CHAPTER 2

Managing a Broader Portfolio of Assets

What we are doing to the forests of the world is but a mirror reflection of what we are doing to ourselves and to one another.

—Mahatma Gandhi

Sustainable development is about enhancing human well-being through time. What constitutes a good life is highly subjective, and the relative importance accorded to different aspects of well-being varies for individuals, societies, and generations.[1] But on some elements most people could probably agree. Having the ability and opportunity to shape one's life—which increase with better health, education, and material comfort—is certainly one of them. Having a sense of self-worth is another, enhanced by family and social relationships, inclusiveness, and participation in society. So is enjoying physical security and basic civil and political liberties. And so is appreciating the natural environment—breathing fresh air, drinking clean water, living among an abundance of plant and animal varieties, and not irrevocably undermining the natural processes that produce and renew these features. Indeed, peoples' self-reported happiness and satisfaction with life are closely associated with all of these factors.[2]

Society's ability to enhance human well-being through time depends on choices made by individuals, firms, communities, and governments on how to use and transform their assets. They might cut down forests to build dams and other physical infrastructure or to make way for commercial agriculture or urban expansion. They might clear mangroves to build shrimp farms. Or they may conserve forests and mangroves to maintain important natural processes or to support tourism. Enhancing human well-being on a sustained basis requires that society manage a portfolio of assets. Different assets have different characteristics that limit the extent to which they can substitute for one another in production and in human well-being.

This chapter discusses the broad concerns that need to be taken into account when balancing the objectives of economic growth and attending to environmental considerations and their social underpinnings in the short to medium term—recognizing that over the longer term prolonged neglect of environmental and social assets is likely to jeopardize the durability of economic growth. More specifically, it addresses the following questions:

- What is meant by sustainable development and how can progress toward it be measured? Although the adjusted net savings indicator is a potentially useful headline indicator at the aggregate level, indicators are most useful when they can be disaggregated and used to diagnose and ultimately address specific problems.
- Why the need to manage a broader portfolio of assets? What choices can and must be made between creating, maintaining, and restoring different assets as part of a long-term, dynamic view of sustainability? Although assets are complementary and substitutable to a certain degree, they all need to be managed, since once the quality or level of an asset falls below a threshold, there can be little further substitution without jeopardizing the productivity of other assets, as well as overall production.
- What are alternative development paths to those followed by developed countries? What tradeoffs and priorities are justified, and when? By taking

advantage of technological innovations and by learning from past mistakes of others, countries today have the option to manage their portfolio of assets in a different way to ensure they are on a more sustainable development path in the long term.

- How to address the almost endemic overuse or underprovision of environmental and social assets while sustaining growth? Wherever spillovers (externalities) exist, there is a coordination problem that needs to be dealt with by correcting market and policy failures. This can be done by using a variety of mechanisms such as command-and-control regulations, harnessing market forces, and improving supporting institutions.

Sustainability—an evolving framework

What is meant by sustainability?

For any given technology, preference structure, and known resource base there are some utilization rates that cannot be sustained. Drawing attention to these unsustainable rates is critical to informing decision-makers and changing course toward sustainability. This will often require altering the pattern of preferences, the resource intensity of technologies, or the relevant time horizon for different decisions. Since none of these is constant or stable over time, defining sustainability in a broader sense is not easy—but there have been many attempts. The most commonly used definition is the one provided by the World Commission on Environment and Development (Brundtland Commission 1987): "progress that meets the needs of the present without compromising the ability of future generations to meet their own needs."

While the Brundtland definition highlights the need to balance the interests of current and future generations, it does not define the concept of *needs* or its implications. For instance, does the Brundtland definition imply that well-being (utility) should not fall below some minimum for any subsequent generation? Does it imply that each generation should enjoy a constant level of well-being? Alternatively, should well-being be nondeclining for each future generation? Most later definitions have retained the core ethic of intergenerational equity, emphasizing the current generation's moral obligation to ensure that future generations enjoy at least as good a quality of life as the current generation has now (Pezzey 1989).

Recent definitions have focused more explicitly on the three pillars of sustainability: economic, environmental, and social. These highlight the need to consider not only the environmental, or even the environmental and economic aspects, but also the social aspects of sustainability. The thinking about social sustainability is not yet as advanced as for the other two pillars. Societies do, and will continue to, transform over time. But it seems clear that significant social stress—and, at the extreme, social conflict—is likely to lead to a breakdown in the accumulation or preservation of all assets, thereby jeopardizing intergenerational well-being.

One concrete approach to thinking about sustainability and intergenerational well-being is to ensure that the flow of consumption does not decline over time. But what is needed for this? The academic literature shows that a country's ability to sustain a flow of consumption (and utility) depends on the change in its stock of assets or wealth. Intergenerational well-being will rise only if wealth (measured in shadow prices and excluding capital gains) increases over time—that is, only if a country's adjusted net savings are positive.[3,4] (See the section titled "Measuring sustainability.")

Not a steady-state concept

Does the composition of the asset base matter? In principle, this depends on the potential for substitutability among assets (see the section titled "The importance of a range of assets"). In the environmental economics literature (Pearce and others 1989) a distinction is made between weak constraints on growth, known as "weak sustainability" (which presumes that assets are fully substitutable) and strong constraints on growth, known as "strong sustainability" (which holds that assets are not fully substitutable because some natural assets, or more precisely some of the functions performed by these assets—such as global life support—cannot be replaced by others). Limits-to-growth type arguments focus on strong sustainability, while arguments in favor of indefinite growth focus on weak sustainability. So far the former arguments have not been very convincing because the substitutability among assets has been high for most inputs used in production at a small scale. There is now, however, a growing recognition that different thresholds apply at different scales—local to global. Technology can be expected to continue to increase

Box 2.1
Not yet able to fully duplicate natural processes

Biosphere 2—a sealed glass ecosystem that was built in Oracle, Arizona, at a cost of some $200 million in 1991—attempted to create a completely self-contained, human-made system to support eight people for two years. It could not.

There is still debate on how to conduct such an experiment. The idea was that there would be no exchange with the outside world except for the energy supplied to run appliances. The people inside the biosphere would grow all their own food. And the system would operate with a fixed volume of air and water, recycled and reused as they are on Earth, the original biosphere.

A year and a half after the sphere was sealed, the oxygen content of the atmosphere had fallen from 21 percent to 14 percent, a level normally found at 17,500 feet and barely sufficient to keep people in the biosphere functioning. Carbon dioxide (CO_2) and nitrous oxide levels surged. All pollinators became extinct, so agricultural production could not be sustained. Worse still, the drop in oxygen and rise in CO_2 meant that the biosphere's systems could not replicate the carbon cycle, the most essential cycle for life.

Source: Heal (2000).

the potential substitutability among assets over time, but for many essential environmental services—especially global life support systems—there are no known alternatives now, and potential technological solutions cannot be taken for granted (box 2.1).

The limits to substitutability among assets are likely to be greater for those assets that enter consumption untransformed (for example, natural forest scenery versus natural desert scenery) rather than as a produced output using the same materials (for example, a wooden window shutter or a glass pane). Ensuring that the well-being of future generations does not decline requires maintaining sufficient levels of some assets for the future, particularly when the drawdown or degradation entails irreversible losses and there is a possibility that these assets matter directly for the well-being of future generations. Of course, the mix of assets that supports improvements in human well-being is likely to change over time, as people's preferences and technologies change. So the concept of sustainability will itself evolve over time.

Proceeding with caution

What is more important for sustainability is how to manage risks by retaining options. There is considerable uncertainty about the consequences of human actions on complex ecosystems: small changes can sometimes accumulate and translate into losses of whole ecosystems (see box 2.5). There is also uncertainty about what technological innovations will be available and when. Where the costs of human actions today are uncertain, with potential for large and irreversible damage, there is a need for proceeding with greater caution in maintaining environmental and social assets.

Measuring sustainability

There are many important things that are not measurable, but in general, people value what they measure. One of the biggest challenges is how to measure all our assets and our progress toward sustainable development. Since the Brundtland Commission, there have been many efforts to develop indicators of sustainability. Much of the progress in developing indicators for measuring sustainability has been in the economic and environmental sphere (box 2.2). Social indexes, such as transparency, trust, and conflict are still at early stages of development. The fact that social indicators are less developed reflects the ongoing debate about the concept of social sustainability: what it means and what should be measured.

Green accounting

Early efforts to link economic and environmental accounting focused on the measurement of "a green GDP," motivated by the genuine concern that the traditional measure of gross domestic product (GDP) provides only a partial picture of changes in welfare—capturing mainly, if not exclusively, elements transacted in markets (only a few imputed services, such as owner-occupied housing, are included). Many environmental assets—especially those that function as "sinks" receiving pollution and waste, and those supporting life—do not operate in markets and are therefore excluded.

These early environmental accounting efforts tried to modify national accounts to include environmental damages, environmental services, and changes in stocks of natural capital. But that proved problematic mainly because of valuation difficulties and some conceptual issues. For example, should expenditure for environmental protection be treated as intermediate or final consumption?

Later efforts have been directed toward constructing "satellite accounts" that try to link environmental

Box 2.2
Indicators for measuring sustainability—a subset

Some of the main approaches to developing indicators of environmental sustainability are the following:

- **Extended national accounts**

  Green Accounts System of Environmental and Economic Accounts. United Nations. A framework for environmental accounting.

  Adjusted Net Savings. World Bank. Change in total wealth, accounting for resource depletion and environmental damage.

  Genuine Progress Indicator, Redefining Progress, and Index of Sustainable Economic Welfare. United Kingdom and other countries. An adjusted GDP figure, reflecting welfare losses from environmental and social factors.

- **Biophysical accounts**

  Ecological Footprint, Redefining Progress. World Wildlife Fund and others. A measure of the productive land and sea area required to produce food and fiber, and in renewable form, the energy consumed by different lifestyles within and among countries.

- **Equally weighted indexes***

  Living Planet Index. World Wildlife Fund. An assessment of the populations of animal species in forests, fresh water, and marine environments.

