Chapter Ten

A PERSPECTIVE ON SUSTAINABILITY

"Man is the only animal that blushes—or needs to."
—Mark Twain

THE SITUATION OF THE "MOST SUCCESSFUL" SPECIES

The last four chapters have explored four very different perspectives on the complicated, surprising, and sometimes troubled interaction of humans and ecosystems. One thing we have established is that humans appear to be highly successful in dominating ecosystems. Whether humans can become sound stewards of enough ecosystems is unclear, though it is also clear that we must meet this test if we are to survive, let alone claim to be the "most successful" in any meaningful sense. In this chapter, we draw the perspectives of Part II together to examine sustainability, the question of whether humans are likely to endure and flourish on this planet while maintaining a high quality of life. In Chapter 1 we introduced the idea that sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."[1] In this chapter, we will see why sustainable development is a grand challenge.

To do that, we will review ideas developed in the first nine chapters of this book. We sketch the outlines of the invisible present—how humans have interacted with

the natural world over long periods and at large spatial scales. Because of the world without edges, our species has developed the ability over the past two centuries to alter the world at large scales, with impacts such as climate change affecting the entire biosphere. Some of these impacts will be felt for centuries; and some, such as the decline in biodiversity, have already altered the world irreversibly. Understanding the big picture in its large dimensions provides both a summary of the challenges facing our species and a framework for evaluating the responses available to meet these challenges, the task of the five chapters that lie ahead in Part III.

What are the circumstances of the "most successful" species today?

- The rate of population growth is decelerating, but human numbers are still increasing and rapid urbanization will continue.
- Economic growth is transforming societies.
- Human well-being has been improving, despite widening inequality.
- Human domination of nature continues to increase.
- People remain dependent on ecosystem services.

One implication of these trends is that environmental considerations have risen on the agenda of the human race, not because environmental activists are noisy but because the material economy faces real challenges. These challenges show up as

Learning Objectives

When you have finished studying this chapter, you should be able to

- put the environmental challenges of the twenty-first century into the historical context of the past thirty, three hundred, and ten thousand years;
- explain the connections between climate change and the way the Earth looks at night from space or an airliner;
- describe how both of these statements are correct: (1) economic inequality across large regions of the world is increasing, and (2) on average, people in every region are becoming economically better off;
- identify the difference between well-being, as measured by the Human Development Index, and average income, as measured by gross domestic product per capita;
- compare the labor you must devote to acquiring the energy you use in your daily life with the labor needed to supply a much poorer person's energy needs in a poor tropical country;
- identify the scale of your competence in an everyday activity such as food consumption or assuring a supply of clean water.

a lack of sanitation for half the human race; as lives shortened by pollution, such as the prevalence of lung disease in China's coal-dependent economy; in abrupt changes in gasoline prices; in the urbanization of the world's population; and in many other circumstances for which the word "environmental" does not seem apt at first. But these are all problems of sustainability, of balancing the needs of the present against those of the future.

The material economy transforms nature. Where there are poorly governed commons, there are environmental problems. Such tragedy-prone commons are everywhere, although not every commons is poorly managed.

Over the next two generations—that is, during the span of the careers and lives of today's students—we are likely to face major difficulties. But there will also be major opportunities. The range of opportunities is implied by the wide range of issues listed above. There is a need for people who understand the pursuit of sustainability in this wider sense, who can bring the knowledge we are sampling in this book to the debates that will shape decisions in every segment of economy and culture.

THE HUMAN TRAJECTORY

How have we humans arrived at this astonishing combination of challenge and opportunity? Humans exhibit a striking diversity—of nationalities, levels of consumption, and ways of life. Yet the genes of all humans lead back to our ancestors in Africa, the technologies that condition our lives owe much to the scientific revolution of Renaissance Europe, we are all dependent on agricultural production and other ecosystem services, and we are all linked to the commercial, technological, and cultural fabric of the world without edges.

The human species came to dominate in stages. Our distant ancestors—whose fossil remains preceded those given the name Homo sapiens—emerged in eastern Africa's Rift Valley, in what is now Kenya. We know about these ancestors from a small number of fossils from sites in different parts of the world. Paleoanthropologists, as those who study these and related fossils are called, are still working out many elements of our story as a species.

By studying the genetic variations in living humans, scientists can estimate the degree to which we are related to one another. By comparison with many other species, we are genetically very similar, from Indonesia to Spain, from the Arctic to the tropics. The fact that our genes are closely related implies that all humans are descended from a population of roughly ten thousand, some of whom migrated out of Africa more than a million years ago.

Our species spread over the world, and by about twenty-five thousand years ago, humans reached the New World, hunting and gathering as they moved eastward from Asia during the last Ice Age. The quantity of ice in polar and mountain glaciers was large enough then that the sea level was more than 100 feet lower than it is today, exposing a land bridge along the track of the Aleutian Islands between eastern Russia and western Alaska. By the time humans reached the Western Hemisphere, the species was already present in all the other continents except for Antarctica. Some remote islands, such as some in the Pacific Ocean, were not settled until after the time of Jesus, two thousand years ago. The South Pole did not have a year-round settlement (a research station) until 1957.

At the end of the last Ice Age, about ten thousand years ago, as the glaciers retreated in the face of warming climates, humans discovered agriculture, a development we discussed in Chapter 6. The domestication of highly productive plants and animals drew our species, which had lived by hunting and gathering for tens of thousands of years, into a settled way of life. This led to extensive environmental changes, as land was cleared for crops and irrigation channels replaced natural watercourses in many parts of the world. The much higher and more reliable production of food from farming also led to large increases in human populations. Permanent human settlements spurred the development of language and the elaborate social structures recorded in human history. The great religions of the world—including Hinduism, Buddhism, and the Judeo-Christian-Islamic traditions of the Bible and Qur'an—all emerged and flourished in agricultural societies.

