THE ECONOMICS OF SUSTAINABLE DEVELOPMENT

Sisay Asefa, Editor

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Sisay Asefa

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1
The Concept of Sustainable Development

An Introduction

Sisay Asefa
Western Michigan University

Sustainable development is the concept of a relationship between economic growth and the environment. The term was first used in 1987 by the World Commission on Environment and Development (also known as the Brundtland Commission for its chair, Gro Harlem Brundtland). In the commission's report, "Our Common Future," it defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development 1987). Although the term has been around for almost two decades, differing interpretations have kept it from being a useful guide for development policy. However, there is now progress in moving the concept toward a more productive exploration of the relationship between economic development and environmental quality. For example, the International Summit on Sustainable Development that convened in Johannesburg, South Africa, in September 2002 provides some promise along this line (Hayward 2003).[1]

Sustainable development analysis differs from the standard economics of growth and development by incorporating natural resources as a form of *natural capital*, defined as the value of the existing stock of natural resources such as forests, fisheries, water, mineral deposits, and the environment in general. Natural capital provides goods and services to people, just as do financial capital, manufactured capital, and human capital, the last created by investments in education and health. The depletion of natural capital can be compensated for, in part, by investments in manufactured and human capital. Conceptually, sustainable development can be measured by taking a country's Gross National Product (*GNP*) and subtracting Depreciation of Manufactured Capital (*Dm*) and Depreciation of Natural Capital (*Dn*) to find Sustainable Net National Product (*SNNP*):

$$GNP - Dm - Dn = SNNP.$$ [2]

It follows that Sustainable Net National Product (*SNNP*) can be expressed as

$$SNNP = GNP - Dm - Dn = C + S - Dm - Dn,$$

where Consumption (*C*) plus Total Savings (*S*) minus Depreciation of Manufactured Capital (*Dm*) and Depreciation of Natural Capital (*Dn*) forms the equivalent of the previous equation. This yields the basic sustainability criterion that Net Savings (*NS*) equals Total Savings (*S*) minus Depreciation of Manufactured Capital (*Dm*) minus Depreciation of Natural Capital (*Dn*), which must be positive:

$$NS = S - Dm - Dn > 0.$$

Moreover, if Depreciation of Human Capital (*Dh*), whether in the form of brain drain or in the form of deterioration in the quality of education and health, is included, Sustainable Net National Product (*SNNP*) can be adjusted as follows:

$$SNNP^* = GNP - Dm - Dn - Dh = C + S - Dm - Dn - Dh,$$

or

$$NS^* = S - Dm - Dn - Dh,$$

where

$$SNNP^* = SNNP - Dh$$

and

$$NS^* = NS - Dh.$$

The basic criterion of sustainability can now be restated as Net Savings (NS^*) must be greater than zero after depreciation of manufactured, natural, and human capital are accounted for, or

$$NS^* = S - Dm - Dn - Dh > 0.$$

This implies that an economy becomes unsustainable if it fails to reverse the depreciation of the three forms of capital—manufactured, natural, and human—or, put another way, if natural resources are degraded and the quality of education and health deteriorates. The effect would be the same if capital flight—including the flight of human capital, or brain drain—occurs in a given country.

Natural and other forms of capital, such as manufactured and human, are both complements and substitutes. Improving either manufactured or human capital can increase natural capital such as soils.

Many of agriculture's gains in land productivity are a direct result of investments in human capital and in farmers' knowledge as much as they are in manufactured capital (investments in mechanical and biological technology such as machinery and improved seeds). So it stands to reason that there is marked deterioration of natural capital in the form of soil erosion, deforestation, and water depletion in economies where manufactured and human capital is lacking, such as in Africa. It is reasonable to assume that there is a finite or limited substitutability between natural and other forms of capital; therefore the preservation of various forms of capital for future generations is crucial, since it matters what type of capital assets future generations inherit from the current generation.

SOME HIGHLIGHTS OF THE CHAPTERS

The six chapters that follow explore various dimensions of sustainable development from an economic perspective. The chapters grew out of essays that were delivered at the fortieth annual Werner Sichel Economics Lecture-Seminar Series, organized by the Department of Economics at Western Michigan University. I directed the series, and the W.E. Upjohn Institute for Employment Research cosponsored it with the university. The six authors in the volume cover a number of sustainable development issues: neglected aspects of sustainability (Malcolm Gillis); inequality, conflict, and war (E. Wayne Nafziger and Juha Auvinen); scientific constraints on sustainable agricultural production (Vernon W. Ruttan); economic perspective on population growth (David Lam); the relationship between property rights and environmental sustainability (Daniel W. Bromley); and rural poverty and sustainable natural resource management (Scott M. Swinton). This introductory chapter will highlight some of the authors' main arguments, preparing the reader for more detailed discussion and analysis by the individual authors.

In the first chapter, Gillis notes that the concept of sustainable development has become quite popular in recent years; there is now even a Dow Jones Sustainability Index, intended to guide managers to opportunities to secure "green growth" based on an improved natural environment—the need for clean air, clean water, and a healthy ecosystem on which human beings depend. An understanding of sustainable development, he says, involves disciplines such as ecology, biology, ethics, economics, chemistry, physics, statistics, and engineering. Economics has a crucial role to play in this multidisciplinary endeavor. Thus, the focus of his chapter is on exploring from an economic perspective a sustainable development path that maximizes the long-term net benefits to humankind, taking into account the costs of environmental and natural resource degradation. Gillis points out that sustainable development is important for all societies but is especially critical for poor ones, which depend more heavily on natural resources such as soils, rivers, fisheries, and forests than do richer nations. Environmental problems in developing countries are primarily driven by poverty, while those of wealthier countries are driven by affluence and overconsumption (Perkins et al. 2001).

Examples of affluence-driven environmental problems include the overuse of energy and fuel, highway congestion, and congestion of fragile watersheds and beaches with vacation homes. Poverty-driven environmental degradation includes deforestation and soil erosion. Gillis points out that until a few years ago 20 percent of the land in Ghana (which was once covered with forests), still remained in forest. But the forests have now receded to less than 5 percent of the land. The problem is similar in many poor economies of Africa, Asia, and Central

America. It is estimated that 80 percent of the trees that are felled in developing countries are cut down for use in cooking.

Beyond the problems brought on by poverty and affluence, Gillis discusses two additional factors that undermine sustainable development: market failure and government policy failure. Market failure comes from the underpricing of natural resources not traded in private markets; it can also be caused by monopolies, externalities, and high transaction costs. Policy failure arises from overlooking the environmental consequences of economic policies such as those governing the tax code, the exchange rate, industrialization and agricultural and food prices. Policy failure often results from a lack of knowledge and understanding by policymakers of the role of markets and prices in resource conservation and ecological protection.

Such policy failures include short-sighted subsidy programs that undervalue soils, forests, water, and energy resources. Gillis notes that energy policy failure has led to unsustainable development in oil producing countries such as Nigeria, Indonesia, and Venezuela in at least three ways:

1) Subsidies lead to overconsumption of energy.
2) Excessive use of cars and the fuel they burn adds to congestion and air pollution.
3) Promotion of cheap energy results in capital-intensive industry inappropriate for a country's resource endowments.

For example, Indonesia subsidized kerosene for 15 years with the aim of helping the poor by reducing the cutting of wood for fuel. But research showed that poor rural families used kerosene for lighting and not for cooking. Furthermore, over 80 percent of kerosene was consumed not by the poor but by relatively wealthy or higher income households. Thus, Indonesia protected some 50,000 acres of forestland each year at a cost of $200,000 per acre, for an annual program cost of $10 billion.

Agricultural subsidy is another example of government policy failure, according to Gillis. This involves the underpricing of chemical fertilizer and herbicides, resulting in overuse of fertilizer, which actually reduces the soil's fertility in tropical agriculture. Agricultural subsidy also results in the overuse of chemicals such as herbicides and pesticides, which actually increase infestation by agricultural pests because of their greater effects on the natural predators of pests. Thus, sustainable use of resources is possible if governments work to correct both market and policy failure.

The following chapter, by E. Wayne Nafziger and Juha Auvinen, discusses the complex relationships that spring from conditions like economic development, inequality, conflict, and war. Nafziger and Auvinen explain how economic decline, income inequality, and weakening or failing states with pervasive rent seeking by ruling elites and by rebels threaten the survival of people in developing societies. Nafziger and Auvinen maintain that competition for control of mineral exports leads to elite- and rebel-driven conflicts that contribute to wars and humanitarian disasters for these societies. Their chapter takes a political economic approach, which includes not only economic analysis but also an examination of the interests of political leaders, rebels, and economic policymakers, and the effects of their decisions on poor societies. Their data are based on a research project that began in 1996 between the World Institute for Development Economics Research (WIDER) of the United Nations University in Helsinki, Finland, and the University of Oxford in England. This project examined 17 case studies of war-afflicted developing countries for periods that ranged from the late 1960s to 2000, including Nigeria, Pakistan, Rwanda, Burundi, Congo, Sudan, Somalia, Liberia, Sierra Leone, Afghanistan, Cambodia, Iraq, Haiti, El Salvador, Colombia, Bosnia, and the South Caucasus.

Nafziger and Auvinen point out that there has been an increase in internecine conflict and humanitarian emergencies in Africa in the last two decades of the twentieth century, which is linked to negative per capita income growth. Indeed, the continent has the world's highest death rates from wars and humanitarian emergencies such as famines. These maladies revolve around economic stagnation and are driven by misguided government policies. Per capita GDP in Africa was lower in the 1990s than it was in the 1960s, when most African countries were becoming independent from European colonialism. Writing in the 1960s, the eminent economist Gunnar Myrdal of Sweden forecast great promise for Ghana and other African states, and a dismal one for Asia and for South Korea in particular. But over the next few decades, African economies declined while East Asia and South Korea burgeoned as vibrant middle income economies.

Although several factors may contribute to the economic problems of African states, the single most important one is the problem of predatory rule that results from monopoly. Political and economic power concentrate in the hands of authoritarian regimes that rule by coercion, rely on personality politics, and degrade the institutional foundations of the economy and the state, according to Nafziger and Auvinen. Such a predatory state is controlled by elites that extract rents rather than provide incentives for economic growth or the creation of wealth. Much of their revenue comes from transfer payments of bilateral or multilateral international aid. In most of these states, the authors point out, ruling elites and their clients use their monopoly on political positions to plunder the national economies through corruption, graft, and extortion. Instead of serving a public cause, the state in Africa tends to be privatized, or appropriated to the service of private interests by the dominant faction of the elite, Nafziger and Auvinen write. This, combined with rulers who stay in power for unlimited periods, leads to violent resistance by rebels. Resistance is fiercest in those states in the thrall of dictatorial rule and possessing rich mineral resources, such as the former Zaire (now the Congo) under former president Joseph Mobuto, and oil-rich Nigeria under former president Sani Abacha. What this implies is that natural resource wealth can be a curse in nondemocratic societies, where economies are subverted by elites with highly concentrated political and economic power.