  Environmental Sustainability Index. World Economic Forum. An aggregate index spanning 22 major factors that contribute to environmental sustainability.

- **Unequally weighted indexes***

  Environmental Pressure Indexes. Netherlands, EU. A set of aggregate indexes for specific environmental pressures such as acidification or emissions of greenhouse gases.

  Well-being of Nations. Prescott-Allen. A set of indexes that capture elements of human well-being and ecosystem well-being and combines them to construct barometers of sustainability.

- **Eco-efficiency**

  Resource Flows. World Resources Institute. Total material flows underpinning economic processes.

- **Indicator sets**

  U.N. Commission for Sustainable Development and many countries.

* Equally weighted indexes are those whose components are equally weighted and then aggregated, while unequally weighted indexes give some components greater weight than others.
Source: Authors.

datasets with (unmodified) national accounts information. In principle, environmental costs and benefits, natural resource assets, and environmental protection are all presented in flow accounts and balance sheets. But in practice, given the difficulty in valuation, the emphasis has often been on using information on physical quantities from environmental accounts. The drawback of this approach is the difficulty in making comparisons across accounts in different units to evaluate priorities or tradeoffs.

Adjusted net savings

The focus of more recent efforts to link economic and environmental concerns has been on determining changes in wealth (adjusted net savings) as an indicator of sustainability. Change in wealth, appropriately defined to include a comprehensive and complete set of assets, is a good measure of prospects for well-being as it indicates a country's ability to sustain a consumption stream—which is what matters for sustainability—not just the consumption flow at a particular time as measured in GDP or green equivalent. In principle, only if wealth (measured in shadow prices and excluding capital gains) increases over time—that is, only if adjusted net savings is positive—will intergenerational well-being rise.

Ideally, measures of adjusted net savings would take into account human capital, natural assets, knowledge, and social assets.[5] But measurement difficulties and the lack of available data preclude this. Estimates of net savings currently account for some key elements of environmental stocks—energy depletion, mineral depletion, net forest depletion, and CO_2 emissions.[6] They also include education spending, as a proxy for human asset accumulation, but they do not yet include changes in the stock of (codified) knowledge or social assets (see table 2.1).[7] It is clear that adjusted net savings is an improvement over traditional savings measures; however, efforts to refine it further will need to continue.

In practice, also, additional adjustments may need to be made to deal with specific issues. First, when a country's population is growing, it is on a sustainable path on a per capita basis only if the percentage change in wealth (adjusted net savings as a share of total wealth) exceeds the population growth rate.[8] If the change in wealth is lower than the population growth rate, the country is "de-capitalizing" or run-

Table 2.1
Toward adjusted net savings, 1999 (percentage of GDP)

Income and region	Gross domestic savings – (	Consumption of fixed capital	Energy depletion	Mineral depletion	Net forest depletion	Carbon dioxide damage) + (	Education expenditure) =	Adjusted net savings
By income								
Low income	20.3	8.3	3.8	0.3	1.5	1.4	2.9	7.8
Middle income	26.1	9.6	4.2	0.3	0.1	1.1	3.5	14.3
Low and middle income	25.2	9.4	4.1	0.3	0.4	1.2	3.4	13.3
High income	22.7	13.1	0.5	0.0	0.0	0.3	4.8	13.5
By region								
East Asia and Pacific	36.1	9.0	1.3	0.2	0.4	1.7	1.7	25.2
Europe and Central Asia	24.6	9.1	6.0	0.0	0.0	1.7	4.1	11.9
Latin America and the Caribbean	19.2	10.0	2.8	0.4	0.0	0.4	4.1	9.6
Middle East and North Africa	24.2	9.3	19.7[a]	0.1	0.0	1.1	4.7	–1.3
South Asia	18.3	8.8	1.0	0.2	1.8	1.3	3.1	8.3
Sub-Saharan Africa	15.3	9.3	4.2	0.6	1.1	0.9	4.7	3.9

Note: Adjusted net savings are equal to net domestic savings (calculated as the difference between gross domestic savings and consumption of fixed capital), plus education expenditure, minus energy depletion, mineral depletion, net forest depletion, and carbon dioxide damage.
[a] Note that the energy depletion figure in the table is stated in terms of GDP. This translates to an annual depletion rate of about 1 percent of proven reserves.
Source: World Bank (2001h); for details on the methodology, see Hamilton (2000).

ning down its assets on a per capita basis. This would imply that it is on an unsustainable path to an eventual decline in welfare per capita. Second, if production processes are subject to thresholds (nonconstant returns to scale), then again an adjustment to net savings needs to be made, if measured net savings are to correctly indicate sustainability.

The adjusted net savings measure is a useful "headline" indicator for the economy. Like all national accounts or monetary-based indicators, it employs an integrating framework that permits weighting and aggregating disparate elements of the economy and the environment. In principle an aggregate indicator such as adjusted net savings allows for comparisons across groups of countries—by region or by income. Figure 2.1 presents a comparison by GDP per capita, and shows that adjusted net savings are negative in some countries—that is, they are de-capitalizing.

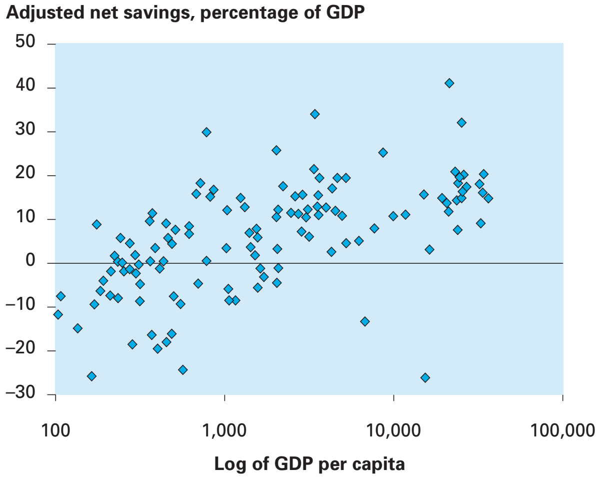
A system of indicators

As just mentioned, the adjusted net savings indicator is a potentially useful headline indicator at the aggregate level. But unlike GDP—which is affected by economywide prices, such as exchange rates and interest rates, and which can be influenced by economywide policies—there are no policy-relevant aggregate indexes on the state of the environment. For policy purposes, these indexes need to be disaggregated (as in table 2.1) and complemented by such biophysical measures as pressure-response indicators. Not only can the latter be disaggregated to a much greater extent, but they also have the added advantage that they can be used to identify the source of the problem.

While recognizing the need for an aggregate index as a headline indicator, it is important to note that indicators are most useful when they address specific problems. To catalyze change, information and signals have to be picked up by specific groups or institutions that can use them to diagnose specific problems, rally support for change, balance interests, and take action.[9]

A good example of this process is *Silent Spring*, the book Rachel Carson wrote in 1962 to alert the public that birds were disappearing or being silenced. She pointed to indicators that no government agency would have considered important in advance—DDT levels in falcons and the fragility of

Figure 2.1
Adjusted net savings rates by per capita GDP level, 1999



Source: World Bank (2001h).

their eggs. This gave birdwatchers in America a new role and put environmental protection agencies on a track to monitor toxins in nature, industry, and elsewhere that might affect human well-being as well.

Policy-relevant indicators emerge and are continually validated and refined in an environment where there is a free flow of information and interaction. To avoid major regrets, there is a need for more credible information and networks that link experts, civil society, and decisionmakers.

The importance of a range of assets

Action to improve asset management need not await resolution of debates on how to define and measure sustainability, but does require a clear understanding of what assets matter and why. The capacity of any society to meet the "requirements" of individual well-being depends on the level and quality of a range of assets—and on how society deploys them. Broadly, these assets consist of the following:[10]

- Human assets—the innate skills, talents, competencies, and abilities of individuals, as well as the effects of education and health.
- Natural assets—both renewable and nonrenewable. These assets have source functions that enter as inputs into production and utility—forests, fisheries, mineral ores, and natural forces (such as air and water currents). They also have sink functions to accommodate the unusable outputs of production and consumption—air, water, and soil receiving pollution and waste generated by human activities.[11] More fundamentally, nature performs critical life-support services on which the well-being of all life depends. So far—despite all the technological advances—no way has been found to fully replace these services through human-made alternatives (box 2.1).
- Human-made assets—created physical products, particularly those used in production, such as machinery, equipment, buildings, and physical networks, as well as financial assets.
- Knowledge assets—"codified knowledge," which is easily transferable across space and time (unlike "tacit" knowledge, which entails an individual's experience and learned judgment and thus cannot be easily transferred until codified).
- Social (or relational) assets—interpersonal trust[12] and networks,[13] plus the understanding and shared values that these give rise to—which facilitate cooperation within or among groups.[14]

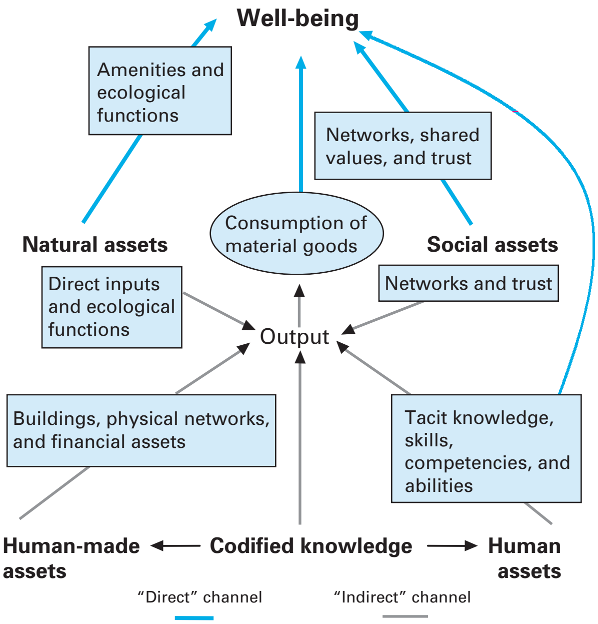
The importance of managing human, physical, and financial assets is well known, but how they interact with other assets is less well developed. Social, and environmental assets enhance human well-being *directly* through their very existence (e.g., the ability to trust another person or enjoy a natural setting).[15] They also enhance human well-being *indirectly* through their contribution to production and material well-being (figure 2.2). A tropical forest provides cut lumber as an input into the production of furniture and houses. A standing forest's environmental services—such as flood control and storm protection—can also improve the production of crops. And a forest's complex ecological functions support life for many species—that are important for the functioning and survival of the forest, which provides humans with material and aesthetic pleasures.