Historical change accelerated once more during the colonial and industrial expansion of European culture and technology that began with the Renaissance and the discovery of the New World. This process produced the Industrial Revolution in the last decades of the eighteenth century as well as the successful harnessing of fossil fuels, as we saw in Chapter 7. When we met Gilbert White of Selborne in Chapter 2, we learned that the cultural idea of environmentalism also arose at the beginning of the age of fossil fuels.

Environmental sociologist William Catton has described colonialism and industrialization as the two most important breakthroughs in human history—and also as the two main roots of our current environmental challenges.[2] According to Catton, for most of our history, people lived in localized economies and accepted the limitations of doing so. Gilbert White saw a widening set of possibilities in the eighteenth century but decided not to pursue them, calling himself a "stationary man" (Chapter 2). With the discovery of whole new continents, however, it became possible for Europeans to create colonial trading relationships and obtain goods from far away. With the development of energy technologies, our ancestors could also appropriate energy from the distant past by burning fossil fuels. In Catton's view, the transformation is impressive, yet ominous because we have not yet learned

to live within sensible limits, the way our ancestors needed to live within their own limits until just a few hundred years ago.

Industrialization brought with it expanding human domination of the natural world, as you read in Chapter 6, together with another round of rapidly increasing human populations, discussed in Chapter 8. Although cities emerged with agriculture more than five thousand years ago, the scale of urban settlements shot up when faster and more powerful means of transportation made it possible to create the city-centered economy of the world without edges.

The ability of humans to affect the natural world escalated as we gained the capacity to organize larger numbers of people and, over the past two hundred years, harness the powers of industrial technologies. We do all this with brains and genetic endowments that seem not to have changed much for more than a hundred thousand years. As the pace of change increases, and as humans do more to intervene in natural processes that we understand incompletely, the chance of serious, irreversible damage also increases. Yet remarkably, the trajectory of the past two hundred years has been one of improving health and growing wealth. Some species have gone extinct, but their absence appears to have caused little inconvenience to human societies, at least so far, as discussed in Chapter 9.

As environmental thinkers such as Catton remind us, however, whether the human species can continue its unprecedented record of success is unclear.

POPULATION IS STABILIZING, BUT URBANIZATION IS ACCELERATING

One measure of the success of a species is its abundance. Human abundance has been increasing dramatically since the middle of the seventeenth century. At the end of the twentieth century, humans numbered more than 6 billion. But it does look as though the end of the demographic transition discussed in Chapter 8 is approaching, and has been doing so for more than a generation. As is shown in Figure 8.4, the rate of growth in human populations has been declining since the 1960s, and the absolute numbers of people added to the population each year have been dropping since 1990.

The projections suggest that the human population may stop growing during the lifetime of today's students at a level between 9 and 11 billion, or roughly 50 percent higher than today's 7 billion. A projection is not a prediction. This is an important point: the population analyses discussed in Chapter 8 do not include specific economic or social factors. Nonetheless, the length of time that the growth rate has been declining suggests that the slowdown is real and still under way.

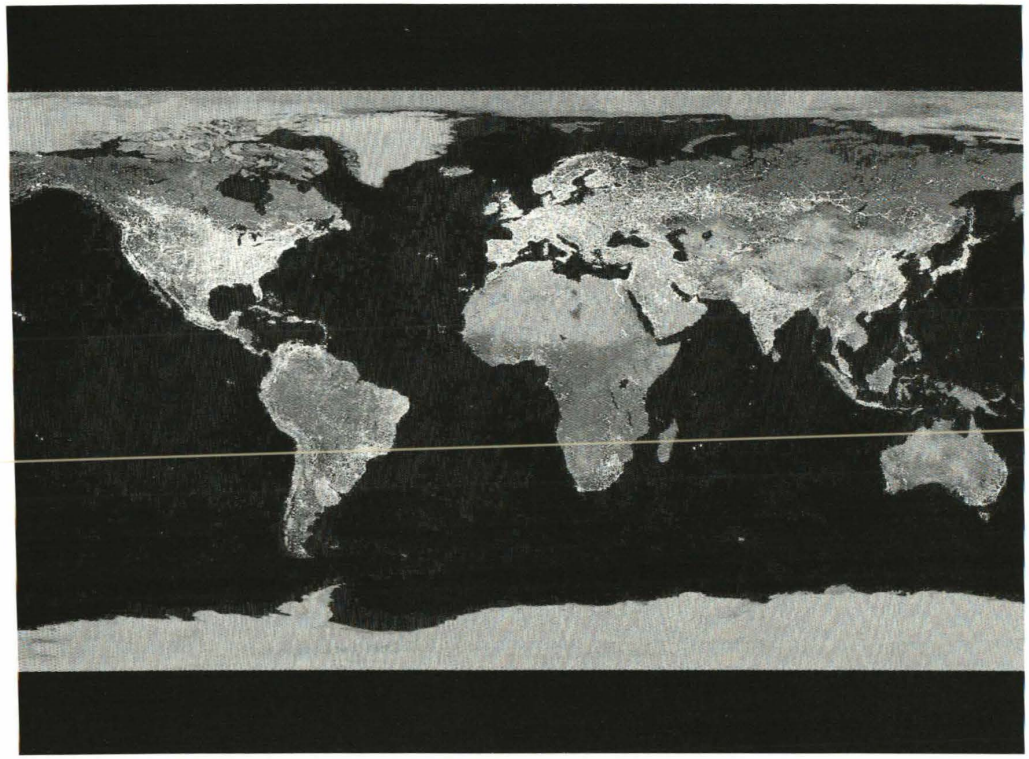


FIGURE 10.1
Earth at night.

As population grows by another 50 percent, the human species will also become more urbanized. One can see the distribution of cities on Earth by looking at the pattern of lights shining at night (Fig. 10.1). The rich parts of the world are the brightest now, but brightly lit areas are spreading, particularly in Asia, and they are likely to continue to do so.

