Figure 3 provides a diagrammatic exposition of the situation facing a single country. The upward-sloping MC curve shows, in a stylized way, the marginal cost of each new method of avoiding carbon dioxide emissions. Some of them—those below the axis—have direct benefits that outweigh their costs. Examples might be the introduction of more efficient appliances or vehicles, the use of surplus energy in efficient appliances or vehicles, or the use of surplus energy in efficient industrial combined heat-and-power schemes. Some are inexpensive enough that the local benefits from reducing carbon dioxide and creating joint products exceed the costs. But once these initial projects have been exhausted, projects that make larger reductions possible have rising costs.

*Figure 3. Choosing the Optimal Abatement of Carbon Dioxide for an Individual Country*



The two downward-sloping curves show the marginal benefits of reducing carbon dioxide (and counterpart reductions in other joint products), first, to the country concerned and, second, to the world. Point A, where MB*i* equals MAC, is the optimal control level for the country, while point B, where MB equals MAC, is the optimal level for the world. GEF's role is to encourage movement from A to B. Policies that yield greater benefits for the individual country are often dubbed "no regrets," although this term is sometimes confusing. Here, no-regrets policies are those where MB*i* · MAC, although some commentators use the term to refer to policies where MAC < 0.

The idea of minimizing the costs of compliance is important. Negotiators should find the most cost-efficient way of achieving a given environmental target. This principle is easily confused with getting environmental quality on the cheap. The idea, however, is not to sacrifice environmental quality but to achieve a quality target at the lowest possible cost. This releases resources for other purposes, including other environmental purposes. The minimum cost principle is also important when considering the probable shape of environmental policy over the next two decades. It seems very likely that all nations will face a rising bill for securing environmental quality. This is very much a legacy of our failure to take action in the past two decades and a reminder that precaution is better than reaction. But if the bill is going to rise anyway, we must seek the most effective ways to minimize those increased costs. In this way, the cost burden to be borne by industrialists and consumers can be contained. This is not just a matter of wise husbandry; it is a matter of strategic importance to the environmentalist case. Inefficient expenditures will risk alienating industry and, for that matter, consumers. Keeping costs down will help minimize the risks of a polluter backlash.

There are only three routes to achieving internationally agreed global environmental targets:

- Command and control, whereby pollution standards are set and polluters are simply required to achieve that standard
- Pollution taxes, whereby the polluter is taxed according to the level of emissions produced
- Tradable permits, whereby polluters are given permits to pollute up to the standard and have the option of buying and selling permits in the marketplace.

What is the relevance of market-based instruments for global environmental issues? A protocol on greenhouse gases would set a target for reducing greenhouse gas. But it is just as inefficient to set the same target for each polluter as it is to do so for each country. There is a real danger

that a global warming protocol will make this mistake. It may seem fair for each country to achieve, say, the stable emissions target, but the fairness is illusory because the target is set regardless of differences in the costs of achieving it. The aim should be to bias the reductions toward countries that can most easily achieve them. The logic of this requirement is fairly simple: if one country has lower costs of abatement than another, it will be cheaper to require control in the country with low costs than in the one with high costs. A protocol that requires the same emissions reductions for every country offends this principle and hence incurs an unnecessary burden of aggregate cost. Equally, any burden-sharing arrangement must allow for the development needs of the developing nations.

It is conceivable that a protocol based on regulation could embrace the principle of minimum cost, but doing so would be complex and, as it happens, unnecessary because using taxes or issuing tradable permits would avoid the problem. Additionally, taxes and permits help solve the other dominant problem in international agreements, namely, how to devise incentives for cooperation.

Global warming affects different countries in different ways. A few may conceivably gain from a change in climate, but even if all lose, some will lose far more than others. Under these circumstances, it will be difficult to secure agreement on appropriate targets and on the allocation of emissions reduction targets among countries. More important, the avoidance or containment of global warming is an example of what economists call a public good. Reducing global warming will generally benefit all countries, and no country can be excluded from the benefit. Any one country could secure the benefit of a global agreement without sharing the cost. The United Kingdom, for example, could refuse to cooperate and wait for the rest of the world to solve the problem. The United Kingdom could avoid the costs, reap the benefits, and thus ride for free.