Nafziger and Auvinen challenge the common view that ethnicity or tribalism is the primary cause of economic decline and state conflict in African societies. Rather, they assert, ruling political elites invent and impose ethnic tensions on society as a way of maintaining power. Thus, ethnic hostilities are merely a symptom of the real problems: poverty and lack of protection of individual rights and liberty. Furthermore, rebel organizations actively manufacture ethnic grievances, Nafziger and Auvinen say, as a necessary way of motivating their forces, which results in chaos for African societies and plunder of African economies. Consequently, where conflicts occur in ethnically diverse African societies, it will appear as though they are caused by ethnic or tribal hatreds. A good example of a state creating divisions where there were none occurred in Somalia. The state of Somalia in the Horn of Africa subregion is one of the most homogeneous ethnic states on the continent. The Somalis speak the same language—Somali—and have the same religion—Islam. But clan-based conflicts between the ruling elite and rebels over scarce natural resources led to a collapse of the Somali state in 1991 and the ouster of dictator Said Barre.

Thus, social scientists that study African societies and economies must rethink their claim that tribalism is the primary cause of conflict. The conflicts most often arise when authoritarian rule is challenged by rebels and rulers refuse to make credible economic and political reforms because of their selfishness, fear of losing power, and lack of a long-term vision. Decentralization and democratization are evolutionary processes that cannot be imposed from above by a dictator or from outside by foreigners. They require the emergence of enlightened leadership that focuses on growing the economy and on carrying out credible political reforms that lead to democratization.

Nafziger and Auvinen's conclusion asserts that the major changes that developing states need to make to achieve sustainable development are economic and political ones. These include the development of a working legal system, financial institutions that increase earnings (and thus taxing capacity), a well-functioning factor and exchange rate market, targeted programs aimed at helping the poorest segment of the population, and the promotion of democratic institutions of governance that lead to representative government and accommodate various ethnic and religious groups and communities.

The next chapter, by Vernon W. Ruttan, examines the sources and constraints of productivity growth in world agriculture. Ruttan traces the role of agriculture in economic development thought, beginning with the years after World War II, when agriculture was viewed as a sector from which resources could be extracted to fund the industrial sector. While this early literature recognized agriculture as a precondition for economic growth and development, he notes, the process by which agricultural growth was generated eluded most development economists.

A new perspective, informed by advances in agricultural science and economics, began to emerge in the 1960s with the recognition that agricultural technology was location-specific and that technologies developed in industrial countries are not directly transferable to developing countries. In the midst of this new thinking, a small but important book by Theodore W. Schultz, *Transforming Traditional Agriculture,* was published. Through empirical observation, Schultz (1964) induced that peasants in agrarian economies are rational persons who allocate scarce resources efficiently, and that their poverty is a result of the limited technical and economic opportunities to which they can respond through enabling institutions. In other words, Schultz maintained that peasants are "poor but efficient" rational agents that respond to economic incentives, not irrational beings as had been argued by some economists of an earlier generation.

The Schultz thesis implies three types of relatively high-payoff investment areas in agricultural development: 1) the capacity of agricultural research institutions to generate new location-specific technical knowledge; 2) the capacity of the technology supply industries to develop, produce, and market new technical inputs; and 3) the schooling and the extension education of rural people to enable them to use new technology effectively. This high-payoff model contributed to the success of green revolution crop varieties at the time. The high-payoff input model, however, did not explain the conditions that induce the development of new institutions, such as public-sector agricultural experiment stations, which supply location-specific knowledge and technology. This required another breakthrough in development thinking under a model of induced technology, in which the development and application of new technology is endogenous to the economic system.

The new model, pioneered by Hayami and Ruttan (1985), suggested that technical change was driven by changes in relative resource endowments and factor prices, in which new technologies are developed to substitute a relatively abundant or cheap factor for a more scarce or expensive factor. This calls for a choice between two kinds of technologies: mechanical and biological. Biological technology involves "land saving" technology designed to substitute labor-intensive production practices and inputs such as fertilizer and plant or animal protection chemicals for putting new land in production. Mechanical technology involves labor saving technology designed to substitute power and machinery for manual labor. These two types of induced technology in agriculture were historically demonstrated in the economic growth of Japan, which focused on biological and chemical technologies, and that of the United States, which adopted mechanical technologies (Hayami and Ruttan 1985; Ruttan 1988).

The implication of Ruttan's essay is that for most developing countries today with high population growth and density, the appropriate technology to pursue should include the advances and application of biological technology that are most relevant to that country. Such technology comprises three elements, according to the author: 1) land and water development to provide a favorable environment for plant growth, 2) the addition of organic and inorganic sources of plant nutrition to stimulate plant growth and the use of biological agents and chemicals to protect plants from pests and pathogens, and 3) the selection and breeding of new, biologically efficient crop varieties specifically adapted to respond to those elements in the environment that are under management.

Ruttan maintains that in rural areas of developing countries, growth in land and labor productivity has led to a substantial reduction in poverty, especially in East Asia and India. During the next 50 years, soil degradation may present serious constraints in some fragile resource areas such as the semiarid and arid regions of sub-Saharan Africa. Subregions such as north China and northeast Africa will experience absolute or severe land and water shortages. Ruttan holds that the achievement of sustained growth in agricultural production over the next half century represents at least as difficult a challenge to science and technology as the transition to a science-based system of agricultural production did in the twentieth century. He provides a rare optimistic perspective on the current bleak state of agriculture in sub-Saharan Africa by noting that for countries where land and labor productivity levels are furthest from pace-setting levels, such as in sub-Saharan Africa, opportunities exist to enhance productivity substantially. These countries would find it beneficial to acquire capacity for agricultural research and technology transfer. In his conclusion, Ruttan warns that if the world is to meet its food demands over the next 50 years, institutional innovation must play at least as great a role as technology.

Chapter 5, by David Lam, provides an economic perspective on how the world survived the so-called population bomb. The half century from 1950 to 2000 experienced unprecedented population growth, yet mankind achieved a decline in poverty in the developing regions of the world, with the exception of sub-Saharan Africa.

Lam notes that world population, which stood at 1 billion in 1900, reached 2 billion around 1930, then added another 4 billion by the year 2000. Given the current age distribution and trends in fertility and mortality, it is unlikely that world population will double in another 40 years, which makes the 1960–2000 period unique in human history.

Before the population explosion began, the world had high birth rates, high death rates, and a relatively low population. But during the first half of the twentieth century, death rates fell rapidly and birth rates initially remained high, generating a gap that caused the rapid rise in population.

A large rise in births leads to an increase in the size of the childbearing population 20 to 35 years later, which in turn creates a powerful mechanism for population momentum. This implies that even with the sharp fertility decline in the 1970s and 1980s, the number of births in many countries will continue to grow for several decades as a result of an increasing number of women of childbearing age. Thus, population will expand for some time to come, even if countries reach replacement fertility rate.

The potential impact of population explosion was dramatized in such writings as Paul Ehrlich's *The Population Bomb* (1968) and the Club of Rome's *The Limit to Growth* (Meadows et al. 1972), both of which envisioned a doomsday scenario in terms of food production, depletion of nonrenewable resources, and rising commodity prices. But the opposite happened: food production increased faster than population between 1961 and 2003. Per capita food production grew by 0.7 percent annually and total food production by 2.4 percent annually during this period. Per capita food production in 2003 was 31 percent higher than in 1961. Moreover, in spite of the warnings made in the 1970s and 1980s that the green revolution would not last forever, the data show no indication that food production will not keep up with population growth, especially given the declining rate of population growth, Lam notes. For example, India, which suffered from famines in the 1960s in much the way Africa is currently suffering, has increased per capita food production to 23 percent above its 1961 level, even though its population has more than doubled since then.

One of the best indicators of whether the world is running out of resources, Lam says, is whether commodity prices are increasing. Here he points out that there has been a decline in four broad real price indices from 1960 to 2000. Prices decreased 40 percent for metals and minerals, 54 percent for food, 60 percent for overall agricultural commodities, and 54 percent for all nonenergy commodities. The exception to falling commodities was petroleum, which, driven by the Organization of the Petroleum Exporting Countries (OPEC) Cartel, rose by the year

2000 to 3.6 times its price in 1960, the year OPEC was formed. But over a period in which world population doubled, real commodity prices declined by more than 50 percent, excluding petroleum. Advances in agricultural production played a crucial role, as did economic globalization led by trade liberalization and advances in global transport and communication.

Lam finds that most developing countries have experienced a marked decline in poverty over the past two decades. The percentage of the population mired in absolute poverty was measured as a ratio of the number of people who earned less than $1 per day to the total population. This percentage declined from 40 percent in 1981 to 21 percent in 2001, and the absolute number of people in poverty fell by 25 percent, from 1.48 billion to 1.10 billion. The largest decline over this period came in East Asia and the Pacific, where poverty fell by more than 40 percent. In general, poverty fell rapidly in Asia and gradually in Latin America. But in Africa, the percentage of people in poverty increased from 40 to 50 percent, and the absolute number of people in poverty roughly doubled over the 20-year period.

Lam's research shows that the total fertility rate (TFR) for major regions of the world declined over the last half century. Asia and Latin America experienced the fastest declines; Africa went through a more gradual decline. The tradeoff between the quantity and the quality of children is a central feature of economic theory of fertility as articulated by Becker and Lewis (1973), who showed that rising incomes lead to replacement of quantity of children with quality of children. Child quality is enhanced by expenditures on children such as investments in schooling, health, and nutrition. Lam points out that Brazil constitutes one of the best examples of rapid decline in fertility without a major effort at family planning. Here, parental schooling, especially of the mother, is a key factor in women having fewer children and in decreases in infant mortality.

Lam concludes that the world's ability to make gains in areas like food production and poverty reduction in the face of increased pressures on resources bodes well for challenges of the twenty-first century such as ocean fishing, global warming, and the seeming intractability of problems in Africa with food production and poverty.