The stabilizing of the human population will change a lot of other things. The current political debate over the future of Social Security is one example. As the proportion of young people decreases, the proportion of old people increases. Every community struggles to pay for those who are too old and too young to contribute directly to economic output. This is a problem to which no nation has found a solution. In poor societies retirement is a family concern, but in rich ones it is also an issue for governments. You might not think of retirement or Social Security as an environmental problem, but it is a problem of sustainable development. Meeting the needs of the present competes with the desire to afford future generations the ability to meet their own needs.

The broad pattern seems clear: population growth rates have declined as people become prosperous and, in particular, as the economic and social status of women has changed. But this pattern is not entirely consistent. Some nations, such as Bangladesh, have seen declining population growth rates before their prosperity has grown. This can occur when women and girls obtain new access to educational and livelihood opportunities even at relatively low income levels, leading a number of researchers to conclude that improved education for women, rather than overall levels of economic development, may be the real force in slowing population growth. Also, it is important to see that a slowdown in population growth may be less helpful for the environment than one might expect. The continued rapid increase in consumption is increasing what is loosely called the "human footprint," both in rich countries and in countries rapidly becoming richer, such as Brazil or India. Our enlarging footprint can outstrip a slowdown in the number of feet (the number of people added to the population). We will look more closely at consumption in Chapter 14.

As the momentum of the demographic transition has become clearer, climate change has displaced population as the chief concern of environmentalists. Similarly, over the past generation, concerns over loss of wilderness in the United States have broadened into support for conservation of biodiversity worldwide, with a focus on tropical waters and terrestrial ecosystems outside U.S. borders. And we may now be seeing concerns over suburban sprawl widening into an awareness of the environmental and social implications of rapid urbanization, particularly in Asia's booming economies and in the poorest nations. Environmentalists are, in these ways, coming to see the world without edges as the province of their activism.

ECONOMIC GROWTH IS CONTINUING, BUT POVERTY PERSISTS

One of the measures of human success is economic growth. From an environmental perspective, growth includes two very different kinds of change. The first is an expansion of the material scale of the economy—the human footprint. Second, growth also includes increases in the value and sophistication of economic activity. The widespread adoption of computers, for example, has increased the value of many workers' time on the job, increasing profits and sometimes pay. However, these increases may not mean that the impact on the natural world has increased. Raising the energy efficiency of a building is one example: it raises the value of the building in the real estate market but decreases its carbon footprint. Yet overall, the human domination of ecosystems has continued to expand, and economic

BOX 10.1

GROSS DOMESTIC PRODUCT:

Imperfect but Influential

GDP is defined as the market value of all final goods and services made within the borders of a country in a year. "Final" means that a market transaction belongs in the GDP if a consumer buys it, rather than a business simply buying something as part of its own production process. GDP includes, among other things, the value of food, gasoline, college tuition, and rent. It also includes expenditures made by government on behalf of its citizens, such as for enforcing government regulations or paying for police and fire departments.

GDP is a measure of economic activity, but it is usually understood to mean something much more: a measure of economic welfare or the well-being of the population. This wider meaning leads to highly consequential errors, as we will see below. But it is also nearly unavoidable because of the significance the GDP numbers have acquired since the measurement was first devised in the 1930s as part of an important advance in economic science. The Great Depression of that period afflicted all the countries in the world, with unemployment rates reaching more than 25 percent in the United States. Faced with this collapse, governments were drawn to intervene in the economy in unprecedented ways. This wider role for national government has now become accepted, and the responses to the worldwide recession of 2008 by Presidents Bush and Obama fit the pattern developed in the 1930s.

But if the government is going to intervene in complex markets, it needs to know what is happening economically. This need spurred rapid innovation, led by Simon Kuznets, a University of Pennsylvania economist who developed a system of national economic statistics, of which the GDP is the most prominent descendant. Kuznets was recognized with the Nobel Prize in economics in 1971, and these statistics have become an indispensable part of public policy making in a wide range of fields, including environmental regulation. Perhaps more significant, GDP has become the most widely watched gauge of the economy—and of political performance. GDP growth or decline has, over time, become correlated with the president's approval rating.

Economists and others who study economic activity recognize a wide range of shortcomings in the GDP indicator. GDP does not measure wealth or inequality, and those two important dimensions of economic welfare are not captured by the widely publicized GDP numbers. As an indicator, GDP does not distinguish

between economic activities that are undertaken to restore damage, such as the cost of rebuilding after a hurricane, and those that add in a positive way to human life. This produces anomalies: GDP increases when people receive high-cost medical treatments, but not if they are healthy and do not need medicines; GDP increases when people buy burglar alarms but not when crime decreases; GDP increases when air pollution damages crops or causes lung disease, but clean air does not change GDP. From an environmental perspective, this last example points to the fact that environmental harm originating from a poorly governed commons inflicts costs that are not captured in market prices. We will return to this subject in Chapter 13.

If GDP is limited and misleading, however, attempts to replace it have so far fallen short, in part because of the political significance that GDP reports have acquired. Later in this chapter we discuss the Human Development Index, a measure that incorporates GDP as only one dimension of a summary measure of human well-being.

growth is often a reasonable way to estimate the widening impact of our species on the world.

A widely used economic indicator is the gross domestic product (GDP) per capita (see Box 10.1: Gross Domestic Product: Imperfect but Influential, page 265). Consider the trends in GDP per capita over the past three centuries (Fig. 10.2). In this graph, note that the vertical scale is **logarithmic**, so that a straight-line trend represents **exponential growth** rather than linear change. This means that the figure is a description of continued doubling and redoubling. This kind of growth leads to major implications for human domination of natural cycles within a single lifetime, as happened when the beavers of New England were driven to commercial extinction less than a century after the arrival of the English settlers. Often, environmentalists have wondered whether economic growth can continue—a worry that has attracted attention among economists, too, in the wake of the global financial crises that began in 2008.