Why the need to manage a broader portfolio of assets?

The complementarity of assets

In improving human well-being, assets generally complement each other. For instance, human assets together with social assets can enhance a person's "freedom to be and to do." Assets can also be complements in the production process—that is, the productivity of one type of asset usually rises with

Figure 2.2
How society's assets enhance human well-being



Source: Authors.

additional amounts of other assets.[16] For instance, there is now a growing body of literature that highlights the role of social capital (interpersonal networks, shared values, and trust)—an asset that has arguably received little attention in the economics literature so far—in the accumulation, preservation, and productivity of other assets—human-made, environmental, and human:[17,18]

- Social capital can improve the management and productivity of environmental assets. For example, the combined effect of attitudes about participation—and the actual participation in a collective enterprise, along with human capital (literacy)—has significantly improved the management of watersheds in Rajasthan, India.[19] Watershed management has, in turn, been crucial in raising incomes. Trust between technicians (agricultural extension agents) and farmers can generate increases in agricultural production. And the degree and nature of trust between the contact groups and the other members of the community can determine the effectiveness of the groups as catalysts for community development.[20]
- Social capital can enhance human capital accumulation: higher levels of trust have been associated with higher enrollment in secondary education.[21]
- Social capital can improve the productivity of physical capital. For example, interfirm social contact in the form of interpersonal networks in the clothing industry has a positive impact on learning.[22] Similarly, interfirm social interactions, as well as customer network ties, have significant effects through their impact on knowledge acquisition and on new product development in a range of high-tech industries, including pharmaceuticals, medical devices, and electronic instrumentation.[23,24] There is also a clear link between interfirm trust and firm performance (through conflict avoidance and lower negotiation costs).[25]

This complementarity generally applies to other assets as well. Cleaner air and water, for instance, improve human health and the productivity of human capital.[26] And the synergies from the complementarity of two or more assets raises overall productivity. But social and environmental assets are underprovided or overused.

Assets and diminishing returns

Most assets are also subject to diminishing marginal returns. The benefits to well-being or to productivity of an additional unit of an asset declines as the level or quality of the asset rises (all other assets kept constant). Why? As J.B. Clark said, "Put one man only in a square mile of prairie, and he will get a rich return. Two laborers on the same ground will get less per man; and if you enlarge the force to ten, the last man will perhaps get wages only."[27] As more people are added, the returns continue to drop, until someone is unable to cover his or her cost.

Only if there are very strong positive spillovers associated with an asset is the tendency of diminishing marginal returns offset. That is true for knowledge, particularly codified knowledge. Because new knowledge complements existing knowledge (there is no crowding out, as with the laborers), it is more valuable the more society already knows. Similarly, it is true for networks, such as telephones, where the advantages of owning a telephone increase with each new member in the network.

Limits to substitutability among assets

Because assets generally complement each other and because the returns to a particular asset diminish, the rate at which one asset can be substituted for another in production (while maintaining a given unit of output) tends to diminish as well. As the level of one asset declines relative to another, the rate at which it can be further replaced falls. Moreover, when the quality or level of an asset falls below a threshold, there can be little further substitution without jeopardizing the productivity of the other assets, as well as overall production.

When environmental or natural assets are fairly abundant relative to human-made assets, substitution of the former by the latter can be expected to lead to higher returns. But there are limits to a long-term strategy that focuses primarily on replacing natural assets by human-made assets. Severely degraded farmland or fisheries will yield little wheat or fish, no matter how many plows or boats are used.

Development strategy to date has often relied on drawing down environmental resources and replacing them with human-made assets. This was the strategy followed by today's industrial countries.[28] Most developing countries' growth strategies continue to focus largely on the accumulation of human-made assets (physical capital). Indeed, a review of 60 countries in the late 1980s and 1990s shows that the growth of 16 countries considered to be serious policy reformers was accompanied primarily by physical capital accumulation. The increase in per capita GDP growth of this group of countries—rising from 2.8 percent in the late 1980s to 3.5 percent in the 1990s—entailed an increase in the rate of physical capital accumulation from 2.1 percent to 3.5 percent. In contrast, spending on education—a proxy for human capital accumulation—rose only slightly, from 3.2 percent of GDP in the late 1980s to 3.5 percent of GDP in the 1990s. And the rate of deforestation—a proxy for the depletion of natural assets—rose from 0.7 percent to 1.1 percent.[29]

The limits to focusing on physical capital alone are borne out empirically. An econometric study of 70 developing countries found that countries with low physical capital–labor ratios tend to experience a rise in their growth rates with increases in the stock of physical capital. But after countries reach a certain capital intensity, the contributions of further physical capital accumulation to growth—for any given human and natural capital—decline.[30] A separate study of 20 middle-income countries also found the marginal productivity of physical capital to diminish.[31] So although there may be economies of scale and technological spillovers for physical capital,[32] these do not seem to be large enough to continually offset diminishing marginal productivity.

The consequences of ignoring the complementarity of environmental assets and breaching thresholds

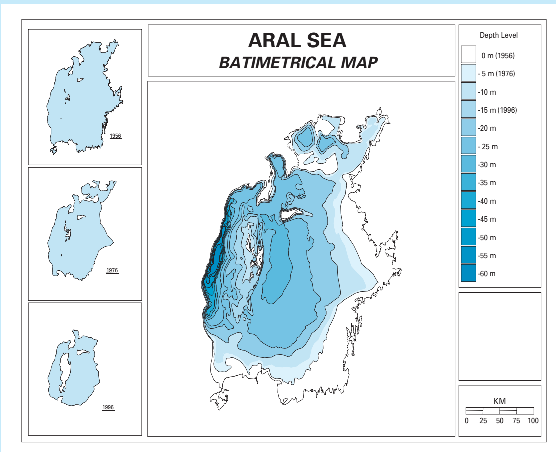
As an illustration of what can happen when the complementary role of environmental assets is ignored and certain thresholds are breached, consider the Yangtze Valley in 1998. Although China has always been susceptible to flood and drought, the 1998 floods were some of the most severe in its history. Rainfall from June to August that year was 38 percent above normal, but later analysis found that these unusually high levels could only partly explain the floods. The rest was perceived to be due to logging of the river's watershed, which eroded the soil. Deforestation had been so great (forest cover had decreased by more than half since the 1950s) that the watershed could no longer stabilize the water flow.[33] The resulting floods had very high costs in human lives—tens of thousands dead—and in lost production in the area.

Similarly, the degradation of the Aral Sea highlights what can go wrong when there is inadequate recognition of the role of environmental assets in the production process—and of the costs for human welfare (box 2.3). Expansion of irrigation schemes in the Aral Sea basin has generated billions of U.S. dollars in benefits and millions of jobs. But the overall costs of these schemes have been high, both in failing to generate the expected high levels of sustainable production over time and in causing serious health effects in areas immediately surrounding the sea. Today, avoiding further declines in the sea level is possible only if appropriate operational adjustments are made to the existing irrigation systems to improve their efficiency.

Some countries' experience with shrimp farming illustrates the costs of ignoring environmental services. Over the past two decades new technologies and production systems have enabled a dramatic increase in the intensity of shrimp farm operations—the production of farmed shrimp has grown at 20–30 percent a year.[34] Compared with traditional systems, however, the more intensive systems require large amounts of feed to support the shrimp and large amounts of water to flush out the wastes.[35] Because of the high concentration of farm units in areas of limited water supplies and inadequate flushing, the effluents in many cases exceeded the capacity of the receiving waters (sink), leading to pollution inside the ponds as well, which adversely affected production since these farms require a lot of water as an

Box 2.3
The Aral Sea—the cost of ignoring the role of an environmental asset

The Aral Sea watershed now spans the national borders of six countries. Over the past 40 years the excessive water diversion for irrigation along the Amu Darya and Syr Darya Rivers—the two main tributaries of the Aral Sea—caused the volume of the sea to fall by 85 percent, and the sea level by 18 meters, exposing more than 40,000 square kilometers of saline seabed and heavily salinating the remaining water (box figure). Today the Aral is divided into a smaller, less saline sea in the north and a larger, saline sea in the south.



Loss of fisheries

Although Soviet planners realized that greater irrigation would lower the sea's water level, it was thought that the increment in agricultural output of the whole basin would yield significantly higher benefits than any damage caused. Not recognized, however, was that the excessive water withdrawal would make the remaining sea water so much saltier that it would become unfit for higher forms of aquatic life. The once fairly substantial fishing industry has now almost completely disappeared.

A drop in agricultural output

At the same time the combination of excessive irrigation and poor management of the irrigated land has led to waterlogging and increased the salinity of the soil in the entire basin. Almost one-third of the irrigated land is now degraded. Effective management in these areas, with an emphasis on environmental assets, could have helped avert the current problems and the environmental degradation surrounding the sea.

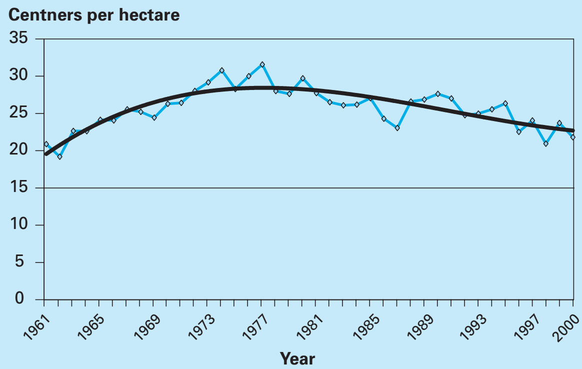
It is no longer possible to maintain irrigation and cotton production at levels experienced during the Soviet period. The land degradation, combined with the reduced availability of appropriate agricultural inputs for production after the breakup of the Soviet Union, has greatly reduced cotton production, both total yields and productivity per hectare. The original conversion of 7.9 million hectares of desert allowed a rise in Soviet cotton production from 2.2 million tons in 1940 to 9.1 million tons (at its peak) in 1980. Cotton production in Uzbekistan, which accounted for 70 percent of the total production (4 million tons) in 1960, peaked at 5.5 million tons in 1980. By 2000, it was down to 1960 levels—which may be more optimal and sustainable—when large-scale irrigation was beginning (box figure).