Chapter 6, by Daniel W. Bromley, explores the relationship between property rights and environmental sustainability. He first discusses the concept of property rights, which means the limits of the law as it pertains to income appropriable from control of income-producing assets, including trademarks, copyrights, and patents. Bromley reviews John Locke's notion that the key justification for the continued holding of land as property is the idea that such holdings form an essential assurance of liberty. Landholders are assured of this liberty because the state forms an implicit pact to protect them from the predations of others, including the government itself. He notes that property rights in the Lockean sense allow for those who come after to buy land from those who have justly acquired it, and that once the initial acquisition is transferred to a new owner for a particular price, all future acquisitions must be mediated with due consideration for the holder of land or property, in perpetuity. But given this right, Bromley asks, what is to preclude holders of land from engaging in social extortion? Thus it is possible for land justly acquired to become unjustly held or imprudently used.

Kant asserted that the community itself must determine whether land justly acquired continues to be justly held (Williams 1977). But how is this determination to be made? Bromley responds that property rights are created in the process of resolving disputes that originated in conflicting claims brought before a court of law. Thus, he holds, a general theory of property rights is not as simple as it appears, but requires a major dose of philosophical pragmatism.

Bromley's analysis leads him to assert that the central challenge for sustainable environmental policy is to understand the process whereby information from a community of scientists is regarded as definitive and pertinent to the problem under consideration. He notes that discussions about sustainability cannot be understood as pronouncements on what must be saved for the future. Rather, coherence in such conversations will flow from a continual dialogue—a political process in which society figures out what works and is worth saving for the future, what is revered now, and what we hope our descendants will revere as well.

The final chapter, by Scott M. Swinton, reviews the poverty-environment debate with the aim of both promoting sustainability of natural resources and improving agricultural productivity. Swinton notes that the Malthusian fears that arose about population growth following World War II were challenged by Boserup (1981), who showed that rising population triggers an intensification of agriculture, leading to higher food production on the same land. As income and demand for food rises, it creates incentives for farmers to increase productivity on land by adding inputs such as fertilizer and irrigation. This process, under a flexible and secure land tenure system, can improve agricultural productivity and incomes and can reduce natural resource degradation. Swinton maintains that in this process it is important to understand the key factors that drive farmers' behavior. For one thing, how farmers respond to incentives and make choices is shaped by the resources at their command, following the "poor but efficient" idea of Schultz mentioned earlier in connection with Ruttan's chapter. These resources include labor or human resources as well as natural resources such as land, water, climate, and biodiversity. Other resources are physical capital, equipment, and the financial capital needed to buy inputs such as feed, fertilizer, pesticides, and related inputs. The author also considers the role of social capital, which is a network of sociocultural institutions that enable communities to gain access to and manage resources at the local level, especially when formal government institutions fail. In addition, external factors such as infrastructure in the form of roads, banks, and institutions for the education and training of farmers are crucial, and these must be provided by the public sector.

Swinton asserts that farmers can respond to demand for increased food production with two alternative strategies: 1) *extensification,* involving expansion into new lands, for which the opportunities are limited in most developing regions of the world, and 2) *intensification,* which has proven capable of increasing per capita food production through investment of capital in agriculture. He cites research in rural Kenya showing how three generations of soil erosion was reversed, as rising food and coffee prices led farmers to invest in land terracing and other soil conservation measures, thus enabling them to increase both food production per acre and environmental recovery (Tiffen and Mortimore 1994).

The distinction between labor-led and capital-led intensification offers one explanation of how a decline and an increase in agricultural productivity can correlate, according to Swinton. The phenomenon occurs when an increase in population leads to declining productivity, which in turn triggers capital investment in land. The subsequent gradual increases in land productivity from a low point result in a U-shaped population–land productivity relationship, which encompasses both labor-led (Malthusian) and capital-led (Boserupian) intensification explanations. However, according to Swinton, the bargain subsistence farmers must make between survival for today and land stewardship for tomorrow directly undermines the goal of sustainable development, defined earlier as meeting present needs without harming the ability to meet future ones (World Commission on Environment and Development 1987). In spite of farmers' manifest preference for the present over the future, Swinton cites case studies from Peru and northern Ethiopia that show that when farmers are confident of passing their land holdings on to their children—when they have security—they are more likely to invest in soil conservation practices such as building terraces than when they expect to control their fields for five years or less—i.e., when land tenure is insecure.

Swinton's essay draws the following policy guidelines to enhance the sustainability of both agriculture and natural resources in rural development:

1) Provide clear and durable property rights, since secured farmland tenure is crucial for increasing farm productivity and making the long term investments needed to conserve and improve natural resources,
2) Develop local institutions that support natural resource stewardship, such as community systems that enforce crop rotation and maintain soil fertility at modest levels,
3) Provide an efficient network of transportation, roads, and communication to support markets for agricultural inputs and commodities, as well as provide a system of credit. Without these things in place, expected benefits from net investments in agriculture and natural resources will not happen,
4) Enhance farmers' capacity by providing quality education and training that include conservation of agriculture and natural resources. This must be complemented by access to external sources of income or credit, either through investment in nonfarm enterprises or through provision of subsidized credit,
5) Develop policies tailored to the specific socioeconomic and biogeophysical settings in which agriculture and natural resources are managed in developing countries.

BRIEF SYNTHESIS AND CONCLUDING REMARKS

The six chapters address the various dimensions of sustainable development under five recurring subthemes:

1) The challenge of promoting economic growth by maximizing the long-term net benefits to humankind and minimizing the net costs of environmental and natural resource degradation, including the challenge of correcting both market failure and policy failure to that effect,
2) The challenge of reducing scientific and technical constraints on sustainable growth of agricultural production,
3) The progress made by societies in overcoming the fear of population explosion in developing countries over the last half of the twentieth century,
4) The challenge of reducing poverty and achieving sustainable management of natural resources in poor societies, including the challenge of establishing property rights aimed at ensuring environmental sustainability for specific communities,
5) The challenge of reducing economic and political inequality and poverty, which in recent years have driven conflict and wars in many parts of the world, leading to humanitarian disasters.

While the book deals with these challenges, it also sees the opportunities available under proper policies aimed at sustainable development. In my view, the authors of the various chapters demonstrate that while societies and economies face stiff challenges, the promotion of policies that enhance human liberty by investing in human capital, democratic institutions, and improved market performance can lift millions out of poverty to sustainable development.

Notes

1. The Johannesburg summit marked a major departure, in structure and outcome, from previous United Nations conferences. This could have a positive effect on the global community's approach to sustainable development. The summit was marked by a new level of dialogue, energy, and commitment to foster collaboration among key stakeholders, including governments, civil society groups, the private sector, and nongovernmental voluntary organizations (NGOs). In particular, the summit spurred commitments to expand access to water, sanitation, and energy, improve agriculture, manage toxic chemicals, protect biodiversity, and improve the management of ecosystems.

   Moreover, the World Bank, which is the leading international institution for development at the global level, laid out a path for the next half century in its *World Development Report 2003: Sustainable Development in a Dynamic World*:

   > Without better policies and institutions, social and environmental strains may derail development progress, leading to higher poverty levels and a decline in the quality of life for everybody. Misguided policies and weak governance in past decades have contributed to environmental disasters, income inequality, and social upheaval in some countries, often resulting in deep deprivation, riots, or refugees fleeing famine or civil wars. Today, many poor people depend on fragile natural resources to survive. Similarly, trust between individuals, which can be eroded or destroyed by civil unrest, is a social asset with important economic benefits, since it enables people to make agreements and undertake transactions that would otherwise not be possible. Development policies need to be sharply focused on protecting these natural and social assets. (World Bank 2003)

   That report enlarges on the bank's *World Development Report 1992: Development and the Environment*, in which the bank first addressed the topic.
2. The equations on this page are adopted, with modification, from Perkins et al. (2001, pp. 228–231).

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2

Some Neglected Aspects of Sustainable Development

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The concept of sustainable development, obscure just 15 years ago, now appears regularly in the mainstream media. There is now even a Dow Jones Sustainability Index to guide managers to opportunities for securing “green growth.”

Chairman Alan Greenspan and the Federal Reserve System have also given the concept pride of place: in its formal announcement on interest rate policy in January 2003, the Fed cited sustainable development as a goal coequal with price stability. That same month, when President Bush announced in the 2003 State of the Union address new initiatives on fuel cells to convert chemical energy into electricity and heat, that too was couched in sustainable development terms. The president even made a point of being photographed examining a hydrogen powered car that would vastly reduce pollution and sharply increase long-term energy availabilities.

Under other labels, sustainable development has long engaged the interests of physical and social scientists. At the beginning of the nineteenth century, Rev. T. R. Malthus predicted an inexorable, inevitable collision between population and subsistence. Through a series of staggering revolutions in industry, science, and technology never envisioned by Malthus, this apocalypse has been deferred time and again. Nevertheless, there is no assurance that humankind can continue to count upon technological innovation to keep the Malthusian wolf at bay. Increasingly, we will need to turn our attention to the possibilities for creating conditions for sustainable use of nature’s bounty. Sustainable development is all about trying to bring about green growth, which benefits both the natural environment and the humans who depend upon it for clear air, clean water, healthy foodstuffs, and so much else. This chapter will address not the whole panorama of sustainable development but some neglected aspects of good policies to promote sustainability.

The search for paths of sustainable development necessarily involves many disciplines: ecology, biology, geology, economics, sociology, ethics, political science, mathematics, physics, chemistry, statistics, and engineering. There is no universal agreement on what is meant by sustainable development. Nor are all definitions of sustainable development sensible. But for the ecologists, economists, and biologists who understand the essence of resource scarcity, sustainable development may be best defined as the path that maximizes the long-term, net benefits to humankind, taking into account the costs of environmental degradation. Net benefits include not merely income gains and reduction of unemployment and poverty but also healthier living conditions. Interpreted in this way, sustainable development stresses not the need to limit development but the need to develop sensibly, in order to be better able to conserve. Sustainable development seeks to make conservation the handmaiden of development while protecting the interests of future generations. In sensible sustainable development, preservation is valued not for its own sake but for what it can do for the welfare of present and future generations. One vital condition for approaching sustainability in development is that natural resources and environmental services not be undervalued or underpriced, a condition frequently violated in practice. This is the chapter's prime focus.

THE ROLE OF POVERTY

Sustainable development is an important concept for all societies. Nevertheless, poor people in developing countries are far more dependent on their soils, rivers, fisheries, and forests than are citizens of rich countries. Therefore, degradation of resources and environment looms as a much larger threat to life and health in developing countries. Fortunately for low-income nations, sustainable development does not necessarily imply low rates of income growth. It does, however, require less wasteful, more efficient growth.