In the graph, notice that the current GDP per capita for Africa is approximately the same as North America in 1830, the time when the Hudson River School artists were painting and Henry David Thoreau made his sojourn to Walden Pond. It is ironic to think that when New England was roughly as rich as Africa is today, Thoreau was retreating from a society he felt was too materialistic.

The richest populations today include those whose populations are growing most slowly. This has not always been true. In the nineteenth century, for example,

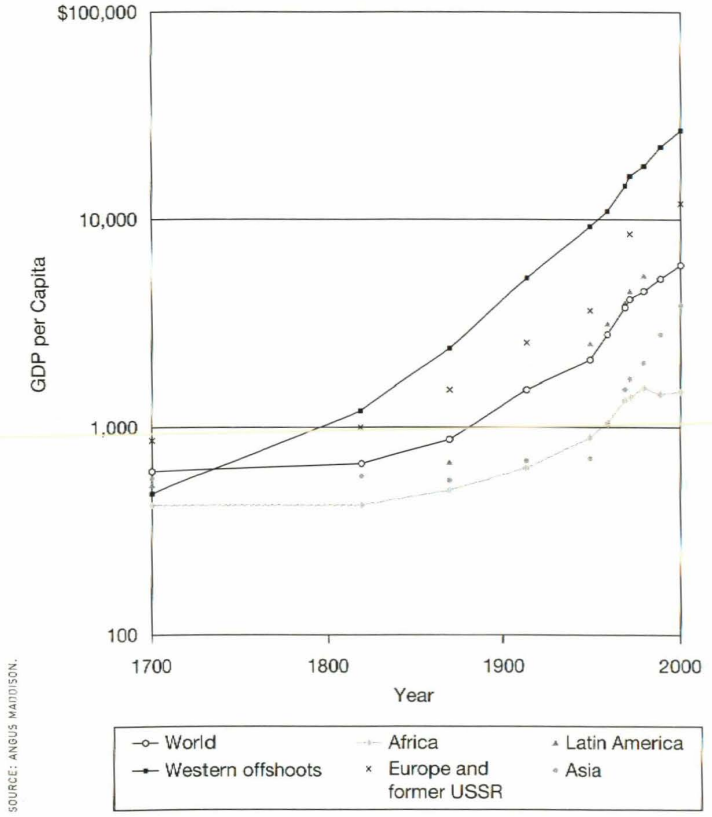


FIGURE 10.2
Gross domestic product (GDP) per capita, 1700–2000. GDP estimates have been adjusted to take into account inflation and differences in purchasing power in different national economies. (Western offshoots = Australia, Canada, New Zealand, and the United States.)

North America was growing rapidly in both population and economic terms, a pattern one sees in India today.

As you can see, the differences among the regions of the world in economic performance have been visible for a long time. The long-term trend, which stretches back to the eighteenth century, is toward widening **economic inequality**. The gap has been opening faster over the past generation. Today, the difference in GDP per capita between the richest and poorest regions is about a factor of 20, whereas this difference was about a factor of 2 in 1800. Figure 10.3 on page 268 shows how the world's 6 billion people in 2000 were distributed with respect to income; Americans are found at the right-hand end—many in the small tail at the extreme right. Notice that the inequality in Figure 10.2 has come about as the rich have been getting richer faster. The poor are getting richer, too, but more slowly.

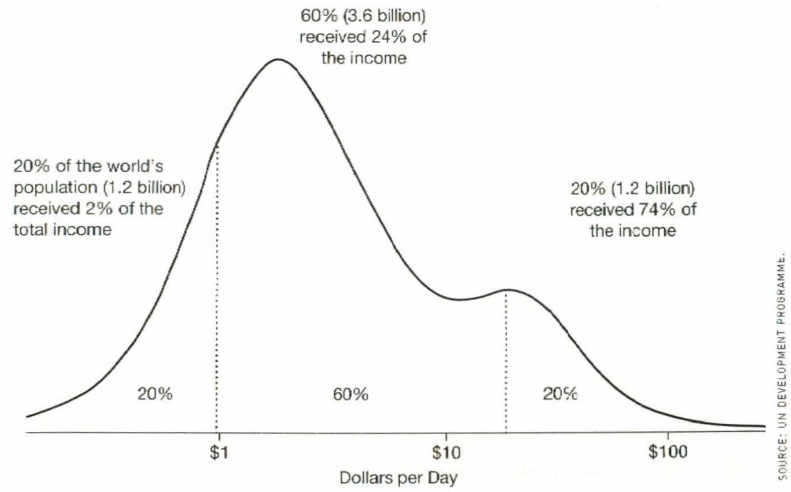


FIGURE 10.3
Distribution of income in the world in 2000.

Also bear in mind that what these plots show are averages over large populations. The very poorest people in every society, even the richest societies, are much poorer than these figures suggest, and the very richest are many times as rich. The differences in economic circumstances between individual families on the planet is thus far wider than these average numbers indicate.

More than 1 billion people worldwide live on less than a dollar a day. By comparison, the daily cost of attending a U.S. private college such as Dartmouth or Williams is more than 100 times as great. What does this extraordinary figure of a dollar a day mean? People cannot live on this amount of money. Instead, they live largely outside of markets, usually pursuing subsistence agriculture. They literally work for a living, getting food and meeting other material needs by labor rather than by getting paid and buying things.

One aspect of work in a very poor country is gathering wood for fuel—back-breaking labor that takes many hours every day. This work is done mostly by women and children in traditional societies (Fig. 10.4, page 270). Where populations grow but technology does not change, wood gathering puts increasing pressure on forests as trees are cut more rapidly than they can regrow. This also means that the wood gatherers must hike farther from home. Living in the wealthy part of the world without edges, we grasp only weakly the meaning of a subsistence life—both its moments of happiness and the too frequent frustrations and loss. (See Box 10.2: The Volunteer in the Cow Path, page 269, for one view.)