An increase in health costs

The exposed seabed and polluted downstream waters have also had high human and health costs. Winds carrying salt from the

Shrinking sea, falling yields

Cotton yields in Uzbekistan, 1961–2000



Note: 1 centner is equal to 0.1 ton.

seabed contaminate lands adjacent to the sea, and increased chemical and pesticide use upstream pollutes drinking water. The people hardest hit live in Karakalpakstan, at the end of the Amu Darya Delta. Reliable data on health costs are hard to obtain. But by some estimates maternal deaths in Karakalpakstan in 1994 were 120 per 100,000 live births (twice the national average) and infant mortality was 60 per 1,000 live births (three times the national average). In the past 10–15 years kidney and liver diseases, especially cancers, have increased 30- to 40-fold, arthritic diseases 60-fold, and chronic bronchitis 30-fold.

Full restoration too costly—how to avoid further decline

It may be too late to fully reverse the damage, but it is possible to stabilize agricultural production in the basin and mitigate negative downstream effects. Restoring the sea to its former level in the next 50 years would mean suspending all irrigation and other water uses in the basin—impossible today, when even water reductions of 3–5 percent meet with strong local opposition from people highly dependent on irrigation. Although the rates of return on the incremental irrigation have not been very high—ranging from 13 percent in the best case scenario (high cotton prices and low irrigation costs) to minus 10 percent in the worst case (low cotton prices and high irrigation costs)*—better returns can be achieved and agricultural production in the region can be put on a more sustainable path. Estimates put potential efficiency gains through operational improvements and greater participation and collective action in the use of irrigation water at 20–30 percent—this, at relatively low financial cost and without constraining production (World Bank 1998a). With these improvements, the decline in sea level could be arrested and some aquatic life could be reintroduced.

* The estimates of the return-to-irrigation investment are based on Uzbekistan, which accounts for more than 70 percent of cotton production in the region. The rate of return calculations are very sensitive to the average raw cotton price and the full cost of irrigation. Cotton prices fluctuated widely over the 1960–2000 period. The average cost of cotton is assumed to be $1,200 a ton (2000 prices) for the high-cost case and $850 a ton for the low-cost case. The average cost of irrigation is assumed to be $500 a hectare for the low case and $300 for the high case.
Source: Authors.

input (source).[36] The quality of the water in traditional shrimp farms is generally better because of the lower intensity of shrimp, which are thus less prone to disease.

The collapse of many shrimp farms in China, Indonesia, Taiwan (China), and Thailand has meant large losses in physical assets and in labor.[37,38] This was a direct consequence of not recognizing the importance of ensuring good naturally provided water quality in the production process, especially as the volume of shrimp and the capital intensity of farms increased.

Breaching thresholds through the cumulative loss of biodiversity can also lead at a localized level to a loss of resilience of an ecosystem—in its capacity to absorb disturbances without undergoing fundamental changes in functional characteristics. A run-down ecosystem, (one degraded by excessive use) can succumb to shocks that would not destroy a healthy ecosystem. A famous analogy made by Ehrlich and Ehrlich (1981) relates ecosystem components to rivets in an airplane.[39] One by one, biological species may disappear and not be missed. Eventually, however, the cumulative loss of biodiversity will lead to the crash of ecosystem functions just as the cumulative loss of redundant rivets will lead to the crash of an airplane.[40]

Thresholds are clearest when a renewable asset has been exploited beyond its capacity to regenerate or reproduce. When that threshold is reached, the productivity of other assets decreases—or if the degraded asset is the main input, production may cease altogether. The change is often sudden and discontinuous, as in cod fisheries in New England (see chapter 7).[41]

In some cases there may be no substitute for some of the functions of the environmental asset, so breaching thresholds can cause irreversible damage. An example of this is the ozone level: wearing a sunscreen lotion all day may protect skin from cancer caused by ultraviolet rays, but there is no known substitute for the protection ozone affords to our food chain.[42]

Thresholds can apply to all assets. Indeed, the experience of 80 countries during 1970–99 suggests that the probability of achieving a relatively high per capita growth of 2.5 percent a year for a five-year period is highly affected by the crossing of certain minimum thresholds of physical assets, human assets, and social assets.[43] That probability drops from 58 percent to 28 percent if the investment of physical capital to GDP ratio is below 15 percent. Even when the ratio is above 15 percent, the probability falls by more than 23 percentage points if the level of social assets—proxied by an index of (the lack of) political and social tensions—falls below a threshold.[44] The probability of such durable growth also falls significantly (from 70 percent to 44 percent) if the education Gini—measuring inequality in the distribution of education—is greater than 0.30.

In sum, the long-term neglect of any set of assets—human, social, or environmental—can at some point sharply reduce the productivity of the other assets, whether for commodities, sectors, regions, or nations.[45] Therefore, while countries may be able to grow for a period based on a strategy of accumulating physical capital, the prolonged neglect of other assets is likely to endanger the durability and sustainability of the growth process—for example, allowing a country to fall into a state of high social and civil unrest (a drop in social capital) is likely to undermine sustained economic growth.[46,47] Similarly, if environmental degradation is irreversible, society can lose the option value of an asset that could make a serious difference to future productivity (box 2.4).

So far the concern has been with the potential for substituting assets in production. What about the potential for substitutions that affect human well-being directly? The need to manage all of society's assets may be even greater. The substitutability of assets that enter people's well-being directly is likely to be lower than the substitutability technically feasible in production. Some minimum bundle of social and environmental assets is likely to be needed if one is to achieve a given level of personal well-being.[48] This argument is just as valid for intergenerational well-being.

There will always be much uncertainty about the tastes and preferences of future generations—and about the technological possibilities open to them. But there is also much uncertainty about the consequences of our current actions. While many ecological problems are gradual, some can switch abruptly from one stable state to another (box 2.5). Such shifts can cause large losses of ecological and economic resources.

Very often, restoring the desired state would require drastic and expensive interventions. And sometimes the process of restoration is not even known. Technological solutions to these problems might be

Box 2.4
How keeping the option value of assets can make a serious difference

In 1970 a new virus—the grassy stunt virus, carried by the brown plant hopper—threatened rice production in Asia. The virus appeared capable of destroying as much as one-quarter of the crop in some years, making it critical to develop a rice strain resistant to the virus. This was done with the help of the International Rice Research Institute (IRRI), which researches rice production and maintains a huge bank of rice seeds—about 80,000 varieties of rice and near-relatives of rice. In this instance, a single strain of wild rice not used commercially was found to be resistant to the grassy stunt virus. The appropriate gene was transferred to commercial rice varieties, yielding commercial rice crops that were resistant to the virus.

Note that this strain was found in only one location, a valley flooded by a hydroelectric dam shortly after the IRRI took the strain into its collection. Without this strain—which apparently had no commercial value—the well-being of hundreds of millions of people would have been seriously affected.

Source: Heal (2000).

Box 2.5
Catastrophic ecoshifts

Recent studies highlight the possibility of catastrophic shifts in ecosystems. Usually the changes in outside conditions affecting ecosystems—climate, injection of nutrients or toxic chemicals, groundwater reductions, habitat fragmentations, losses of species diversity—occur very gradually. And sometimes the ecosystems will respond to such changes smoothly and continuously. But studies of lakes, oceans, coral reefs, forests, and arid lands show that these smooth changes can be interrupted by sudden, drastic switches to another state. The gradual changes in external conditions can lead to a loss of resilience and make the ecosystem more vulnerable to catastrophic shifts. Once a threshold is passed, the shift can occur suddenly, with little warning. So under some conditions the ecosystem can move from one stable state to another, separated by an unstable state.

Coral reef ecosystems can exhibit such dramatic shifts—from having high biodiversity to being overgrown with fleshy algae. Factors that make them vulnerable to such shifts include increased nutrient loading from changed land use and overfishing, and reduction of the number of large, and later the smaller, herbivorous fish species that control the algae. In the Caribbean, overfishing had already reduced herbivorous fish when a pathogen reduced the population of sea urchin Diadema (which also controls the algae). As a result, the reefs became overgrown with fleshy brown macro algae—the spread is now difficult to reverse because adult algae are less palatable to herbivores and the persistence of the former prevent the settlement of coral larvae.

Source: Scheffer and others (2001).

available in the future—or they might not be. When the potential damage can be very large—where the effects may be irreversible and where substitution possibilities may be limited—a "precautionary principle" applies: act more conservatively when you are uncertain about the effects (see chapter 5 and box 5.6 on the precautionary principle).

Tradeoffs and sustainable development

Balancing objectives and choosing how to act

Improving human well-being over time is a broader goal than increasing economic growth that focuses primarily on material comfort. This has some important implications. Since social and environmental assets also affect human well-being directly, a strict policy of "grow now, clean up later" has costs for today's generation, costs that often fall disproportionately on today's poor.[49]

Moreover, any serious attempt at poverty reduction requires, at a minimum, durable economic growth—not economic growth in fits and starts. This means paying enough attention to social and environmental concerns to ensure that durable growth is not jeopardized.

And while there is potential for substituting assets over a range, there are limits to such substitution (see earlier section on this topic), perhaps even more from the perspective of people's well-being than of production. So to ensure that the well-being of future generations is not compromised, some attention has to focus on environmental concerns—in particular the avoidance of irreversibilities that may matter for future well-being.

The way the economy grows—the pace and pattern of growth—can matter for the well-being of both the current generation and that generation's children and grandchildren. Developing countries do not have to follow the path of development traversed in the last century by the industrial countries. Technological options have improved and it is now possible to avoid repeating the mistakes of industrial countries in their development (i.e., the use of lead in gasoline). On the other hand, some options open to industrial countries in their development phase are not open to developing countries now (land-labor ratios, extent of global competition, and so on).