For affluent countries such as the United States, Canada, Japan, and France, many of the most serious environmental problems are caused by affluence. Examples include too much pollution of the air from overuse and waste of motor fuel, street and highway congestion caused by the addition in each country of several hundred thousand more automobiles every year, conversion of fragile watersheds and beaches into vacation homes on Cape Hatteras or Hilton Head Island, and housing developments on mountain slopes in Aspen or Jackson Hole.

But the situation is very different in almost all of Africa, in much of Latin America, and in south and Southeast Asia. In much of the rest of the world outside the United States and Europe, many of the most serious environmental problems are caused not by affluence but by poverty. Poverty itself is the prime adversary of good ecological practices in poor nations. For example, there can be little doubt that poverty by itself, or in combination with other factors, is the main cause of deforestation in most tropical nations.

Consider Ghana. In 1900, one-third of Ghana's land area was covered by natural tropical forest. When I first worked in Ghana for Harvard University in 1967–1971, the forest still covered about 20 percent of the land; there was still a lot of forest for me to study. That is no longer the case. By 1995, forest cover had shrunk to less than 5 percent. As elsewhere in West Africa, Southeast Asia, Brazil, and Central America, poverty has been killing the forest. Poor, landless Ghanaians, Ivorians, Indonesians, and Burmese practice destructive, slash-and-burn agriculture, not because they are ignorant or venal, but because they have no other options. These are not the traditional shifting cultivators of Africa or Asia who for centuries past have moved from parcel to parcel. Rather, they are landless, mostly urban people who have become "shifted cultivators," driven to migrate to the forest by hunger and population pressures.

Slash-and-burn agriculture is only one manifestation of the effects of poverty on deforestation. In many poor nations, the role of poverty in deforestation has been magnified by the ever-more-desperate search for fuelwood by impoverished people. In Ghana in the mid eighties, for example, for every tree harvested for lumber, nine trees were cut down for firewood, leading to a pattern of deforestation that accelerated soil erosion, groundwater depletion, and loss of agricultural productivity. For developing nations generally, 80 percent of trees cut down are felled for fuel for cooking or other domestic use, not for export as logs or wood products.

Most of the species on earth occur in the tropical forest. The tropical forest used to make up 12 percent of the earth's land surface before extensive deforestation began. Now it covers less than 6 percent of the earth's land. Worldwide, the tropical forest estate shrank by more than 55,000 square miles per year in the early nineties, an area roughly 240 miles square, or the size of Iowa. Of that amount, almost 60 percent fell to slash-and-burn agriculture. Another 3,900 square miles, an area 62 miles square, was deforested by the search for fuelwood. Forest clearing for cattle ranching, mostly in Brazil and Central America, took another 5,850 square miles per year, or 76 miles square.

It is important to note that the role of poverty-induced shifting cultivation in deforestation has been steadily increasing, while the relative roles of logging and cattle ranching have been declining. Nearly 1.5 billion people in the world live in absolute poverty; at least a third of these are landless poor engaged in destructive forms of shifting cultivation. The number of these poor is growing, so we should expect growing damages from shifting cultivation.

The point: so-called solutions to tropical deforestation that do not take into account the needs of the poor and landless are no solutions at all; they worsen the conditions of the poor in almost every instance.

In forestry, fishing, agriculture, or natural resource extraction, poverty is, of course, far from the only culprit in national resource degradation. Two other shortcomings have undercut sustainable development: market failure and policy failure. We have long known that market failure has been instrumental. Market failure arises when valuable services provided by an ecosystem are not traded in markets. For example, intact tropical forests provide a wide variety of vital but nontraded ecological services such as control of runoff, soil protection, microclimate control, and protection of animal habitat. Because there are no organized markets for such services, they are not priced and are therefore overused (wasted). However, some progress in valuing these vital services has been made over the past two decades (Repetto and Gillis 1988).

But market failures, whether due to monopoly, externalities, free riders, or transaction costs, now involve few mysteries. They have been studied for many decades by economists, at mind-numbing length. While it has long been recognized that market failure accounts for an important part of the story, it is now much more widely appreciated that policy failures, or government failures, have also loomed quite large in environmental degradation.

THE ROLE OF POLICY FAILURES

One of the prime causes of policy failure leading to needless ecological and economic damage has been a widespread tendency of policymakers to overlook the environmental consequences of nonenvironmental policies. Even today it is still not widely recognized that policies intended primarily to attain nonenvironmental goals can have large impacts upon the environment. Nonenvironmental policies include tax policy, exchange rate policy, industrialization policies, credit, and agriculture and food price policies. In much of Africa, Latin America, and Asia, a by-product of the pursuit of agricultural, energy, urbanization, and industrial objectives has been significant corrosive effects upon soil endowments, watershed management, water quality, coastal fishing, and survival of coastal reefs. From this experience, we should have learned that it is not enough that nations follow sensible environmental policies. Greater attention to the environmental impact of nonenvironmental policies and development projects is required as well, not only for more efficient resource use, but also for more equitably distributed growth. Ecological disasters are almost always economic disasters too; in low-income countries the reverse is often true as well, as illustrated by the experiences of Romania, Bulgaria, and Albania over the past five decades. Little imagination is required to see that measures that reduce the environmental damages of nonenvironmental policies are both good ecology and good economics, while policies that help to overcome poverty are also both good economics and good ecology.

A second, not unrelated, reason for policy failures that damage ecological and environmental values has been a persistent lack of understanding of the role of the market and the role of prices in both resource conservation and ecological protection. An unusually high proportion of such policy failures is traceable to short-sighted government subsidy programs that deeply underprice water, soils, forest, and energy resources. A perfect example occurred on public lands out West, where the United States government charges extremely low prices for grazing leases, leaving pastures cow-burnt from overgrazing.

Everywhere, societies persist in underestimating the role of market prices in resource conservation or in resource allocation generally. Another recent example from the United States comes from outside of the environmental area: pricing of Internet access. A few years back, a major company adopted a pricing mechanism involving a flat fee for Internet service: this amounted to a zero price for overuse of scarce Internet access. Because the price of the service was not incremental, it was unrelated to intensity of use by the subscriber. And the managers were actually surprised when the scheme resulted in catastrophic collapse from overuse. Although this example has nothing to do with natural resources, the same kinds of miscalculations are often responsible for unsustainable development. Virtually all of the policy failures I am about to depict have resulted primarily from deep underpricing of vital natural and environmental resources, leading to unsustainable, wasteful development.

Forestry Resource Policy

Quite apart from the effects of poverty, policy failures in forestry have been especially destructive to ecological and economic goals in dozens of tropical countries. Brazil's government long provided heavy subsidies to ranching and other activities that encroached heavily on the Amazon rainforest. Three to four thousand square miles of the Amazon was deforested each year throughout the 1970s. When pastureland replaced the rainforest, it destroyed rainforest occupations, such as plant collection and harvest of forest meat, that provided more jobs than the subsidized ranching operations. Nevertheless, the government made deforestation as cheap as possible. Government policies provided new ranchers with 15-year tax holidays, investment tax credits, exemptions from export taxes and import duties, and loans with interest substantially below market rates. Although a typical subsidized investment yielded a loss to the economy equivalent to 55 percent of the initial investment, heavy subsidies allowed private ranchers to earn a positive return of 250 percent, on average, of their investment, while the forest was relentlessly destroyed.

Most tropical countries, including Indonesia, the Philippines, and many African nations, have charged very low fees for timber concessions, and virtually all impose inadequate timber royalties too low to encourage conservation. Thailand's forestry policies were so wanton that its rainforest has all but disappeared. The same can be said for the Ivory Coast, and Gabon and the Philippines are on the same path.

Water Resource Policy

Underpricing of water resources has long been common all over the world. It is safe to say that where one finds acute crisis in water availability, heavy subsidies for water use are usually the prime suspect, except for regions with extended drought.

Subsidies apply both to agricultural water and to potable water. By 1990, public irrigation systems operated by government owned enterprises and by governmental departments in developing countries had already absorbed $300 billion in public funds. It has been estimated that over half of all investments in agriculture in less developed countries (LDCs) in the 1980s went into water resource development; in Mexico fully 80 percent of all public investment in agriculture from 1940 to 1990 went into irrigation projects (Gillis 1991, pp. 248–256). There, charges for irrigation water average only 11 percent of total costs. And in a sample of World Bank irrigation projects in less developed countries, revenues covered only 7 percent of project costs, on average, while in most other countries revenue from farmers covers less than 20 percent of capital and operating costs (Repetto 1986, p. 43). When a resource is underpriced, it will be overused and wasted. Cheap prices for irrigation water have, of course, resulted in high rates of water waste, whether from the Colorado River, the Indus River, or the Aral Sea of the former Soviet Union, straddling Uzbekistan and Kazakhstan.

Markets also have other roles to play in the sustainable use of drinking water. In most of the world, provision of drinking water is dominated by government departments or government-owned enterprises. But in dozens of those countries, infant mortality from unsafe water remains high. Three million children a year die from water related diseases. What are the possible implications for health and for efficiency when reliance is placed on market mechanisms instead of on government enterprises to provide water? Here is one example.

In the 1990s Argentina embarked on one of the largest privatization campaigns in the world, including the privatization of local water companies serving approximately 30 percent of the country's municipalities. American and Argentinean researchers found child mortality fell 8 percent overall in areas that privatized their water services; the effect was largest (26 percent) in the poorest areas. Privatization there was associated with significant reductions in deaths from infectious and parasitic diseases.

Energy Resource Policy

Energy pricing provides an altogether frightful history of policy failure leading to unsustainable development. In such oil-rich countries as Nigeria, Indonesia, and Venezuela, domestic use of energy has been kept artificially cheap as a stimulus to industrialization and diversification. This has had multiple adverse effects on ecology and on the economy. First, these subsidies encouraged wasteful domestic consumption, thereby reducing the country's petroleum and gas reserves and its export earning potential. Second, underpricing of energy artificially promoted the use of auto transport, adding to urban congestion and air pollution. Third, artificially cheap energy promoted industry that was ill-suited to the country's endowments: with cheap energy, industries (and consumers) have little incentive to adopt energy-saving technologies. Thus, on several counts, underpricing contributed to environmental degradation as well as to sizable economic losses from needless waste of energy.