The potential existence of free riders means that any protocol must have built-in incentives to cooperate. In order to persuade the potential free riders, it is necessary to create incentives for them to cooperate. This involves transferring resources—funds, technical assistance, technology—to the countries not cooperating. The scale of these transfers could be large, and the world's leaders do not seem to understand the scale of the transfers that are likely to be required. In the ozone case, however, the transfers are relatively modest. Perhaps $1.8 billion–$2.0 billion are needed to help developing countries create substitutes for CFCs. Much larger sums will be needed to help them find substitutes for coal, enforce energy efficiency, and so forth. In short, the critical feature of a global warming protocol has to be incentives for cooperation, and that means resource transfers. The twin features of minimizing costs and transferring resources make the use of

market-based instruments attractive for implementing a global warming protocol. Both the tax and tradable permits solutions need to be considered.

OZONE. The benefits of safeguarding the ozone layer appear to be better defined and more tangible, in relation to the costs involved, than those of mitigating the greenhouse effect. Benefits from reduced global warming may appear dubious, and the costs large, given scientific and forecasting uncertainties. This could make securing international cooperation on the greenhouse issue difficult. Another main difference is that CFCs are produced by only a few firms, making monitoring relatively easy. The sources of carbon dioxide, on the other hand, are many, making enforcement more difficult.

Moreover, the Montreal Protocol is a game played by few nations. A global warming agreement, however, must account for not just existing polluters, comprising relatively few countries, but also rapidly growing polluters. In other words, there have to be many players in a global warming game.

THE INTERNATIONAL TAX SOLUTION. In discussing an international tax solution, we focus on carbon dioxide, although a protocol allowing individual greenhouse gases to be traded off in ratios determined by their radiative properties would be more efficient. A tax administered internationally and collected by some central agency is too bureaucratic and would interfere with domestic sovereignty. A tax implemented by each government would run foul of the free rider problem since governments could easily offset a carbon tax by reducing other fuel taxes. The solution therefore has to be one in which a central agency taxes each country according to emissions levels. The same tax level would be set for each country. Tax revenues would then be reimbursed, that is, handed back to countries according to some formula of allocation. Each individual country would then act to minimize the sum of its tax payments and abatement costs. It prefers to pay the tax if the cost of abatement is higher than the tax, and it prefers to abate if doing so is cheaper than paying the tax. We would expect some combination of both actions. The size of the tax would be determined by the agreed reduction in carbon dioxide emissions. Some countries will then be net payers of tax to the central agency, and some will be net recipients of tax revenues, depending on the reimbursement rule chosen. The net payers of tax will still be better off under the agreement than they were without it for they will have secured the benefits of avoiding some damage from global warming. Indeed, for the agreement to be successful, each country must be better off with the agreement, taking into account net tax payments, abatement costs, and environmental benefits.

The rationale for reimbursing tax revenues arises from the need to transfer resources, as we have already demonstrated. Reimbursements should therefore relate to the costs of controlling carbon dioxide emissions and the damage likely to be caused by global warming. As the cost of control increases, so does the amount of reimbursement required. Coal-based economies such as China or India, for example, will tend to require large reimbursements. Countries that can switch easily from coal to gas-fired electricity will have low reimbursements. The United Kingdom might be such a country, although it has an incentive to focus a protocol on all greenhouse gases in order to minimize the extent to which adjustments will have to be made to carbon fuels and hence to its coal industry.

Countries that stand to lose most from warming, such as deltaic or island countries, are likely to cooperate because they will want the protocol to succeed. They will tend to require lower reimbursements from the tax revenues.

The problem of determining costs and benefits for each country arises with reimbursement. This may well be impossible to do to any meaningful degree of accuracy. Apart from the difficulty of determining costs, tax receipts may or may not be sufficient for this purpose, depending on the level of the tax, the abatement costs of the countries cooperating, and the number of countries not cooperating. In addition, such a solution would not solve the problem of countries enjoying the benefits without paying the costs.