BOX 10.2

THE VOLUNTEER IN THE COW PATH

Living in a developing country for a time is an indispensable experience for an American who wants to be aware of the challenges of sustainable development. In the developing world, one finds three-fourths of the world's people—those for whom meeting the needs of the present are both difficult and urgent. In the tropics, where the developing countries are nearly all located, one finds the preponderance of the world's biodiversity. There, too, are some of the greatest opportunities to shift the trajectory of energy use into directions that slow global warming and promote human well-being—opportunities that will require substantial investment from rich nations. That is, the tropics are an arena in which sustainable development will either succeed or fail, and where the ability of future generations to meet their own needs will be tested, in parallel with the global ambition to improve well-being.

Dorothea Hertzberg is an American who joined the Peace Corps and was sent to Burkina Faso, a nation in western Africa whose Human Development Index score put it 174th out of 177 countries in 2006. One day, her bike broke down, and a man from the local Mossi people stopped to help her. He did not know how to repair the fancy American mountain bike Hertzberg had been issued, so he tied her bike behind his and towed her 7 miles through the blistering midday heat to the village she was trying to reach. She wrote in 2003:

> Two years ago, at the age of 27, I volunteered for Peace Corps service to "give back" to the world. Today, I realize I gained much more in return. . . . When I think back on that moment when I was stranded on that deserted cow path, there was a part of me that was calm, because I knew where I was. I was in a place where you never feel alone or abandoned because someone will always come along to help you; where a starving woman would give her last bowl of food to a stranger; where kids are elated to play with an old tire and a stick. A place where family unity is everything and the guest is paramount.[1]

By living among the people of a developing country, one learns, first, that some of the conveniences of life in a rich country are really important, but others are not. One also gains factual, analytical, and experiential understanding of ways of living that are at once different and profoundly similar to our own.

1. Dorothea Hertzberg, "A Lesson in Giving," *New York Times*, August 23, 2003, A13.

FIGURE 10.4
Villagers gather firewood in Java, Indonesia.

The poorest people today live in ecosystems different than those found in rich countries, however. Moreover, traditional uses of land and water are organized on principles that often conflict with notions of modern government (see Box 10.3: Nature, Wealth, and Power, page 271). For these reasons, the science and agriculture developed by rich countries cannot simply be transferred to the poor. In addition, large cultural gaps—in many instances turned into wounds by the cruel inequities of colonialism—have slowed the attempts of poor countries to enter the modern economic system. Since the end of colonial rule in the 1950s, the institutions of rich nations have sought to bring rapid economic growth to developing countries, most of which are located in the tropics. These institutions include the World Bank, the United Nations, and national aid agencies such as the U.S. Agency for International Development. Economic growth has been ardently desired by the leaders of poor countries and many of their citizens. Yet, as Figure 10.2 shows, these desires have been frustrated, and the gap between poor and rich has widened at an accelerating pace.

Only Asia has seen sustained regional growth, and even there one finds great contrasts between nations. Singapore and South Korea have created developed economies like Japan's, but the Philippines and Burma (Myanmar) have struggled. With the acceleration of growth in India and China over the past generation, however, have come large environmental costs, such as life-threatening levels of air pollution in industrializing cities.

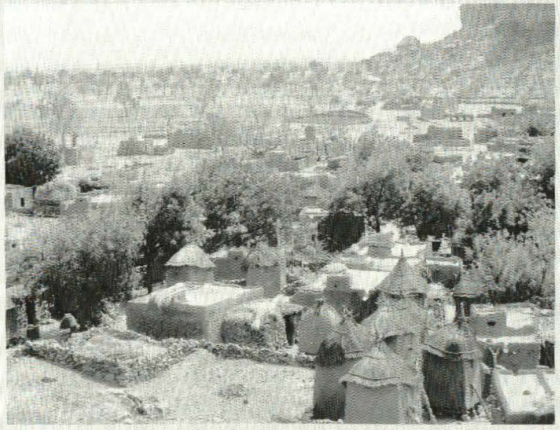
BOX 10.3

NATURE, WEALTH, AND POWER

Although ecosystem services are essential to life and well-being the world over, different societies organize their dependence on nature in different ways. In Chapter 8, we discussed the central role of infrastructure in creating a Second Nature in settlements familiar to Americans. In the western African desert nation of Mali, we see a different approach, yet it is one that makes sense when one thinks of the discussion of commons in Chapter 3.

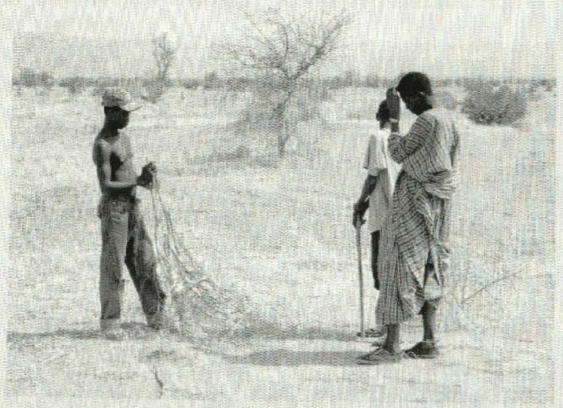
In the Malian village of Songo, the Dogon people have lived sustainably for generations, although the severe droughts in the Sahel not far away devastated large areas in the 1980s. In the photograph below, notice the parkland agro-forestry system of cultivation in the background: irregularly spaced trees stand amid farm fields bordered by lines of rocks, designed to retard the flow of rainwater from the infrequent storms that visit this arid land. In the foreground, within the village, granaries are clustered together.

In such a landscape, people manage their ecosystem services with care. Grass is essential to the survival of the animals around which the village economy revolves. In the second photograph, in a village not far from Songo, the man on the left is holding a rake made from the branch of an acacia tree. He has been gathering grass to haul off in his cart. But there is a problem: the grass is not his. He is from a distant community. The men on the right, from the local village, are enforcing the rules of the commons by confiscating the grass he has gathered. This is what happens in well-managed commons: a community lays claim to it, and its members monitor and enforce the rules that keep the use of the commons sustainable.