Indonesia's kerosene policy furnishes another instructive example. For 15 years the government of Indonesia heavily subsidized the consumption of kerosene and other fuels. The kerosene subsidy was justified as a way to reduce environmental degradation and to aid poor rural dwellers, who were thought to use kerosene for cooking. Heavily subsidized kerosene prices were seen as a disincentive to the cutting of fuelwood, which was denuding mountain slopes and causing major soil erosion on Java, Indonesia's most densely populated island. But the subsidy was totally misplaced. Research clearly showed that rural families used kerosene predominantly for lighting, not for cooking. In any case, the subsidy protected only 50,000 acres of forestland each year, at a cost of almost $200,000 a year per acre. Replanting programs, in contrast, cost only $1,000 per acre. Moreover, 80 percent of the kerosene turned out to be consumed by the relatively wealthy, not the poor. And the low price of kerosene made it necessary to subsidize diesel fuel as well, because kerosene could be substituted for diesel in truck engines, causing greater environmental damage. The multiple costs of this policy finally led the government to sharply reduce its subsidy on kerosene. Indeed, Indonesia now tries to price most fuels at world market levels.

Some of my colleagues have studied commercial energy use per unit of GDP for almost 90 countries. The variance in utilization of commercial energy, even among poor countries, is notable. Mistaken energy policies are principally, but not wholly, to blame for very high rates of domestic energy consumption in countries like Colombia, Bolivia, and Venezuela. Even recently, Venezuela has priced gasoline at less than 30 cents a gallon. The environmental consequences of underpricing energy were particularly notable in countries formerly under the control of communism, such as Poland, Bulgaria, Hungary, Czechoslovakia, and Romania, where markets played little role in resource allocation until the 1990s. Consequently, air and water pollution in these nations were among the worst in the world.

Agricultural Subsidy Policy

Another arena for environmental policy failure has been agricultural subsidies. These have yielded notable economic and ecological damage everywhere, but especially in poor nations. Governments all around the globe have adopted policies that have resulted in severely underpriced chemicals, especially fertilizer made from natural gas. Attempts have been made to justify heavy fertilizer subsidies not only on grounds of their effect on agricultural production, but also on grounds that the subsidies serve soil enrichment and conservation purposes. These arguments do not stand up to analysis, particularly in semiarid tropical countries where what is most needed are organic fertilizers (which are better adapted but rarely subsidized) and the use of moisture-retaining methods. Indeed, there is evidence that sustained use of chemical fertilizers can actually reduce soil fertility over the long term. Furthermore, overuse of subsidized fertilizer and other chemicals such as pesticides and herbicides has often caused significant environmental damage rather than providing environmental protection, and high subsidies on fertilizer have led to substantial waste. In Indonesia, for example, fertilizer use increased by 77 percent from 1980 to 1985 alone, to the point that rice cultivation in that nation used three times as much fertilizer per hectare as Thailand or the Philippines (World Commission on Environment and Development 1987, p. 102).

Finally, many agricultural subsidies have not only been expensive but strongly counterproductive. This was the case with heavy pesticide subsidies, also in Indonesia. Not only did the overused pesticides damage the environment but they also proved ineffective: they actually increased infestations of agricultural pests because they had a greater effect on the natural predators of pests than on the pests themselves.

WHAT CAN BE DONE?

In the face of persistent market failures and ubiquitous policy failures, is sustainable development in poor nations even possible? The answer is, I believe, a qualified yes, at least for any one country, provided attention is strongly focused on rectifying both market failures and policy failures that corrode sustainability, and on measures to reduce rural poverty.

The Malaysian case is instructive. Malaysia contains plenty of contemporaneous examples of both sustainable and nonsustainable development. West Malaysia is separated from East Malaysia in the South China Sea by nearly 400 miles of ocean. West Malaysia consists primarily of the Malaysian Peninsula, whereas East Malaysia includes the two states of Sabah and Sarawak, on the island of Borneo.

After an inauspicious, largely wasteful start in the twentieth century, West Malaysia has enjoyed mostly sustainable development for nearly three decades because it finally successfully capitalized upon its initial natural resource base. Real economic growth was in excess of 3 percent from 1965 to 1990 and has been at nearly 5 percent since. This rapid growth has virtually banished rural poverty as a cause of deforestation and other environmental degradation. Moreover, the environment in Peninsular (West) Malaysia has suffered only lightly from policy failures.

Sabah and Sarawak in East Malaysia had, if anything, an even richer natural resource base than Peninsular Malaysia. But for Sarawak since the mid-1980s and Sabah since 1970, development has been unsustainable. Efforts at sustainable development in Sarawak continue to be plagued by the scourge of rural poverty, while in both Sarawak and Sabah, natural forest endowments have been consumed by unsustainable practices, largely as a result of serious policy failure, particularly through grossly misguided forestry policy involving subsidies to timber firms.

In any case, the answer to the question, "Can economic development be sustainable?" is yes for any given country that pays appropriate attention to resource scarcity and avoids artificially cheap prices for natural resources and environmental services. But the answer becomes much less certain when we consider sustainability for the entire planet, or global sustainability.

The Malthusians are still with us, insisting that growth cannot be sustainable. Some argue that what sustainable growth means is that the rich have to sharply curtail their living standards to make room for more consumption by the poor. The implicit assumption is that the reason poor people are poor is that rich people are rich: that is, that they consume more than their fair share of resources. But is this the cause? Jeff Sachs, director of Columbia University's Earth Institute and special advisor to United Nations secretary-general Kofi Annan on poverty, says that rich people in rich countries are rich because they have developed technology to successfully deal with challenges, and because of geographical advantage.

CONCLUSION

Mainstream economics offers hope. In the short term we can make incremental progress in rectifying market failures leading to environmental degradation. And in the short and long term we can do a great deal to reduce damages from policy failures. Given that this is so, one major feature of a strategy for global sustainability would be to move quickly toward more effective markets, so that real resource scarcities will be reflected in the prices people pay for all commodities and services. An end to underpricing and heavy subsidies on fuels, fertilizers, pesticides, water, timber, land clearing, and other destructive uses of resources would be a major step towards sustainability. Most countries are far from this ideal market environment. They could easily reduce resource wastage without jeopardizing economic growth, through better policies, better pricing of scarce natural resources, in some cases judicious reliance on privatization, and above all, measures to reduce poverty, especially in rural areas.

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3
Economic Development, Inequality, and War

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Recently the media have focused on the threat that insurgents in failed states with weapons of mass destruction pose to wealthy nations of the West—the United States, Canada, and the countries of Europe. Scholars predict that a clash between the West and Islam is inevitable. Amid this peril, we should not forget that war, state violence, and rebel resistance threaten the livelihood and the very lives of millions of the poor in Africa and Asia. About 20 percent of Africans live in countries seriously disrupted by war or state violence. The cost of conflict includes refugee flows, increased military spending, damage to transport and communication, reduction in trade and investment, and diversion of resources from development. The World Bank (2000, pp. 57–59) estimates that civil war in an African country lowers the gross domestic product (GDP) per capita by 2.2 percent annually. Scholars must focus on reducing this danger to the survival income and human rights of the world's poorest.

Economic stagnation, political decay, and deadly political violence interact mutually: economic and political factors contribute to war, while war has an adverse effect on economic growth and political development. This paper analyzes how economic decline, income inequality, a weakening state, pervasive rent seeking by ruling elites, an extensive threat to survival income, and competition for control of mineral exports contribute to humanitarian emergencies. These emergencies compose a human-made crisis in which large numbers of people die and suffer from war, state violence, and refugee displacement, and they are usually accompanied by widespread disease and hunger (Väyrynen 2000a).

What are the sources of humanitarian emergencies? Auvinen and Nafziger (1999) show that stagnation and decline in real (inflation-adjusted) GDP, slow growth in average food production, high income inequality, a high ratio of military expenditure to national income, and a tradition of violent conflict are sources of emergencies. The study also finds that countries that failed to adjust to chronic external deficits were more vulnerable to humanitarian emergencies. In addition, political variables, such as predatory rule, authoritarianism, and state decay and collapse,[1] interact with economic variables to affect vulnerability to humanitarian emergencies. The findings are by and large consistent for three measures of the dependent variable and for many different regression models.[2]

However, the focus of this chapter is much less on econometrics than on a discussion of how factors embedded in the political economy of developing countries contribute to humanitarian emergencies. "Political economy" includes not only economic analysis but also an examination of the interests of political leaders and policymakers who make economic decisions and of members of the population who are affected by these decisions. This politico-economic analysis is based on a research project begun in 1996 by the United Nations University's World Institute for Development Economics Research (WIDER), Helsinki, and Queen Elizabeth House, Oxford (QEH). It generalizes on the case studies of 17 war-affected less-developed countries (LDCs) and explains the reasons for econometric findings from the annual data of 124 LDCs from 1980 to 1995 (Auvinen and Nafziger 1999).[3] The case studies include Nigeria and Pakistan from the late 1960s and early 1970s and Rwanda, Burundi, Congo, Sudan, Somalia, Liberia, Sierra Leone, Afghanistan, Cambodia, Iraq, Haiti, El Salvador, Colombia, Bosnia, and the South Caucasus from 1980 to 2000.

STAGNATION AND DECLINE IN INCOMES

Contemporary emergencies are found in low- and middle-income (that is, developing) countries, suggesting a ceiling above which war and massive state violence do not occur. A disproportional number of these states are also weak or failing (Holsti 2000, pp. 243–250), a trait that interacts as both cause and effect of their relative poverty. Moreover, emergencies are more likely to occur in countries experiencing stagnation in real GDP per capita and a breakdown in law and public services. These phenomena affect relative deprivation, the actors' perception of social injustice from a discrepancy between goods and conditions they expect and those they can get or keep. This deprivation often results from vertical (class) or horizontal (regional or communal) inequality (Stewart 2000, p. 16), where the actors' income or conditions are related to those of others within society. Relative deprivation spurs social discontent, which provides motivation for collective violence (Gurr 1970). Among the components of emergencies, war and violence have major catalytic roles, adding to social disruption and political instability, undermining economic activity, spreading hunger and disease, and fueling refugee flows. A marked deterioration of living conditions, especially during a period of high expectations, is likely to produce socio-political discontent that may be mobilized into political violence.