INTERNATIONALLY TRADABLE PERMITS. The last option for implementing a protocol is through tradable permits. In essence, the permit solution gives countries an incentive to trade permits with each other and make net gains in the process without compromising the overall emissions target. As with pollution taxes, countries have an incentive to trade their permits until the marginal costs of abatement are just equal to the price of the permits in the marketplace. If costs exceed price, the countries will try to buy further permits. If abatement costs are lower than the price of permits, they will sell the permits, collect the revenue from their sale, and use some of the proceeds to abate emissions. This is entirely analogous to trading emissions credits between companies in the United States, although here the trading partners are countries. A number of other trading systems exist, as with fisheries quotas in New Zealand and Iceland and milk quotas in the United Kingdom.

Several problems accompany the trade in permits. Some countries emit large amounts of carbon dioxide, notably the United States, the Soviet Union, and members of the European Community. This may adversely affect the efficiency of the tradable permit approach because the sales and

purchases made by big countries will influence the price of permits on the open market. In addition, while the tax solution penalizes countries that emit too much, the permits system penalizes countries that exceed the level permitted. This is particularly relevant to global warming since it is not clear what sanctions can be applied if countries persistently exceed their permitted emissions.

An overriding problem is how to allocate permits in the first place. This is akin to the problem of how to allocate tax reimbursements among countries. The grandfathering of permits, which allocates permits initially according to the existing level of emissions, favors the industrial countries and does little or nothing to create incentives for the developing world to cooperate. At the same time, any allocation other than grandfathering is likely to be resisted strongly by the major emitting nations.

Some authors favor a system that bases the initial allocation on GNP, but this again favors the industrial countries, as does using GNP per capita. Per capita allocations have found most favor, and an initial allocation based on such a rule would provide developing countries with a large quantity of permits that could then be sold to industrializing and industrial countries at a profit over the cost of abating greenhouse gas emissions suggests avoiding giving countries an implicit reward for overpopulation by counting adult populations only. Another suggestion is to allocate all permits to countries that do not pollute, that is, the world's poor, and allow trade thereafter. To keep rich countries from hoarding them, permits could be subject to renewal, that is, they could be leased rather than owned. Countries with a capacity to create carbon sinks, such as new forests, could secure credits under the system; they could be allowed to emit beyond the level of their permits provided the carbon sinks offset the excess.

The reality of the international political economy is likely to work against any system that allocates permits based on population. Such a system would require assurance at the outset that international trade in permits would take place, otherwise the burden of adjustment would fall heavily and rapidly on the countries with high emissions per capita, such as the United States. In those circumstances, such countries are unlikely to agree at the outset. Grandfathering of some kind is likely to be the only initial allocation acceptable to the existing polluters. The sheer newness of tradable permits on the international scene may, in any event, militate against them. If so, one essential message for international negotiators is that the system of permits should mimic as far as possible the efficiency of market-based approaches. To this end, allocated emissions reductions must bear some resemblance to the pattern that would emerge if they were allocated according to the costs of abatement. Even that requirement is formidable for international negotiation.

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The World Bank

IF WORLD POVERTY is to be reduced, businesses and governments must continue to pursue economic growth. But growth cannot continue without attention to the environment. The book summarized here, *World Without End*, by David W. Pearce and Jeremy J. Warford, explores how growth can become environmentally sustainable.

It shows that a balance between economic growth and care of the environment is needed in all nations—especially poor ones—to prevent environmental degradation, which results in lost economic output and endangers people's health. For example, erosion of soil depletes resources for fuel and fodder and causes food output to decline.

In the full-length book, the authors address a wide variety of subjects, ranging from how to measure sustainable development, to the relation between population and environment, to market paradigms and pollution, to terms of trade and the environment. They use a great deal of material, such as background papers and research conducted for the World Bank, that has not been readily available to the public. And they present a more complete synthesis of the literature relevant for policymaking than has been given elsewhere.

The book is comprehensive and is the outcome of several years of research, fieldwork, and policy advice concerned with the rapidly growing field of environmental economics in developing countries. Policymakers, economists, and students alike will find it of great value.

DAVID W. PEARCE is professor of environmental economics and director of the Centre for Social and Economic Research on the Global Environment, University College, London, and was a consultant to the World Bank for the writing of the book. At the time of writing the book, JEREMY J. WARFORD was senior adviser, Environmental Department, the World Bank.

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