What do these considerations imply for a country's development strategy—or how does a country balance the objectives of addressing environmental concerns and pursuing economic growth? Over the longer term, economic growth is unlikely to be sustained unless enough attention is paid to environmental assets. But over the short to medium term it may be possible to do so, on the grounds that such short-term growth could generate more resources for addressing environmental concerns later. Indeed, having limited resources usually makes it necessary to choose priorities between tradeoffs. But the priorities will not always favor growth over attention to environmental assets in the short run, or vice versa.

The appropriate ranking of priorities will vary by locale (region or nation) and at different times, depending on the issue and on several other factors. What environmental depletion or degradation has already taken place? How important is the asset in either the production process or in utility directly? Are the poor particularly vulnerable if the issue is left unattended?

Three broad cases can be distinguished for different emphasis and sequencing:

1. Simultaneously addressing environmental concerns along with economic growth, even in the short run
2. Placing a higher priority on economic growth, while addressing environmental concerns that can be dealt with at relatively low cost in the short run
3. Placing a higher priority on maintaining or restoring the environment in the short run.

Case 1. Win-win: preserve natural assets and keep growing

Addressing both growth objective and preservation or restoration of environmental assets can sometimes be critical to raising production and incomes, even in the short to medium term. That would be the case in Madagascar, where almost three-quarters of the people, most of them poor, live in rural areas. The bulk of rural poor people are in agriculture, and productivity growth in agriculture is critical to poverty reduction. Yet agricultural productivity has been stagnant for the past four decades.[50]

One of the deep constraints to increasing agricultural production in Madagascar is resource degradation and low soil fertility. The country has already lost 80 percent of its original forest cover, more than half in the past 40 years (see box 8.3 in chapter 8). In the east of the country, under the *tavy* agricultural system, rice is grown on steep slopes after slashing and burning of virgin or secondary forests. In the central highlands population pressure forces people from the valley bottoms to farm the hillsides, evident in the big increase in rainfed agriculture. The resulting erosion causes nutrients to wash off the already poor soil and to silt irrigation schemes in the valleys.

The annual cost of environmental degradation—from soil erosion, silting, declining soil fertility, and lost forest—is high, estimated at over 5 percent of GDP, and the agricultural resource base has not kept up with population growth. That is why arresting this cycle—through agricultural intensification to reduce the pressure of cultivating new uplands—is paramount. Today, little use is made of fertilizers and of new higher yielding varieties—for several reasons. The absence of secure land tenure reduces the incentives for investing in intensification. The lack of credit and liquidity hampers the use of inputs. And the very poor quality of rural infrastructure constrains the supply of inputs and makes it more expensive.

Indeed, for countries that rely heavily on renewable natural resources and have few alternatives in the short to medium term (because they are poor in human and human-made assets), it is especially important to contain environmental depletion or degradation. For these countries, maintaining natural assets is a critical component of economic growth. For example, in southern Africa, the Caribbean, and the Indian and Pacific Oceans, nature-based tourism has become an important source of foreign exchange and local income.

In some cases restoring or maintaining an environmental asset may not be critical for economic production (other factors of production could replace its functions), but it may be more economically efficient (box 2.6).

Case 2. Tradeoff: place more weight on economic growth and only address low-cost environmental concerns

When environmental degradation is reversible and has limited impact on economic growth in the short to medium term, placing greater weight on economic growth entails lower opportunity costs and should be

Box 2.6

Replacing natural assets with human-made assets can be costly

For years the Catskill watershed provided New York City residents with water of such high quality that it needed no filtration or chemical treatment. New York could even bottle and sell its water to other cities.

This began to change in the 1990s. The U.S. Environmental Protection Agency warned the city that it would soon have to invest in a filtration plant—for $6 to $8 billion, with annual operating costs of about $300 million. Given the huge sums, the city began to ask why a watershed that performed so well for so long was now beginning to fail. The main causes were uncontrolled land development in the Catskills and the intensified use of land in and around the watershed. The combination of pollutants from residential communities and farms was overwhelming the soil microbes that naturally filtered and cleansed the water as it percolated through.

Because there had been little deforestation or soil erosion, and because much of the natural infrastructure of the watershed was still intact, it was possible to reverse the situation. New York City then faced a choice: restore the watershed, or build and run a filtration plant. Costs of the first option—improving sewerage treatment in the watershed and buying lands to prevent development—were estimated in the range of $1 to $1.5 billion, one-fifth the cost of an artificial filtration system.

The choice was clear. As the commissioner of the city's Department of Environmental Protection commented at the time, "All that human-made filtration does is solve a problem. Preventing the problem, through watershed protection, is faster, cheaper, and has lots of other benefits."

Source: Heal (2000).

pursued. But as discussed below, this does not justify ignoring environmental concerns altogether.

To justify a strategy of "grow first, clean up later," policymakers rely on the argument that is only partially borne out by observation—that environmental degradation gets worse initially and then gets better as a country develops—the environmental Kuznets curve. Often they also act as if the relationship is automatic—so that there is little need to actively address the problem. This could be the case if, say, shifts in the scale and sectoral composition of output and changes in technology within sectors result in a move away from pollution-intensive production to less pollution-intensive methods.

But it cannot be assumed that environmental quality will necessarily improve with economic growth. First, such a relationship is observed only for some environmental factors. For local air quality, there is a strong inverted-U shape relationship with income for sulfur dioxide and carbon monoxide, and even a one-for-one downward relationship between particulates and per capita income.[51] But for water quality the evidence is mixed. And for per capita emissions of CO_2 there is a steady worsening as per capita incomes grow.[52] Indeed, recent research concludes that, on the whole, there is little evidence of environmental quality getting worse with initial growth and then getting better at higher per capita incomes.[53]

Second, even for environmental assets that show a positive association with per capita income growth, the association is not structural. Instead, the better environmental outcomes reflect the impact of regulations and other polices put in place in response to public action and pressures from society as preferences for environmental quality become stronger with higher per capita incomes—not to any natural changes in the composition of production or consumption.[54]

It is important to recognize that, although the resource degradation or depletion may be reversible, its impact on human well-being is not (recall the degradation of Aral Sea described in box 2.3). Future remedial action cannot compensate the generation or generations that live during the transition to a better environment. Consider the costs of air and water pollution for human health. Recent estimates suggest that about 11 percent of illnesses and premature deaths in developing countries are due to environmental health risks from water supply and sanitation and from urban and indoor air pollution.[55] This is about the same as from malnutrition, which accounts for 15 percent of all illnesses and deaths. The poor are particularly vulnerable since they have fewer alternatives to polluted drinking water and are more likely to live near heavily traveled roads where air pollution is highest.

For this reason, there is little justification for not addressing at least some of these environmental concerns along with economic growth. And often a large proportion of the problem can be addressed at relatively low cost (see figure 2.4 on page 31).[56] Indeed, several cost-benefit studies have shown that the costs of addressing a sizable proportion of pollution can be relatively low—and that the benefits of doing so can often be very high. In such cases there would be grounds for stricter pollution control when pursuing a high growth strategy even in very low-income countries.[57]

Although policymakers often worry that pollution control measures hurt the competitiveness of firms, research does not support their concern.[58] What is observed is that countries can have quite different environmental outcomes while achieving the same economic growth rates. There is, for instance, a fairly wide range of environmental outcomes in countries averaging a 3 to 5 percent annual growth (figure 2.3).

Indeed, environmental outcomes at given incomes are strongly influenced by how parties (citizens, business leaders, policymakers, regulators, NGOs, and other market actors) react to economic growth and its side effects.[59] This suggests that there can be a demand in society for better environmental quality even at fairly low incomes. In a policy formulation setting that allows for participation, voice, and channels for feedback, countries are likely to experience better environmental outcomes at all levels of income (see chapter 3).

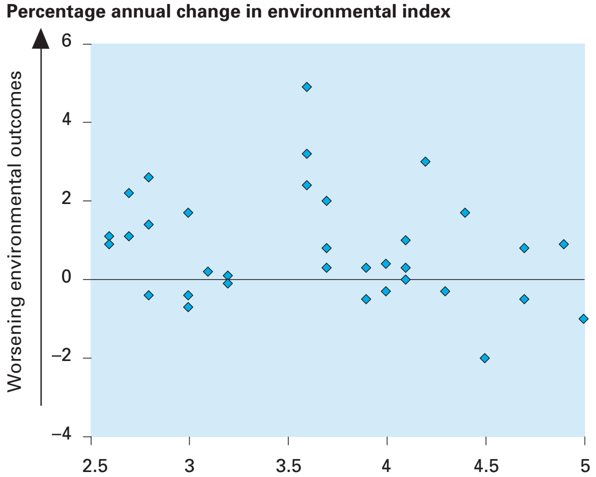
Case 3. Tradeoff: place more weight on the environment

When current depletion or degradation threatens to be irreversible—or when the degradation has significant and long-lasting implications[60] and having the asset may be important to the nation in the future—the environmental concerns need to be addressed today.

Forests rich in biodiversity may have little amenity value to the people in a poor country today. But as the country's per capita income rises, that value is likely to increase—making it important to have prevented irreversible losses. Since these assets often yield significant benefits to poor people in the country today, who rely heavily on it for their livelihood (food, fuel, fodder, and medicinal plants), it may be possible to address the environmental degradation and poverty reduction simultaneously through financing or cost-sharing from the larger community within the country or from abroad. Such schemes need to be appropriately designed to provide, where necessary, alternative livelihoods for the local populace.[61] By avoiding irreversible degradation, these schemes can also keep the option value of the resource for the nation in the future. Such cost-sharing schemes are interim proxies for economic growth insofar as they align the preferences of the current (poorer) population with those of future (richer) populations.