During the twentieth century, some 200 million people were killed in war or state violence (Rummel 1994), but only a small proportion of these deaths came from insurgent action or fighting between belligerents. Holsti (2000, pp. 250–267) demonstrates that the policies of governing elites are at the root of most humanitarian emergencies,[4] a fact not recognized in most research on war (cf. Collier 2000a; Collier and Hoeffler 1998). Slow or negative per-capita growth puts pressure on ruling coalitions. Ruling elites can expand rent-seeking opportunities for existing political elites, contributing to further economic stagnation that can threaten the legitimacy of the regime and increase the probability of regime turnover. To forestall threats to the regime, political elites may use repression to suppress discontent or capture a greater share of the majority's shrinking surplus. These repressive policies may entail acts of direct violence against or withholding food and other supplies from politically disobedient groups, as in Sudan in the 1980s (Keen 2000, pp. 292–294). Moreover, repression and economic discrimination may generate relative deprivation and trigger socio-political mobilization on the part of the groups affected, leading to further violence and thus worsening the humanitarian crisis.

Since economic deceleration or collapse can disrupt ruling coalitions and exacerbate mass discontent, we should not be surprised that since 1980 the globe, particularly Africa, has been more vulnerable to humanitarian emergencies. This increase in intrastate political conflict and humanitarian emergencies in Africa in the last two decades of the twentieth century is linked to the continent's negative per-capita growth in the 1970s and 1980s and virtual stagnation in the 1990s. Indeed, in Africa, which had the highest death rate from wars in the 1990s of any continent, GDP per capita was lower in the late 1990s than it was at the end of the 1960s (World Bank 2000, p. 1).[5]

This stagnation and decline was often associated with, and exacerbated by, a predatory state, driven by ethnic and regional competition for the bounties of the state. Predatory rule involves a personalistic regime ruling through coercion, material inducement, and personality politics, tending to degrade the institutional foundations of the economy and state. Elites extract immediate rents and transfers rather than providing incentives for economic growth. In some predatory states, the ruling elite and their clients "use their positions and access to resources to plunder the national economy through graft, corruption, and extortion, and to participate in private business activities" (Holsti 2000, p. 251). Ake (1996, p. 42) contends that "instead of being a public force, the state in Africa tends to be privatized, that is, appropriated to the service of private interests by the dominant faction of the elite." People use funds at the disposal of the state for systematic corruption, from petty survival venality at the lower echelons of government to kleptocracy at the top.

Humanitarian crises are more likely to occur in societies where the state is weak and venal, and thus subject to extensive rent-seeking, "an omnipresent policy to obtain private benefit from public action and resources" (Väyrynen 2000b, p. 440). Cause and effect between state failure and rent seeking are not always clear. State failure does not necessarily result from the incapacity of public institutions but from the interests of rulers. While "state failure can harm a great number of people, it can also benefit others," especially governing elites and their allies (Väyrynen 2000b, p. 442). These elites may not benefit from avoiding political decay through nurturing free entry and the rule of law and reducing corruption and exploitation. Instead political leaders may gain more from extensive unproductive, profit-seeking activities in a political system they control than from long-term efforts to build a well-functioning state in which economic progress and democratic institutions flourish. These activities tend to be pervasive in countries that have abundant mineral exports (for example, diamonds and petroleum), such as Sierra Leone, Angola, Congo-Kinshasa, and Liberia, while predatory economic behavior has a lower payoff in mineral-poor economies such as Tanzania and Togo.

The majority of countries with humanitarian emergencies have experienced several years (or even decades) of negative or stagnant growth, where growth refers to real growth in GNP or GDP per capita. Widespread negative growth among populations where a majority is close to levels of subsistence increases the vulnerability to humanitarian disasters. From 1980 to 1991, 40 of 58 Afro-Asian countries, or 69 percent, experienced negative growth, according to the World Bank's World Development Report (1993, pp. 238–239). In contrast, from 1960 to 1980, only 9 of 53 had negative economic growth, according to the earlier World Bank annual (1982, pp. 110–111). In addition, the positive growth of Latin America and the Caribbean during the 1960s and 1970s also reversed to negative growth in the 1980s, according to the same World Bank sources. The interrelationship between growth and emergencies suggests that the increased emergencies in the early 1990s are connected to the developing world's disastrous growth record of the 1980s. This disastrous growth was accompanied by state decay, as ruling elites, facing limitations in dispersing benefits to a wide-ranging coalition of ethnic communities and economic groups, struggled for control, allied with other strongmen, and strengthened their military capability to repress potential rebels and dissidents.

Econometric and country evidence indicates that, holding other variables constant, slow real GDP growth helps explain humanitarian emergencies. Humanitarian emergencies also contribute to reduced (often negative) growth (Stewart, Huang, and Wang 2001, pp. 11–41), although according to econometric tests by Auvinen and Nafziger (1999) the direction of causation is weaker than from growth to emergencies. Contemporary humanitarian disaster is rarely episodic; rather, it is usually a culmination of longer-term politico-economic decay over a decade or more. Negative per-capita growth interacts with political predation in a downward spiral, a spiral seen in African countries such as Angola, Ethiopia, Sudan, Somalia, Liberia, Sierra Leone, and Zaire (Congo).

Economic stagnation, frequently accompanied by chronic trade deficits and growing external debt, intensifies the need for economic adjustment and stabilization. A persistent external disequilibrium has costs whether countries adjust or not. But nonadjustment has the greater cost; the longer the disequilibrium, the greater is the social damage and the more painful the adjustment.[6] Most LDCs face frequent international balance-of-payments problems, which reduce the ability of political leaders to maintain control. But abundant exports, such as minerals, together with a strong military, can provide the ruler or warlord with a modicum of security.

More than a decade of slow growth, rising borrowing costs, reduced concessional aid, a mounting debt crisis, and the increased economic liberalism of donors and international financial institutions, compelled LDC (especially African) elites to change their strategies during the 1980s and 1990s. Widespread economic liberalization and adjustment provided chances for challenging existing elites, threatening their positions, and contributing to increased opportunistic rent-seeking and overt repression. Cuts in spending reduced the funds available to distribute to clients and required greater military and police support for rulers to remain in power.

INCOME INEQUALITY

Large income inequality exacerbates the vulnerability of populations to humanitarian emergencies. Alesina and Perotti's (1996) cross-section study of 71 developing countries, 1960–1985, finds that income inequality, by fueling social discontent, increases socio-political instability, as measured by deaths in intrastate disturbances and assassinations (per million population) and coups (both successful and unsuccessful). Moreover, the policies of predatory and authoritarian rulers increase income inequality.

To measure income inequality, Nafziger and Auvinen (2003, p. 90) used Gini coefficients calculated from an expanded and qualitatively improved dataset from Deininger and Squire (1996, pp. 56–91), although we decided not to use data from studies they relied on that were based on incomparable research methodologies. We were able to find relationships between Gini and war, which World Bank researchers

Collier and Hoeffler (1998) and others, without this dataset, could not find. Collier and Hoeffler (1998, p. 563) indicate "there is insufficient data to introduce distributional considerations into the empirical analysis." Our regressions indicate that high Gini or income concentration contributes to humanitarian emergencies.

Indeed, because of inadequate income inequality data, Collier (2000b, pp. 10–11, 13) concludes that "inequality does not seem to effect the risk of conflict. Rebellion does not seem to be the rage of the poor . . . Conflict is not caused by divisions, rather it actively needs to create them . . . However, it is the military needs of the rebel organization which have created this political conflict rather than the objective grievances."[7]

WIDER researchers (Nafziger, Stewart, and Väyrynen 2000, both volumes), who include deaths from state violence as a part of humanitarian emergencies, examine deadly political violence more broadly than merely by focusing on rebellions, and they hold a contrasting view to that of Collier. Indeed, the WIDER approach is consistent with the finding that objective grievances of poverty and inequality contribute to war and humanitarian emergencies.

Severe social tensions leading to humanitarian emergencies may even arise under conditions of positive (even rapid) growth and expanding resource availability. High inequality can contribute to the immiseration or absolute deprivation of portions of the population, even with growth. Absolute deprivation during substantial growth was experienced, for instance, by Igbo political elites, dominant in Nigeria's Eastern Region, in the early 1960s. The East lost oil tax revenues from a change in allocation by the federal government, which ceased distributing mineral export revenues to regional governments.

Moreover, through the demonstration effect of consumption levels of the relatively well off, high income concentration increases the perception of relative deprivation among substantial sections of the population, even when they do not experience absolute deprivation. The risk of political disintegration increases with a surge of income disparities by class, region, and community, especially when these disparities lack legitimacy among the population. Class and communal (regional, ethnic, and religious) economic differences often overlap, exacerbating perceived grievances and the potential for strife.

This type of wide income inequality results from historical legacies of discrimination (colonialism, apartheid, failed policies), from government policies in distributing land and other assets, taxation, and the benefits of public expenditure, from regional and ethnic economic competition, and from predatory rule. Growing regional inequality and limited regional economic integration, associated with economic enclaves, can exacerbate ethnic and regional competition and conflict.

Regional factors contributing to conflict include educational and employment differences, revenue allocation, and language discrimination, which disadvantages minority language communities. There are many examples:

- The struggle for petroleum tax revenues and employment in the civil service and modern sector in Nigeria in the early to mid-1960s
- The distribution of resources from East to West and employment discrimination against Bengalis in Pakistan in the 1950s and 1960s
- The conflict between Hutu and Tutsi for control of the state and access to employment in Burundi and Rwanda
- The contention over the distribution of falling economic resources and rising debt obligations in Yugoslavia in the 1980s and early 1990s
- State discrimination against Tamils in language, employment, and education in postindependent Sri Lanka

While high inequality is associated with emergencies, insurgency is more likely if the less advantaged can identify the perpetuators of their poverty and suffering. The examples of Nigeria in the 1960s, South Africa from the early 1970s through the early 1990s, and Chiapas, Mexico, in the 1990s (Nafziger and Auvinen 2000, pp. 105–108) illustrate the diverse patterns of how discriminatory government policies cause economic inequality, fuel social discontent, and lead to political conflict and humanitarian emergencies. These dynamics may even occur either when the nation's real per-capita GDP is growing, as in Nigeria in the 1960s, or when the disadvantaged group's economic position is improving, as for nonwhite South Africans from the 1960s through the early 1980s.

High income inequality can be a source of humanitarian emergencies in both rapidly and slowly growing countries. But, once a population is dissatisfied with income discrepancies and social discrimination, as the majority nonwhites were in white-ruled South Africa, the rising expectations associated with incremental reductions in poverty and inequality may actually spur the revolt, conflict, and hostile action from the state that increase the probability of a humanitarian emergency (Davies 1962, pp. 5–19).[8]

COMPETITION FOR NATURAL RESOURCES

Collier contends (Collier and Hoeffler 1998, pp. 568–569; Collier 2000a, pp. 92–95) that the possession of primary commodities, especially exports, increases the occurrence and duration of civil war. Mwanasali (2000, p. 145) indicates the reasons why. "Primary commodity exports present several advantages to the belligerents. Because they are generic products, rather than brand names, their origin can easily be concealed. They are usually the most heavily taxable, especially in kind, and their production or marketing does not require the complicated processes, as is the case of manufactured goods."