Songo, Mali.

Community rules are determined by the elders of a village, shown in the third photograph meeting in the sparse shade of a tree in the center of the settlement. But they face a problem. Under Malian law, the land does not belong to traditional communities such as theirs. It is instead public land that is owned by the government. This means that an outsider might come with a government permit to harvest timber or



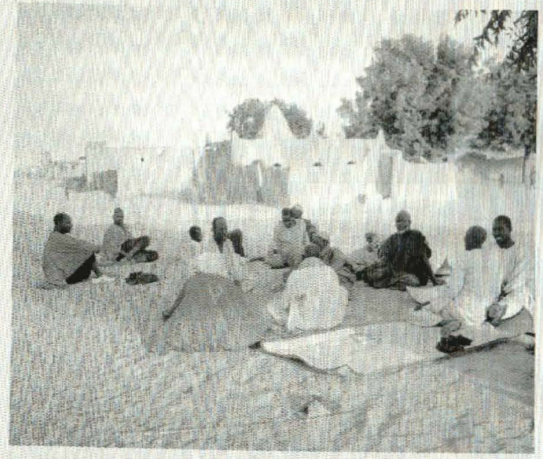
Enforcing rights to harvest grass for animal forage.

another valuable resource, and the national authorities, acting through the forest service officer in a nearby town, may enforce that permit over the objections of the local community.

Remember that the last of the eight principles of governing commons listed in Chapter 3 is that higher levels of authority must allow local rules to work. Where higher levels intervene, the commons may slide into tragedy. In this harsh environment, the word tragedy is not a metaphor but a description.

Until the late 1990s, international development agencies such as the World Bank favored modernization. This meant strengthening national governments' authority over their own territories so that economic development might take hold. This approach inadvertently fed corruption and incompetence in many governments, however, so there has been pressure in the last decade for decentralization, based on the recognition that top-down management does not work in many situations in very poor countries that lack adequate government administrators.

Yet the way the community organizes itself to govern its commons may not be fair or democratic as an American would see it. The elders in this village are all older men, and the minority ethnic groups of the community are not included in the governing council.



The Songo council of elders.

This puts a different light on top-down rule, perhaps. Consider the civil rights movement in the United States half a century ago. Quite a few white people living in racially segregated communities thought they were managing their commons—drinking fountains, buses, and public schools—just fine. So the imposition of rules in the name of majority rule at the national level can be disruptive to local communities, sometimes for a legitimate purpose.

Legitimacy is problematic in many situations in the developing world, where democratic rule can be dodgy and where local management of natural resources may indeed be far more sustainable when local people are

in charge. Whether management in this particular village is better left in local hands is not so clear from the U.S. perspective, however, in part because this apparently isolated village is in fact connected to the world without edges.

In some parkland ecosystems like the ones shown in these images, people gather sap from trees and sell it in markets that put the gum into consumer products we all know, such as the soft drink Mountain Dew. As we saw with the history of beavers in New England, connection of local resources to distant demand can lead to unsustainable harvesting and other practices that put pressure on ecosystem services and biodiversity.

The point for those of us in rich nations to take away is that community governance of commons can work and may be superior to the superficially modern institutions of central governments. This is a possibility that has often been overlooked in the headlong but frustrating pursuit of economic development.

We must not forget that the rise in economic activity has transformed the material conditions of human life. That is, despite widening economic inequality, the life chances of poor people—their **well-being**—have improved substantially in at least some parts of the world, such as East Asia. How do social scientists try to assess this notion of overall well-being? It is widely agreed that monetary income, although important, does not capture human well-being adequately. The UN Development Program, the world's poverty agency, has a simple way to bring together other important dimensions. The **Human Development Index** is a useful summary number that combines income with measures of health and education. The idea is that a population can enjoy significant well-being, even when its money income is not high, as long as people have good health and their children are learning the skills needed for life beyond subsistence agriculture. By this measure, the well-being of people in Albania (GDP per capita just under $4,000 per year) is slightly higher than that of people in Saudi Arabia (GDP per capita of $14,000 per year).

By these measures, human well-being in most regions has increased in recent generations (Fig. 10.5, page 274). Efforts the world over to cure disease, fight malnutrition, and provide basic education have made a real difference to billions of people. These are efforts carried out by pharmacists in small towns in Latin America, by the World Health Organization and the Rockefeller Foundation, and by teachers in villages and cities from western China to the Muslim suburbs of

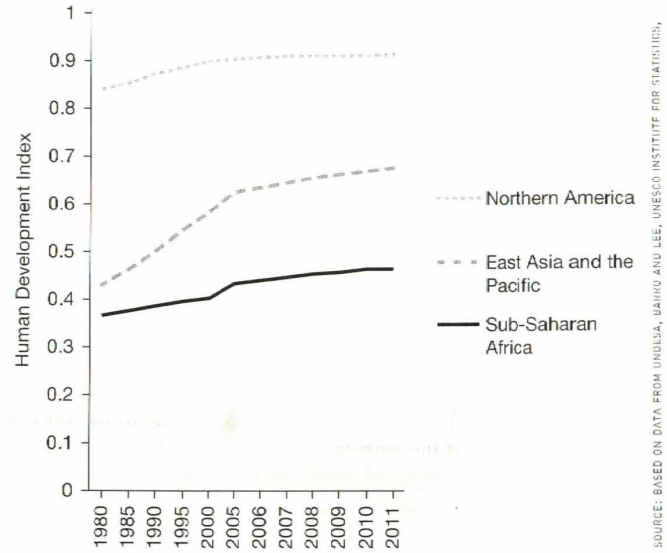


FIGURE 10.5
The Human Development Index in three geographic regions, over time.