An example of such cost-sharing is Costa Rica's environmental services program. Costa Rica's forests are attractive to tourists worldwide, given the rich biodiversity there. But the rate of deforestation in the 1970s and 1980s was one of the highest in the world. To protect this asset, Costa Rica designed a very innovative scheme, the Payments for Environmental Services Program, in which those who benefit from the environmental services of the forests compensate those who bear the burden of maintaining the forests. Under the scheme, a market has been created for a variety of services, with carbon sequestration among the most successful (see box 8.5 in chapter 8).

Figure 2.3
Very different environmental outcomes with the same growth rates



Note: The environmental index is constructed by giving equal weights to annual rates of deforestation, water pollution proxied by emissions of organic water pollutants in per capita metric tons, and the increase in CO_2 emissions in per capita metric tons between 1987 and 1995.

Source: World Bank (2001h).

Some assets are overused or underprovided—why?

From the preceeding discussions it should be clear that there is real value in designing development strategies based on better management of a broader portfolio of assets. A major problem in pursuit of this goal is that some assets (knowledge, environmental, and social) tend to have characteristics of public goods or externalities—that is, their use generates spillover benefits or costs to others that are not taken into account. As a result, the stocks of these assets are generally too small from society's perspective. This is a consequence of market or policy failures.

Market failures

It is difficult to exclude people from using many of the functions of environmental assets—they are nonexcludable. That means there are no well-defined private (individual or group) property rights, so markets cannot be used to ration the use of these assets or to expand their provision where that would be justified. Without property rights, it is not possible to charge others for the use of a good or service. Therefore not only does an individual or group have little incentive to preserve or provide the asset (since he or they cannot prevent others from using it), he or they have every incentive to free-ride on others' efforts to preserve or provide those assets. From the perspective of society, then, the assets will be overused or underprovided.

Overuse. For some renewable assets that are common property goods (nonexcludable but rival) consumption by one individual or group will reduce the supply for others. Each individual or group can gain from overexploiting it in the short run, but lose in the long run as everyone else does the same and the asset falls below its regenerative capacity. Society then ends up worse off.

As an example of the common property problem, consider offshore fisheries, many of which are greatly depleted by overfishing. The fish biomass of several important fisheries is now a mere tenth of its pre-exploitation level—90 percent of initial stocks have been destroyed.[62,63] Although all fishermen would benefit in the long term from a flourishing fishery, individuals tend to act in their own interests and catch as many fish as they can. This is the "tragedy of the commons"—or open access, with users over-exploiting what would otherwise be a renewable resource as they race to get their share before others deplete the resource. The same behavior applies to ozone depletion and climate change—clear examples of global common property goods (see table 2.2). As discussed in chapter 8, the emission of ozone-depleting substances, or the use of fossil fuels (and, to a lesser but still important extent deforestation and other land use practices that release CO_2 and other greenhouse gasses), results in gases accumulating more rapidly in the atmosphere than natural sinks can remove them. They change the climate in complex ways. Their global effect is the same regardless of where they are emitted. Again, individuals (and individual countries) do not factor in the spillovers of their actions on others.

Underprovision. Knowledge is a public good—since once generated, it is difficult to exclude others from using it (nonexcludable) and consumption by one individual does not reduce the supply for others (nonrival). Individuals or groups have less incentive to invest in generating information and knowledge than is socially desirable. There is a tendency to free-ride, expecting to benefit from a piece of knowledge created by someone else. And since an individual's use of a piece of extant knowledge does not reduce the knowledge available to others, the generation of new knowledge can have large positive externalities or spillovers to society that are not taken into account in decentralized decisions to invest in creating new knowledge. Thus knowledge also tends to be underprovided from society's perspective.

The existence of spillovers (externalities) that are not taken into account by individuals gives rise to the need for a "market for external effects" that can align the marginal costs and benefits to the individual with those of society as a whole—so that individuals take into account their impact on others (internalize the externality). When transaction costs are low, and property rights relatively well defined and perfectly and costlessly enforceable, all affected parties could get together to negotiate an outcome that is efficient from the perspective of society.[64] Under such circumstances, there is little need for policy intervention.

But generally transaction costs are significant, and for many environmental assets private property rights are difficult to define. The costs of transactions are likely to depend on the number of people involved and on whether the parties are concentrated or diffused groups. (Clearly, not all problems deserve being addressed—sometimes the transaction costs may be higher than the social benefits.) Usually, transaction costs are likely to be higher—and the problem more difficult to solve—when the effects of the spillover fall on a large, diffuse group. The problem is likely to be even more difficult to solve when a small concentrated group (that can organize itself at lower costs) generates the spillover, while the effect of the spillover is borne by a diffused

Table 2.2
Examples of types of externalities addressed in each spatial arena

	Nonexcludability leading to market failures		
Space/scale arena	Common property goods (rival)[a]		Public goods (nonrival)[a]
	Externality effect of many on many (dispersed interests)	Externality effect of a few (concentrated) on many (dispersed, who could also lack voice or be otherwise excluded)	Usual case: externality effect of many on many (dispersed interests)
Fragile rural	Wells and grazing land (chapter 4, box 4.2)	Mines (chapter 4, box 4.7)	Schooling for girls (chapter 4, box 4.6) Knowledge outreach in Tunisia (chapter 4, box 4.5)
Commercial rural		Groundwater (chapter 5, box 5.10) Frontier land (chapter 5, box 5.12)	
Urban	Disposal of solid waste in drains (chapter 6) Automotive air pollution <in wealthy countries>	Pollution in Cubatão, São Paulo (chapter 6, box 6.3) Automotive air pollution <in poor countries>	Public works in favelas in Brazil (chapter 6, box 6.5)
National		Cameroon forestry (chapter 7, box 7.8)	Public health services in Ceara, Brazil (chapter 7, box 7.2)
Global	Ozone depletion (chapter 8) Global warming (chapter 8) <individuals>	Global warming (chapter 8) <countries>	

Note: Nonexcludable means that a user cannot be prevented from consuming that good or service.
[a] *Rival* means that consumption by one user reduces the supply available to other users. Public goods are nonrival up to a threshold. Once that threshold has been breached they can become rival: for instance, a freeway, as it shifts from being underutilized to being congested; or the atmosphere once the pollutant concentration exceeds the atmosphere's absorptive capacity.
Source: Authors.

group that incurs higher costs to organize itself because it lacks the ability or voice to negotiate. Solving such problems requires policy interventions and supporting institutions (see the section titled "Correcting the overuse and underprovision of important assets" and chapter 3). And as discussed in the rest of this Report, where such institutions do not exist, it is necessary to find mechanisms or catalysts that may spur their emergence. Table 2.2 shows some examples that are taken up in each of the chapters of this Report, which is organized by space and scale.

Policy failures

The overuse or underprovision of an environmental asset can sometimes be the result of policy interventions to correct market failures that in turn have consequences for another set of problems—leading to a policy failure in the case of the latter. For example, countries may implement policies—to improve the competitiveness of certain products, industries, regions, or to support particular social groups—that have adverse environmental impacts. When the social costs outweigh the social benefits, this constitutes a policy failure, requiring offsetting corrections or even elimination of the policy intervention.

So-called perverse subsidies are an example. Many subsidies are introduced initially to stimulate the use of a good or service that is underutilized—fertilizer, electricity, water. But in the absence of sunset clauses and with the creation of a constituency based on perceived acquired rights, these subsidies can persist beyond their economically useful life and be detrimental environmentally. They can be economically costly if they sustain processes that would otherwise not be viable (for example, producing rice in California). They can also be economically harmful if they reduce the costs of environmental inputs to the point that eventual degradation of this complementary

Box 2.7
Perverse subsidies in India

Power subsidies in India have resulted in overpumping of aquifers, reducing the availability of drinking water, and encouraging water-intensive crops in areas where water is scarce.

In not distinguishing between peak and nonpeak tariffs, the implicit subsidy has also increased the incentive to overbuild capacity. (In fact, the World Bank estimated in 1991 that various measures to reduce peak power usage could reduce power generation requirements by about 12 percent in 10 years.)

In addition to facilitating the excess drawdown of aquifers, the subsidy is costly for poor people, who typically lack access to power but suffer the opportunity costs of having subsidies go to others. Since State Electricity Boards are not allowed to charge realistic tariffs, their accumulated deficits are at least partly serviced by deducting their dues from the Central Plan Assistance to the states. This reduced central assistance, along with the direct state subsidies to power, means that the poorest do not receive adequate basic services, such as health care and primary education.

Source: World Bank (2000e). Adapted from box 5.2.

asset affects productivity (for instance, power subsidies in India encouraging the overpumping of ground water—box 2.7) or if in attempting to benefit one activity, they harm others, so that their net impact is negative.[65]

Energy subsidies,[66] the bulk of which are directed to fossil fuels[67] in both industrial and developing countries, entail economic efficiency losses. But they also have highly deleterious effects on the environment, some reflected in higher economic costs.[68] Subsidies to fossil fuel and nuclear energy in Organisation for Economic Co-operation and Development (OECD) countries total $71 billion annually.[69] Studies that simulate the effects of removing coal and other energy subsidies—either for individual countries or the world—all find significant environmental benefits in reducing CO_2 emissions. And most studies that look at the economic effects also find real GDP gains.[70] The problem is not limited to industrial countries. While many developing countries significantly reduced their energy subsidies in the 1990s, they would still gain considerably by removing the subsidies altogether (table 2.3). Although it is often argued that these subsidies are needed to help poor people, the poor rarely benefit.

In general, subsidies encourage the use of the supported inputs, processes, or products—and reduce the incentives to find alternatives that may be more economically efficient. Fuel subsidies to fossil fuels reduce the incentive to develop renewable energy sources.[71]

Although dismantling perverse subsidies may be good for society, some groups would lose. For example, studies looking at the effects of removing energy subsidies in industrial countries point to a significant loss of jobs in the coal sector (although there would be real GDP gains associated with their removal).[72] Social considerations may thus call for incentive-compatible transfers and compensation (see chapter 7, box 7.7), as well as other support (vocational training for other jobs) to enable the transition out of perverse subsidies.

The costs and benefits of correcting underprovision or overuse

If environmental assets are generally overused or underprovided, how can society begin to weigh the returns to addressing an environmental issue against the costs? It depends on the starting point.