Primary goods include both agricultural (usually renewable) and mineral (largely non-renewable) commodities. According to de Soysa's statistical tests (2000, pp. 123–24), "the incidence of civil war is completely unrelated to the per capita availability of natural resources, defined as the stocks of both renewable resources . . . and nonrenewables." But, once de Soysa refines her independent variable to include only mineral resources, her result is highly significant. She finds that "the higher the per capita availability of . . . mineral wealth, the greater the incidence of conflict" (ibid., p. 124). The following, based mainly on work by WIDER researchers (Nafziger, Stewart, and Väyrynen 2000, both volumes), explains why minerals contribute to conflict and state violence.

In the struggle for allies during the Cold War, the United States and the Soviet Union provided military and economic aid for developing countries. Sovereignty provided the opportunity for newly formed African states to extract resources from the major powers in exchange for diplomatic support. Yet aid could provide the basis for supporting a patronage system for either the state or for insurgents. When the Cold War ended in the early 1990s, nation-states and rebels in the developing world required different strategies and new sources of funds. Many countries in Africa and Asia needed control of resources to provide military and police power but needed to provide only minimal services to control territory. Indeed, with the emphasis from the International Monetary Fund (IMF) and the World Bank on the market and private enterprise, predatory rulers often undermined their own bureaucracies to build personal power at the expense of their citizens' health, education, and agricultural development (Reno 2000, pp. 231–232; Väyrynen 2000b, pp. 437–479).

The struggle for control over minerals and other natural resources is an important source of conflict. In Angola, Sierra Leone, Liberia, and Congo-Kinshasa, rulers and warlords used exclusive contracts with foreign firms for diamonds and other minerals to "regularize" sources of revenue in lieu of a government agency to collect taxes (Reno 1996, 1998, 2000). In comparison, Tanzania and Togo lacked the tradable resources to become a predatory society (Väyrynen 2000b, pp. 444–445).

After the decline of aid following the Cold War, Sierra Leone became more susceptible to pressures for liberalization and adjustment from the IMF and World Bank. In 1991, the IMF, the bank, and bilateral creditors (national governments) offered loans and debt rescheduling worth $625 million—about 80 percent of GNP—if Sierra Leone reduced government expenditure and employment. Freetown heeded the World Bank's advice (1994, pp. 22–51) to use private operators to run state services for a profit. But privatization did not eliminate the pressures of clients demanding payoffs; it merely shifted the arena of clientage to the private sector. Sierra Leone's ruling elites, needing new ways of exercising power, used foreign firms to consolidate power and stave off threats from political rivals. In the 1990s, Sierra Leonean heads of state relied on exclusive contracts with foreign firms for diamond mining to stabilize revenue, on foreign mercenaries and advisors to replace the national army in providing security, and on foreign contractors (sometimes the same mining or security firms) to provide other state services. In the process, rulers have found it advantageous to "destroy state agencies, to 'cleanse' them of politically threatening patrimonial hangers-on and use violence to extract resources from people under their control" (Reno 1996, pp. 7–8, 12).

In Liberia, Charles Taylor used external commercial networks (foreign firms), some a legacy of the Samuel Doe regime of the late 1980s, to amass power, at times extending his control to the eastern periphery of Sierra Leone. Taylor's territory had its own currency and banking system, telecommunications network, airfields, export trade (in diamonds, timber, gold, and farm products), and (until 1993) a deepwater port. All went to support arms imports. For Taylor, a warlord during most of the 1990s before being elected Liberia's president in 1997, controlling territory by building a patronage network was easier than building a state and its bureaucracy (Reno 1995, p. 111). Indeed, from 1990 to 1996, Taylor had access to annual revenues exceeding $100 million, with an upper limit around $200 million (Reno 2000, pp. 243, 252).

Zaire's President Mobutu Sese Seko (1965–1997), like other hard-pressed rulers in weak African states, mimicked the approach of warlords. But with the shrinking patronage base from foreign aid and investment, to prevent a coup by newly marginalized groups in the army or bureaucracy, Mobutu, as did rulers in other retrenching African states, needed to reconfigure his political authority. In this situation, foreign firms and contractors served as a new source of patronage networks. Indigenous commercial interests that profit from the new rules are not independent capitalists with interests distinct from the state's, but rather clients of predatory rulers. As Reno (1996, p. 16) points out, "Those who do not take part in accumulation on the ruler's terms are punished." Mobutu weathered the collapse of the state bureaucracy but fell because his strategy of milking state assets had reached a limit, seriously weakening the patronage system. In 1997, his forces fell to the Alliance des Forces Democratique pour la Liberation (AFDI) of Laurent Kabila, who became president of the Democratic Republic of Congo but was assassinated in 2001 (Reno 1996, pp. 9–16; Reno 1998, pp. 147–81).

State failure, as in Sierra Leone, Liberia, and Zaire, increases vulnerability to war and humanitarian emergencies. Yet in a weak or failed state some rulers, warlords, and traders are more likely to profit from war and violence than from peacetime. Indeed, as Väyrynen (2000b, p. 442) argues, war, political violence, and state failure do not result from the incapacity of public institutions but from the fact that rulers, warlords, and their clients benefit from the harm thereby befalling a substantial share of the population.

Relative deprivation also helps explain the increased violence by belligerents and their clients. An abrupt rush of mineral wealth raises not only the expectations of prosperity by the allies of rulers and warlords that control the resource but also the lure of combat to potential rebels that want to control the resource. Indeed, as Gurr (1970, pp. 73, 79) indicates, the intensity of deprivation felt increases with the discrepancy between potential and actual conditions, and with the length of time the deprivation persists. In Angola, Congo-Kinshasa, and Sierra Leone, the length and intensity of perceived deprivation were considerable.

DEMOCRACY AND AUTHORITARIANISM

Legitimacy is not only materially defined. Political deprivation arises from a lack of meaningful participation in making political decisions, whether this participation is prevented by law or through repression. In effect, a constant and frequent use of repression indicates lack of legitimacy and political capacity (Jackman 1993). Efficient repression may prolong authoritarian rule, as demonstrated for example by Augusto Pinochet's Chile and Hastings Kamuzu Banda's Malawi, but eventually the people are likely to challenge the regime from a "desperate bargainer" position. Democratic regimes do not guarantee the absence of conflict, but since they are likely to be more widely accepted, expressions of discontent are not aimed at challenging their basic tenets. Large-scale conflict and humanitarian emergencies are virtually nonexistent in democratic societies.

Authoritarianism and the Extent of Conflict

What are the empirical findings on the relationship between extent of political conflict and authoritarianism? On the one hand, openness in a political system encourages political actions of all kinds, and not all of them are likely to be voiced through formal institutions. Graham and Gurr show that democracies typically have more extensive "civil conflict" than autocracies. Gurr and Eckstein see chronic low-level conflict as "a price democracies have to pay for freedom from regimentation, from the state or from authorities in other social units" (Eckstein 1980, p. 452).

Democratic political regimes do not repress their citizens or inflict severe sanctions on protestors. Authoritarian regimes are prone to repress unrest (see Hibbs 1973), and the citizens are more likely to refrain from rebellious action when these regimes are in power. Turkey (1980–1984) and Morocco (after 1984), for instance, imposed "long term and systematic repression—serious restrictions on civil and human rights, persistent arrests of suspected 'activists,' use of heavy prison sentencing and torture, banning of political movements and opposition trade unions—on protestors" and were spared serious unrest until the end of the 1980s (Seddon 1992, p. 49). The threshold of rebellious political action is higher, and therefore authoritarian regimes are likely to experience less political protest than democracies.

Nevertheless, authoritarian political structures are conducive to conflict because repression increases opposition group activity. By adopting coercive politics against dissidents, the regime loses legitimacy, and its actions thereby become the catalyst for the mobilization of previously neutral actors (Davis and Ward 1990, pp. 451–452). Repression may also harden the determination of members of the opposition and ignite a tougher response from rebellious groups. As a consequence, relatively innocent incidents of protest may escalate into large-scale rebellions with a large number of casualties.

Most research (see Auvinen 1996, p. 79) has detected an inverted U-curve relationship between type of regime and political conflict: mild repression incites conflict, and only intense repression deters it.[9] The rationale behind the inverted U-curve is that, on one end of the curve, the severe costs of rebellion in an extremely repressive political system inhibit resource mobilization by dissident groups; on the other end, the availability of reasonably effective peaceful means of political action in a nonrepressive political system makes rebellion an undesirable strategy of opposition for most people; but in the middle, rebellion is likely to be the preferred strategy of opposition for many dissident groups in a semirepressive political system in which resource mobilization is possible and peaceful opposition typically is ineffective (Muller and Weede 1990, p. 627).

A distinction is sometimes made between structural or institutionalized repression and behavioral repression. Structural repression refers to the repressive capability of the regime, while behavioral repression refers to actual acts of coercion by the government or parts thereof. The two are not necessarily the same because even the most democratic regimes do not guarantee the absence of repression. This is demonstrated by the occasional use of repression by Western democracies (Henderson 1973, p. 133). Nevertheless, Muller and Weede (1990) found that the inverted U-curve applies to both structural and behavioral repression.

Muller and Weede suggest that an inverted U-curve relationship supports a theory of belligerents as rational actors. An actor who calculates utilities and, particularly, costs of action, takes into account the probability that when the level of repression is high, the expected benefits of either rebellion or peaceful collective action will be relatively low because of high costs and a low expectancy of success. When repression is low, the expected benefits of rebellion will be exceeded by the expected benefits of peaceful collective action. When repression is moderate, the expected benefits of rebellion will exceed those of peaceful collective action (Muller and Weede 1990, p. 628). This explanation of conflict as a function of rational actors calculating costs and benefits provides some support to Collier's greed theory, even if only political and not economic benefits are evident. However, Muller and Weede admit that you may arrive at the same proposition from a relative deprivation perspective (1990, p. 647), which corresponds to grievance theory.[10]

Authoritarianism and the Form of Conflict

Authoritarian regimes are more susceptible to rebellion than to political protest. In Gurr and Lichbach's study (1986, p. 69), autocratic governments faced proportionally three times as much revolutionary opposition as democratic governments, but were less likely to hear reformist demands. In Chile, the coup d'état of 1973 interrupted a long tradition of democratic rule. Legitimate opposition was disallowed and repressed, which led to the development of new and radical forms of political resistance.