France. The real concerns that persist—especially in sub-Saharan Africa—should not obscure this immense and historically unprecedented progress (see Box 10.4: Health and Wealth over Half a Century, page 275). One of the direct consequences of the dramatic decline in infant mortality in many societies is that families have fewer children because they are confident that the children they have are more likely to survive.

It is important to bear in mind that these increases in well-being have made the most difference in poor countries, where reductions in child mortality and increases in education have greatly raised the life chances of hundreds of millions of people. The Human Development Index is a rough and ready measure, combining readily available data in a simple way. If one looks deeper, however, the picture becomes more complicated and less rosy. Rising economic inequality in the United States, for example, has meant that median income has risen over the past forty years mainly because more women have gone to work. However, their unpaid services, such as child care and household management, still must be done, so the net increase in well-being of families is low and negative in many instances. Surveys of people's satisfaction with their lives in the United States and other rich countries indicate little change over time. That is, a rising average income does not necessarily lead to greater fulfillment or contentment.

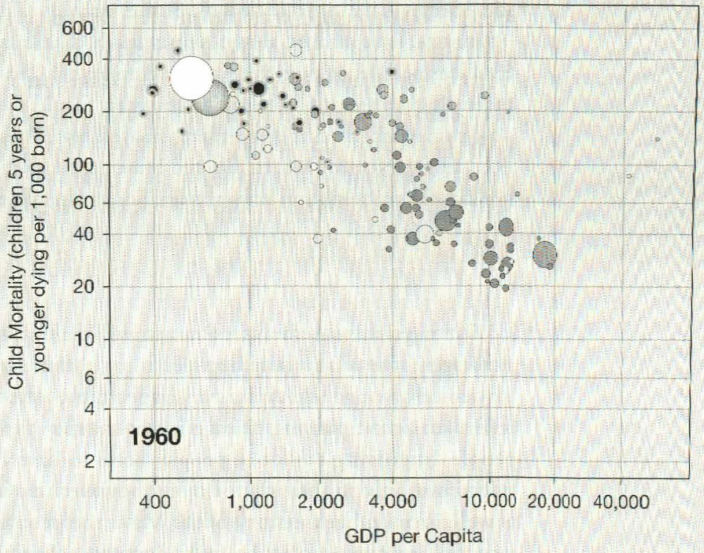
BOX 10.4

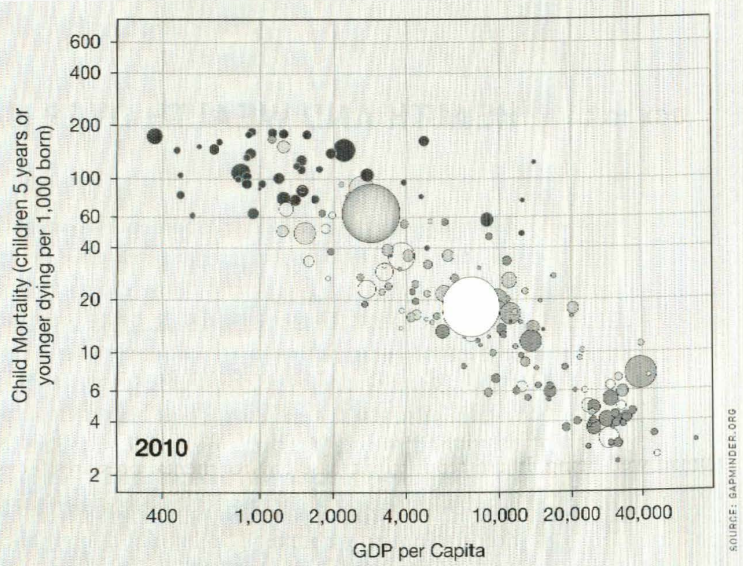
HEALTH AND WEALTH OVER HALF A CENTURY

The first goal of sustainable development is to meet the needs of the present. How well have we been doing in pursuing that goal? (See video by Rosling cited at the end of this chapter.) The graphs below show two snapshots of the world's nations in 1960 and 2010. They are plotted to bring out four different pieces of information. Each country is shown as a circle whose size is proportional to its population; the circles are shaded by region. In the graph for 1960, the large circle at the upper left is China; you can see how China has grown in population and wealth during this period because it is the largest circle in the middle of the graph for 2010.

Along the vertical axis is plotted child mortality, a statistic that is regarded as a basic indicator of the health of a population. The better the health of a population, the lower the country's circle will be. Along the horizontal axis is plotted the standard economic measure, GDP per capita. You'll see that in both 1960 and 2010, the nations of the world lay along a rough diagonal line. That is, a correlation exists between health and income: in poorer nations more babies perish, and in richer ones more survive.

(a)





Child mortality and GDP per capita for the countries of the world in 1960 (a) and 2010 (b).

Now compare the plots for 1960 and 2010. The world has gotten richer (the circles have moved to the right), and the world has also seen infant mortality drop (the circles have moved down). Some, such as China and India, the two largest circles, have moved down substantially. These two nations house more than 2 billion people, or one-third of the human race. So their improvements in health mean that tens of millions of babies who would have died a half-century earlier now survive. But other circles have moved, too. These are large changes in human experience. Notice that the United States, the largest circle in the lower right corner, has fallen behind in infant mortality compared to other rich nations.

The rapid improvements in human well-being among the poorer nations mark a change in the relationship between microparasites and their human hosts. People, particularly young children, live longer more often. This change also seems to reflect an accompanying change in the relationship between macroparasites and people. Improving the lot of people seems to have become an objective of many rulers, not only in their rhetoric but, however unevenly and haltingly, in practice as well. Remember the story of the Maya: the people who suffer as ecosystem services fail and the people who make decisions affecting the suffering are usually not

the same individuals. Building reliable linkages, such as democratic accountability, between rulers and those who feel the impact of their rule can make a difference.