Starting from a moderately degraded state, it is often possible to make significant improvements at fairly low cost. Very simple low-cost measures to abate water pollution (for example, installing water filters) can often remove close to half the pollutants. The costs of additional reductions in degradation are likely to rise more steeply because more sophisticated measures are needed. Consequently initial costs are low and rise more steeply as the quality of the asset is restored.

In another example, consider the costs (estimated in the early 1990s) of reducing air pollution from transport in Mexico City. The cheapest emission reductions were found initially among the busiest vehicles, especially those that were driven downtown during most of the day. Further emission reductions required modifications for a larger part of the vehicle fleet—which became more expensive. (Emissions reductions for buses and taxis would have cost only $300 a ton because of their higher annual mileage, compared with $1,600 a ton for passenger cars.) The incremental costs of mandatory inspection and maintenance programs for vehicles in use would have been higher still (with costs rising as the standards

Table 2.3
The benefits of full-cost energy pricing

Country	Average subsidy (percentage of reference price)	Cost of subsidy ($ billion)	Effects of subsidy removal: Gain in economic efficiency[b] (percentage of GDP)	Reduction in energy consumption (percent)	Reduction in carbon dioxide emissions (percent)
Islamic Republic of Iran	80.4	3.6	2.2	48	49
República Bolivariana de Venezuela	57.6	1.1	1.2	25	26
Russian Federation	32.5	6.7[a]	1.5	18	17
Indonesia	27.5	0.5[a]	0.2	7	11
Kazakhstan	18.2	0.3	1.0	19	23
India	14.2	1.5	0.3	7	14
China	10.9	3.6	0.4	9	13
South Africa	6.4	0.08	0.1	6	8
Total	21.2	17.2	0.7	13	16

[a] Based on 1997 (hence, pre–financial crisis) prices and exchange rates.
[b] Transfers in the form of subsidies lead to increases in consumer and producer surplus (defined as the difference between what consumers are willing to pay for a unit of the good and what they actually pay, and as the difference between what producers actually receive when selling a product and the amount that they would be willing to accept for a unit of the good, respectively). These increases however are smaller than the total amount of the transfers (subsidy), which means that the subsidy entails a net loss in social welfare. Hence removing the subsidy would entail net economic efficiency gains.
Source: International Energy Agency (1999a); Myers and Kent (2001).

were tightened) and the additional reduction in emissions would have been lower assuming the cheaper alternatives had already been implemented. Improvements in the fuel mix are at the high end of marginal costs, providing even less additional reductions in emissions (figure 2.4).[73]

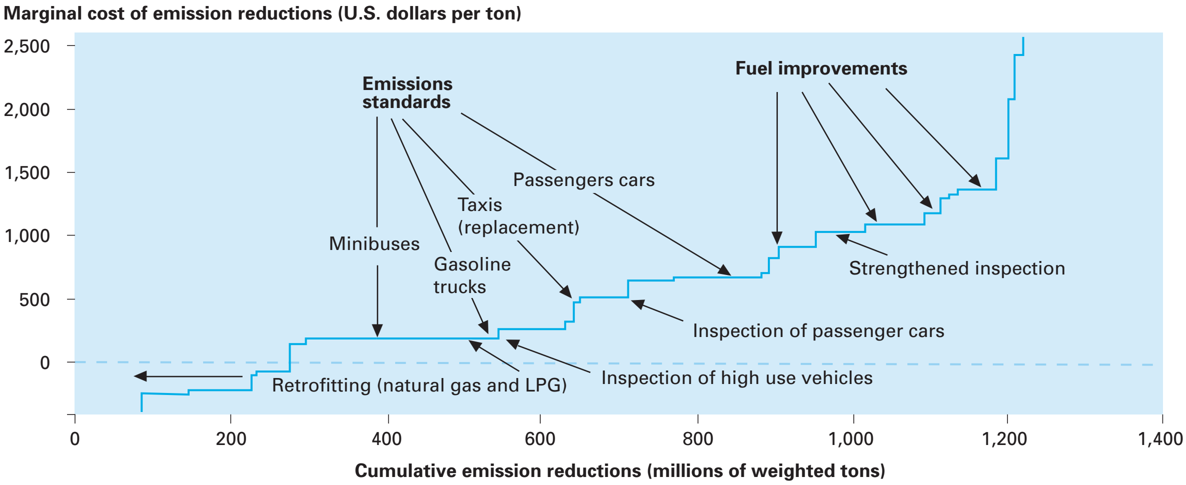
But if a resource is substantially degraded, the costs of restoring it can jump dramatically. For example, restoring water to the Florida Everglades is estimated at $7.8 billion. Sometimes, when the depletion or degradation reaches very high proportions, even if it is technologically feasible to address the problem, it may not be economically viable to do so. And when the problem is technically irreversible, the costs become infinite. For example, once substances such as oil, petroleum, and chemical solvents (which are part of a certain type of contaminants known as nonaqueous phase liquids) penetrate an aquifer, they are almost impossible to remove.

Complications arising from long time-horizons and uncertainty

One of the difficulties with environmental problems is that the costs and benefits of addressing the issue are sometimes highly uncertain. The problem is even more complicated when the costs and benefits are realized at different points in time—often benefits materialize in the long term while costs are incurred in the short term, as with climate change. Sometimes the costs and benefits that occur in the future at different points in time can be discounted or converted into an equivalent set of costs and benefits today, using the consumption rate of interest—the rate at which consumption tomorrow can be substituted for consumption today without changing social well-being. But the farther the benefits occur into the future, the greater the bias toward inaction, because discounting automatically reduces the valuation of these benefits.[74]

However, if one recognizes that a longer time-horizon also means that there could be significant uncertainty about the interest rate itself, and if the cost-benefit analysis takes this uncertainty into account, the valuation of benefits over distant horizons increases. (Since the consumption rate of interest depends in part on the forecast of future consumption, uncertainty about long-run economic forecasts would imply an uncertainty about the interest rate.)[75] As a nonrigorous but illustrative example, an exercise allowing for such uncertainty looked at the benefits of addressing climate change. Using the government bond rate (generally taken to be the best proxy for the consumption rate of interest) of 4 percent as the initial rate, the study assumed that future rates could either rise to 7 percent or fall to 1 percent, and showed

Figure 2.4
Reducing emissions in Mexico City



Source: Eskeland and Devarajan (1996).

how allowing for this uncertainty could add about 80 percent to the expected present value of addressing climate change (carbon mitigation) relative to the valuation under a constant interest rate of 4 percent.[76] Thus, if a dollar's worth of benefits in the future is worth 25 cents under a constant interest rate of 4 percent, it would be worth 20 cents more (45 cents) allowing for this uncertainty in interest rates.

Reducing uncertainty generally requires the generation of knowledge and information. The possibility of hitting thresholds also highlights the importance of developing and monitoring key indicators that can signal coming problems. Unfortunately, as discussed earlier, such knowledge and information is also usually underprovided because individuals, in deciding whether to invest in knowledge and information gathering, do not take into account the positive spillovers that this can generate for society.

Correcting the overuse or underprovision of important assets

Developing indicators to determine how assets are being used is a challenge (see earlier section on measuring sustainability). Addressing the overuse or underprovision of assets is another. This section discusses the mechanisms to address the two main reasons for the overuse or underprovision of environmental assets discussed earlier—market and policy failures.

Addressing market failures

Whenever spillovers (externalities) exist, there is a coordination problem—private marginal costs and benefits diverge from social marginal costs and benefits, and policies that align the two are needed. While the focus is generally on formal policies or mechanisms, informal community institutions, which rely on informal norms and networks, can also be key means for addressing coordination problems.

It is usually most efficient to address market failures at the lowest level that can internalize the externality—this is known as the principle of subsidiarity. Note that this can have a bearing on the roles of informal and formal mechanisms.[77] Spillovers that affect people in a single community should be addressed at that level. But quite often spillovers extend much beyond a single community and must therefore be dealt with in a broader setting. For example, maintaining a hillside forest is of interest to groups at many levels. Local communities and those living near the forest may want to manage it to provide fuel and food. Communities in the larger watershed may have an interest in maintaining the same forests to mitigate flooding and siltation downstream. The nation may want to maintain the ecotourism potential of the forests. The world at large may be concerned about the forest's ability to support biodiversity and carbon stocks. This requires corresponding action at all levels.

Appropriate formal mechanisms to address a market failure can range from using command and control regulations and harnessing market forces to creating markets and engaging the public (figure 2.5). Usually a mix of mechanisms is required to address a problem, although occasionally one is applicable or sufficient. In general, the choice of mechanisms needs to be guided by the following:

- The effectiveness of the instrument in meeting the objective
- The efficiency of the instrument—including whether it ensures static efficiency (achieving the goal at minimum cost to society) and dynamic efficiency (providing incentives for innovation and the search for alternative, more efficient ways of meeting the objective)—while minimizing the implementation costs (monitoring, enforcement)
- The extent to which the instrument minimizes the costs of meeting other objectives when there are tradeoffs
- The effects on distribution and poverty.

Regulations—command and control

Regulations, or command and control measures, have traditionally been the means of aligning public and private interests. Such measures—which include licenses, permits, quality standards, emission standards, process standards, product standards, and prohibitions—have the advantage of targeting a desired level (quantity) or quality of an asset more easily than other mechanisms. For example, air quality can be addressed by process standards or emissions standards.

Similarly, management and planning, also a regulatory approach, can sometimes work. For urban pollution, zoning and land use restrictions can be important if, for instance, there are economies of scale in dealing with pollution when firms are in one place. Though blunt, zoning can be an effective tool in handling environmental damage when the spatial dimension matters. Experience suggests, however, that regulations are sometimes less efficient and effective than market-based instruments—and costly in the institutional capacity they require for implementation.

Using markets—taxes and subsidies

Pollution can also be addressed through such market instruments as a tax, but the impact of tax rates on the levels of emissions cannot be known before the fact. Only by trial and error would a regulatory agency know the effect of a given tax rate. Increasingly it is being recognized that a combination of command and control and market-based instruments is superior to either alone. So if the interest is in reaching a desired quantity or quality at lowest cost, a target can be set for overall emissions, and permits or licenses would allow industry to emit up to the total but trade amongst themselves to achieve the overall goal at lowest cost to society.

Countries are thus moving to economic instruments to address environmental concerns. These offer more potential in terms of efficiency now (static) and over time (dynamic). They can offer more flexibility in meeting objectives. And they provide a source of government revenue that can address other public concerns. There are difficulties: many environmental assets do not have well-defined property rights, and operating in the market requires that property rights be assignable. Even so, some part of the depletion or degradation of the asset often takes place in the arena of markets—and is thus amenable to correction through economic instruments.[78] And technology can sometimes change whether an asset can have well-defined property rights and hence operate in the market (meters can foster water markets that would otherwise not be feasible).

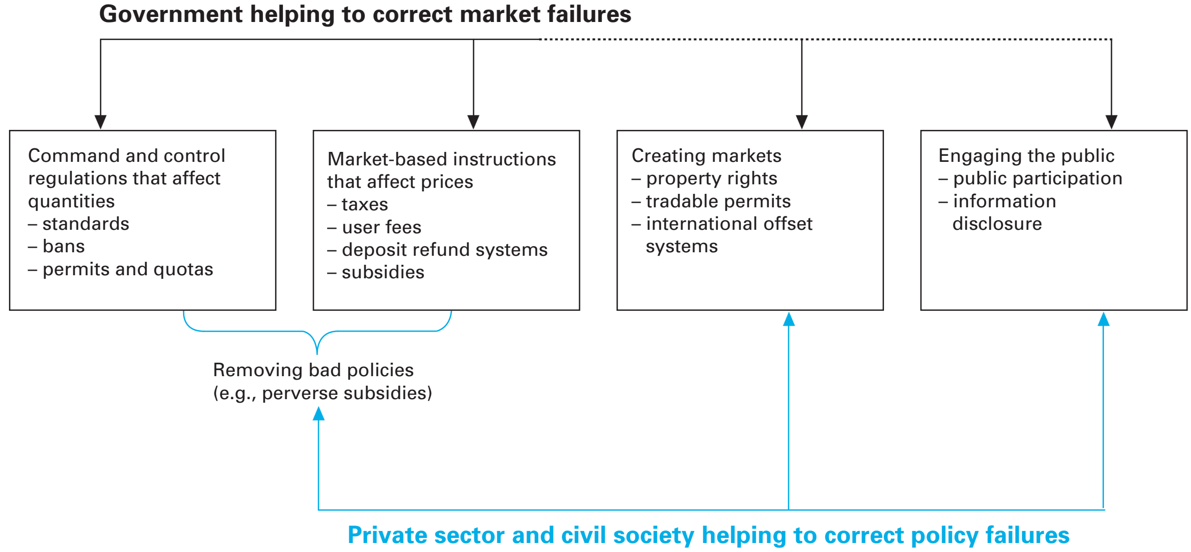
For example, even though private property rights to clean air—the asset—are not assignable, it is still possible to deal with aspects of the degradation within markets. Emissions or fuels can be taxed, or vehicle use in the case of vehicles.

One proposal for dealing with global common–related concerns such as ozone depletion and climate change is to impose user charges or levies at the global level.[79] (Of course, curbing air pollution by taxing vehicle and industrial emissions in cities, as mentioned above, would also be an important component of a strategy to deal with climate change.)[80] User charges create incentives to reduce environmental pressures (the incentive function of user charges). They can also mobilize financial resources that can be earmarked to fund the conservation and restoration of global common goods (the financing function of user charges).

Creating markets: property rights and trading permits

Sometimes it is possible to define and allocate property rights that are supported through regulations and institutional arrangements, which then create markets

Figure 2.5
Mechanisms to address market and policy failures



Source: Adapted from *"Five Years after Rio: Innovations in Environmental Policy,"* World Bank (1997a).

and allow the advantages of efficiency. Indeed, this approach (tradable permits for pollution emissions) has been a major innovation in the last decade.[81] The use of command and control to regulate the overall allowable pollution levels, together with tradable permits, creates a market for pollution abatement that would not otherwise exist. Making permits tradable gives firms an incentive to look for the most cost-effective solutions for pollution abatement, because firms that lower their pollution more effectively or at a lower cost than do other firms can sell their excess credits to those firms. Firms then face an opportunity cost of pollution, which creates incentives to find cheaper abatement methods, encourages less pollution in aggregate, and ensures dynamic efficiency.

In OECD countries, tradable permits are seen as a way of harmonizing environmental protection with economic efficiency.[82] The U.S. sulfur dioxide reduction scheme to reduce acid rain is an example, relying on tradable rights and credible threats in cases of noncompliance. Similarly, Iceland and New Zealand have revived fish stocks by assigning fishing rights at a sustainable level and allowing fishers to trade their quotas freely.

These arrangements, despite their advantages in providing the right incentives to adopt least-cost solutions, can still be costly to administer and implement. Finding the right balance between giving free play to market forces and monitoring and enforcement is a big challenge.

Engaging the public: publicizing and sharing information

Civil society can monitor and ensure compliance with regulations. A good example is Indonesia's PROPER program, which discloses the noncompliance of polluting firms to the public (while rewarding compliance), encouraging local communities to put pressure on companies that score poorly. The program focused initially on water pollution. It ranked companies by their emissions, and disclosed the results in stages, recognizing good performers first and giving the bad ones six months to clean up. Within 18 months, half of the noncomplying firms were observing the legally established standards.[83]

Public participation and monitoring can also make voluntary compliance agreements more effective. Such agreements with the private sector are becoming popular in addressing environmental problems in many OECD countries, especially when regulatory structures cannot address specific issues. The agreements can be commitments devised by the government (or an environmental agency), with individual firms invited to participate. Or they can be negotiated commitments for environmental protection developed through bargaining between a public authority and industry. They can also be unilateral commitments initiated by the private sector. These agreements are not limited to environmental issues. For instance, tour operators have agreed with the City and Borough of Juneau (Alaska) to minimize any adverse impacts of tourism on the local community.

Voluntary approaches—designed, implemented, and monitored properly—can work. But they can also have problems. Control can be weak because industry does not provide adequate control mechanisms or because of a lack of sanctions. Free-riding is possible when other firms bear no cost of complying with the agreement while reaping the benefit. Then there is the possibility of regulatory capture—when powerful businesses exert undue influence on the process.[84] Encouraging the participation of civil society can help to mitigate these problems.

Addressing policy failures

Many environmental stresses today are not the result of ignorance about what policies to adopt. Indeed, 10 years ago *World Development Report 1992* addressed the complex issues of environment and development and concluded that several doable, "win-win" policy options were available (box 2.8). A decade later these policy recommendations remain valid, but many of them have, at best, been adopted or implemented only partially.[85] As discussed, the widespread use of subsidies remains high across the globe (for water, energy, and food—especially in industrial countries). Damaging races for property rights abound (individuals or companies pushing to develop the remaining natural resources ahead of someone else: minerals, forests, fisheries). While the world is moving toward greater trade liberalization, trade restrictions (tariffs and non-tariff barriers) remain on precisely the goods in which developing nations are competitive, including agricultural products and textiles.

If the policy recommendations of a decade ago continue to be the best route to improving the welfare of millions of people, why have they not been implemented? In reality, even the win-win policies have been much harder to implement than initially thought—vested interests were much more entrenched, and institutional development was harder to foster. The persistence of policy failures even when society as a whole can benefit from their removal often reflects powerful interest groups blocking the necessary reforms. Just as participation by civil society, together with greater information disclosure and transparency, can help in monitoring the implementation of environmental regulations by individual companies, so too can it be an important means of improving the accountability of the public sector (see figure 2.5). The blocking of reforms by powerful groups represents one of the deeper barriers to the emergence of the institutions needed to support environmental policies.

This Report as a whole tries to show that environmental problems are, at their root, social problems. The distribution of assets, and of the costs and ben-

Box 2.8
***World Development Report 1992:* Development and the Environment**

World Development Report 1992 identified the challenge of pursuing development and poverty alleviation in a generation (1990–2030) that would see world population increase by 3.7 billion, food production double, and energy use triple. It called for actions that would mutually reinforce environmental protection and development: provide clean air, sanitation, and clean water; improve management of soils; and protect biodiversity. It saw great scope for win-win interventions that would simultaneously improve the environment and provide local economic benefits.

That report also called for improved institutions for environmental regulation, using market-based incentive principles where possible, and made a series of policy recommendations:

- *Win-win policies.* Eliminating subsidies for energy inputs, pesticides, fertilizer, irrigation water, logging, and ranching (perverse subsidies); taxing urban road emissions
- *Priorities for action.* Removing perverse subsidies, strengthening property rights over common pool resources, expanding service provision, increasing voice and participation, carefully evaluating environmental tradeoffs with special regard for long-term irreversible or large-scale damage, matching the government's role to its capability
- *Policies for sustained development.* Where possible, relying on incentives rather than regulations; curbing the influence of vested interests
- *Partnership for solutions.* Partnering with high-income countries to expand market access and to increase development assistance; partnering with high-income countries to finance the costs of global environmental priorities, especially those requiring the protection of natural habitats in developing countries.

Source: Authors; Acharya and Dixon, background paper for the *WDR 2003.*

efits of different policies, as well as the role of trust, are all critical to the ability of societies to develop competent rules and institutions (chapter 3) to address environmental, social, and economic problems.

This chapter has discussed the importance of managing and ensuring a better balance of assets to enhance human well-being on a sustained basis. It also covered the externalities and coordination problems that generally lead to the overuse or underprovision of some of society's key assets, detailing the policy instruments and mechanisms to address these externalities. As discussed, the nonadoption or nonimplementation of these policies reflect the fact that the supporting institutions—with the appropriate characteristics—have not yet emerged. Chapter 3 looks at the characteristics of appropriate institutions, the potential barriers to their emergence, and how these may be addressed; it focuses on catalysts that may increase the likelihood of the timely emergence of these institutions.