Yet in the world without edges, many kinds of actions and consequences have become more widely separated and distant, crossing national boundaries more often than before. At this point in history, the rich live mainly in temperate regions, the poor in tropical places. The poor nations live in ecological and social settings altered, sometimes drastically, by colonialism. A disconnection is evident at the conceptual level: it is difficult for Americans to understand how tropical ecosystems are vulnerable. This makes the relative powerlessness of tropical peoples even more problematic. Not only are those affected not the main decision makers but the main decision makers don't understand the ecosystems their choices are changing. Some relevant differences are summarized in Table 10.1 on page 278. The point is that the differences are great—biologically, economically, and culturally.

As one would anticipate, rising economic activity does more than improve human well-being. It also tends to increase environmental pressures. These pressures are transforming ecosystems, just as the European colonists changed the landscapes of the Americas. But now, when these pressures are played out in tropical settings rich in endemic species, there is widespread but hard-to-see erosion of biodiversity, as discussed in Chapter 9. There are exceptions, however: urban air quality is better in wealthy cities such as London and New York than in less prosperous cities such as Delhi and Johannesburg. Still, indicators such as energy use, carbon dioxide emissions, and solid waste generation seem to increase steadily with income.

What is more immediate, and yet still invisible, is that we continue to depend on the services provided by these modified ecosystems. The poor see their dependence on ecosystem services clearly, especially if they earn their livelihood by subsistence, living directly from nature. Crops, water, protection from floods, and the waste treatment provided by healthy wetlands are all essential to life and well-being. But, being poor, people who live from subsistence agriculture cannot do much to secure ecosystem services if they are imperiled. Instead, they can suffer from forms of enclosure that are every bit as severe as those suffered by English grazers hundreds of years ago, as discussed in Chapter 3. If a mangrove swamp long used by fishermen is cleared to grow shrimp for European food markets, for example, the poor people there, whose lives once depended on catching fish from those wetlands, often cannot do much about it. Their fate is like that of the herders who once depended on the common grazing lands in Europe, who were driven from their customary lands. Many of the survivors became workers in urban factories, a pattern now seen in Asia.

The rich nations can readily harvest ecosystem services and have done so for a long time. We do this through the infrastructure of urban and suburban environments. We take those services for granted. Our food is inexpensive and our

TABLE 10.1 SOME DIFFERENCES BETWEEN THE TROPICAL (POORER ECONOMICALLY, RICHER BIOLOGICALLY) AND TEMPERATE REGIONS OF THE HUMAN ECOSYSTEM.

Environmental issue (and location of book discussion)	Tropical regions	Temperate regions
Climate (Chapter 5)	Equatorial cell: desert, monsoon, rain forest	Mid-latitude cell: clearly marked seasons, Mediterranean
Biological diversity (Chapters 5, 9)	High; many localized (endemic) species	Low to moderate
Impact of land clearing (Chapters 2, 5, 9)	Widespread loss of species (irreversible extinction)	More local loss of species (recovery over decades)
Political history (Chapters 10–12)	Colonial: local culture stressed or extinct; indigenous institutions delegitimated	Imperial: dissemination of culture and institutions; rising influence of environmentalists
Population distribution (Chapter 8)	75% of human population	25% of human population
Population growth (Chapter 8)	Rapid but slowing; more than 90% of population growth is here	Slow, negative in some places
Urbanization (Chapter 8)	Rapid urbanization (migration; land conversion)	Sprawl (land conversion; traffic)
Wealth and income (Chapter 10)	Poor, high inequality	Rich, moderate to low inequality
Consumption per capita (Chapters 10, 13, 14)	Low (chronic hunger) to moderate	High to very high
Energy use per capita (Chapters 7, 14)	Low	High
Economic base (Chapters 2, 10)	Agrarian, often with communal landholding	Industrial and information economies, with private and state-owned property dominant
Dependence on environment (Chapters 6–8, 10)	Direct impact on economic production	Localized impacts on health, aesthetics; large, global, indirect impacts through consumption and investment
Cultural orientation (Chapters 2, 10, 11)	Historically "stationary" and traditional	"Edgeless," highly mobile

nutritional problem is obesity rather than hunger. We also use the bulk of the fossil fuels produced each day, driving climate change. Our consumption propels the world's manufacturing and shapes investment. So much of it is out of sight, though, that the environmental and social implications of industrial production are now largely out of mind, too.

The rich cause environmental problems of which they are only dimly aware. The poor suffer environmental problems that they are powerless to solve. To this paradox, add the challenge of thinking about the future. This is the grand challenge of sustainable development—meeting the needs of the present, including the needs of the more than 1 billion people who live in absolute poverty, but without compromising the ability of future generations to meet their own needs. At present, we are far from meeting this grand challenge. Over the course of your lifetime, it will become increasingly critical to do better.

The grand challenge of sustainable development, as we now see, means that we must conserve the ecosystem functions that deliver services needed by humans. We don't fully know how to do that, except by protecting entire ecosystems, such as watersheds that supply drinking water. As you know from Chapter 9, we are far from being able to conserve large, complex ecosystems, though we have made some progress.

"THE SCALE OF OUR COMPETENCE"

Like the other grand challenges, sustainability is daunting. Clearly, in the world without edges, virtually all people have become citizens of the planet. What is not clear is how to respond.

For many of our students over the years, the reaction to learning about environmental problems has been guilt and anger—guilt at the role each of us plays in the consumerist economy of the United States, and anger that this should be so. Given the logic of the commons, together with the disproportionality between individual consumption and collective environmental impact, the personal changes induced by guilt are not enough to cure the problems that arise from defective institutional arrangements. Moreover, the scale of the world without edges implies that the institutional changes that might be suggested by anger will not be achieved easily or soon. These are frustrating realizations. What can a person do to gain perspective about the problem?

In a provocative 1989 essay entitled "The Futility of Global Thinking," poet and writer Wendell Berry wrote that "our understandable wish to preserve the planet must somehow be reduced to the scale of our competence."[3] Berry derided those who proclaimed an environmental crisis of planetary dimensions. "Nobody,"