The prevailing norms of political regimes, whether democratic or authoritarian, influence the tactics of dissidents and the responses of the elites to them. Democratic elites are disposed to make appreciable concessions to protest, whereas authoritarian regimes, be they of the left or the right, are more likely to rely on repression. In democratic countries, this reinforces the utility of protest over rebellion, whereas in autocracies it increases the relative usefulness of rebellion for challengers who are desperate enough to act at all (Gurr and Lichbach 1986, p. 12).

Democracies may not discourage political protest, but they are successful in eliminating or strongly reducing the probability of rebellion. Gurr and Lichbach found that in democratic countries, dissidents rarely had revolutionary objectives; reformist demands were 10 times as common (1986, p. 69). Civil conflicts are also less deadly in democracies than in autocracies (Graham and Gurr 1969). Hibbs (1973) shows this by employing Cutright's (1963) index of political development, although the relationship disappears if economic development is controlled for.[11] Hazlewood divides political systems into polyarchic, centrist, and personalist. He finds that in polyarchic systems the number of revolutions, guerrilla wars, and assassinations was smaller but the number of governmental crises and riots was larger, compared to the sample mean. Personalist states were above the mean for all states on these five conflict indicators and above the mean for each of the other groups on all indicators except riots. Centrist systems had the lowest mean values on all indicators except revolutions (Hazelwood 1973, p. 184).[12]

Authoritarianism and Irregular Executive Transfer

The chances of peaceful regime change are limited under authoritarian rule. In the 1980s, before the end of the Cold War, political liberalization was infrequent. The most common mechanism for changing an authoritarian regime was by force, sometimes through mass rebellion or revolution but more commonly through a coup d'état by the elite. Authoritarianism was the most important determinant of political instability in Central America, save in Costa Rica, where peaceful and routine procedures for the transfer of power were established. In such coups, Lindenberg says, "The seeds of discontent for the next crisis cycle have been planted during the period of stable military rule without concurrent mechanisms for channeling this discontent into peaceful regime change" (1990, pp. 416, 419). In autocratic regimes, coups are invariably the preferred mode of succession. More than 80 percent of the countries in sub-Saharan Africa experienced at least one successful or unsuccessful coup from the 1950s to the early 1980s (Johnson, Slater, and McGowan 1984). In most cases, authoritarian regimes followed one another. More than two-thirds of the executive transfers between 1965 and 1987 were "irregular" (Hughes and May 1988). Adelman and Hihn conclude that "the possibility of political instability, or that of discontinuous political transitions, can be greatly reduced if governments make a conscious effort to pursue a development process that leads to greater social mobility and is combined with increased political participation" (Adelman and Hihn 1984, p. 20).

In closed political systems, elites are the main contestants for political power and enrichment. The main elite groups may unite to support the government if economic growth is sufficient to accrue benefits to all of them. On the other hand, economic hardship is likely to affect distribution and form cleavages within the elite, so that the threat of a coup d'état by relatively deprived groups increases. Democratic regimes imply more open decision-making. Political participation and competition should reduce the exclusiveness of opportunity for enrichment in political office. The elite is more likely to be divided into different pluralist power centers that compete for political power within democratically functioning institutions (Morrison and Stevenson 1971, p. 349). Of course, elites may use democracy's liberties for personal enrichment and corruption. Nevertheless, democratic regimes are likely to discourage coups, even while encouraging political protest as a favored mode of dissent.

Although democratic political regimes may be less susceptible than authoritarian regimes to elite instability in general and to irregular executive transfer in particular, they too have been overthrown during periods of economic hardship. On the basis of Latin American developments in the 1960s and 1970s, the bureaucratic-authoritarian approach postulated a causal link between economic crises and political authoritarianism in countries at middle levels of economic development (O'Donnell 1973, 1978): the military took political power when it perceived that democratic regimes were incapable of coping with the social consequences brought about by economic decline. This argument lost much credibility in the 1980s when democratic regimes replaced authoritarian regimes in Latin America (see Frieden 1989, p. 123). O'Donnell explained this new development by those countries' citizens attaching an increased intrinsic value to democracy. The populace brought about this value change in two ways:

first, by discrediting groups that sought a violent and immediate route to socialism, and second, by reflecting on experiences with authoritarian regimes that, despite using unprecedented repression and violence, failed to bring about economic progress (O'Donnell, Schmitter, and Whitehead 1986, pp. 15–17). Democracy became a preferable alternative to authoritarian rule.

In fact, Latin American democracies were more durable than autocracies during the debt crises of both the 1930s and the 1980s. No democratic government was brought down in the 1980s as a result of continued debt outflow (Drake 1989, pp. 53–54). In Asia, the countries of Pakistan, South Korea, and the Philippines all moved toward more democratic rule. In some African countries the trend was slightly different. Ghana (1981), Nigeria (1983), and Sudan (1989) experienced a shift from fairly democratic to authoritarian regimes as a result of coups d'état. Notably, in Ghana a democratic paralysis had brought the economy to the brink of collapse before the coup. Overall, however, the recent empirical evidence runs contrary to the bureaucratic-authoritarian argument.

Authoritarian regimes have been able to cling to power during periods of relative prosperity, but they are more prone to collapse during economic crises than democracies. All of the breakdowns of authoritarian regimes discussed in the collection by O'Donnell, Schmitter, and Whitehead (1986) were accompanied by economic crises (Bermeo 1990, p. 372). Dictatorships have a narrow base of legitimacy and support, which makes them dependent on being able to keep an efficient economy and an orderly society (Drake 1989, pp. 53–54). But democracies gain legitimacy from electoral, not merely effectual, means.[13] Compared to democracies, authoritarian regimes are also more dependent on foreign lenders to stay in power. Neither Turkey nor Morocco experienced social unrest in the context of macroeconomic stabilization and structural adjustment policies; both were generously supported by IMF, the World Bank, and other lenders. This "made possible a degree of 'cushioning' in the economy which would otherwise have been impossible" (Seddon 1992, p. 49).[14]

OTHER FACTORS

Military centrality, as indicated by the ratio of military expenditure to GNP, contributes to humanitarian emergencies through several dynamics. On the one hand, military resources may be used to support predatory and authoritarian rulers, who generate desperate action and military response by the opposition. Under political deprivation and in the absence of political mechanisms to settle grievances, full-scale rebellion becomes more likely. Alternatively, a strong military may overthrow either a democratic or an authoritarian regime, which may lead to political instability and humanitarian crisis. Powerful armed forces constitute a constant threat to civilian regimes in less-developed countries. Particularly during economic austerity, the regimes are afraid to cut back on military spending; they may even strengthen the military to stave off threats from the opposition. This, in turn, entails heavy socioeconomic costs for the population, inducing further discontent and increasing the risk of rebellion. In very poor countries, an increasing budget allocation for the military may produce downright starvation and destitution.

Citizens adapt to a certain acceptable level of violence through the cultural experience of violence. A tradition of intensive political violence makes societies more susceptible to war and humanitarian emergencies.[15] Countries with a history of mass political mobilization for conflict, such as Rwanda, Burundi, and Colombia, are likely to be more susceptible to conflict in humanitarian emergencies than other, historically more peaceful countries. A tradition of conflict is an indicator of the legitimacy of political violence.

In empirical studies, including conflict tradition in the model helps improve model specification. Auvinen (1997, p. 187) found that levels of previous political protests, rebellions, and irregular transfers were related to present levels.

ETHNICITY

Ethnic identity is not a primordial given. Ethnicity, when implicated in humanitarian emergencies, is created, manifested, combined, and reconstituted in struggles to share benefits from modernization and selfgovernment but is not a source of these struggles (Nafziger, Stewart, and Väyrynen 2000, both volumes). As Widner says (1999, p. 406), "Ethnic identities are socially constructed, highly malleable, and situationally defined." For example, the concept of the Yoruba people in Nigeria expanded under British reorganization after the beginning of the twentieth century, when Yoruba referred only to the people of the Oyo kingdom. Elites use identification with ethnic and regional communities, and even accentuate them, to transfer potential hostility toward themselves, because of inequalities and power disparities within their communities, to the elites and subjects of other communities. Alexander, McGregor, and Ranger (2000, pp. 305–306) argue that "the salience of ethnic antagonism in some recent wars cannot be explained as the inevitable resurgence of ancient tensions—rather, [such tensions] are the product of a reworking of historical memories in particular political contexts . . . Ethnicity is widely understood to be unnatural, to be historically 'invented,' 'constructed,' or 'imagined,' and used 'instrumentally' by politicians." In many instances, ethnic antagonism emerges during conflict rather than having been the cause of conflict.

In 1980s South Africa, ethnic consciousness and cleavages were deliberately aroused as part of the government's strategy of divide and rule implemented through the security apparatus. Chief Mangosuthu Buthelezi of the Zulu-based Inkatha Freedom Party used cultural symbolism to strengthen his and his party's political power. During the most violent phase of conflict, 1991–1993, ethnic identities became further strengthened and reified, and their relevance as sources of political mobilization increased (Auvinen and Kivimäki 1998, p. 42; 2001; Taylor and Shaw 1994). In a similar way, former Yugoslav President Slobodan Milosevic redeemed Serb nationalism by evoking the account of the Kosovo Polje battle of 1389–still painful to Serbian pride 600 years later. In Somalia, President Siad Barre succeeded in holding power for 13 years after his failed military campaign in the Ogaden in 1977–78 by manipulating clan identities and thus dividing the opposition into several different movements. This strategy, however, led to his ousting in 1991. By having fueled clan antagonisms, Barre made the instrumental use of clan affinities much easier for his opponents, who turned his work to their advantage (Auvinen and Kivimäki 2000, pp. 187–230).

According to Collier (2000b, pp. 12–13): "Ethnic grievance is actively manufactured by the rebel organization as a necessary way of motivating its forces. As a result, where conflicts occur in ethnically diverse societies, they will look and sound as though they were caused by ethnic hatreds . . . Conflict is not caused by divisions, rather it actively needs to create them. When such conflicts are viewed during or after the event, the observer sees ethnic hatred. The parties to the conflict have used the discourse of group hatred in order to build fighting organizations. It is natural for observers to interpret such conflicts as being caused by ethnic hatred. Instead, the conflicts have caused the intergroup hatred and may even, as in Somalia, have created the groups."[16]

CONCLUSION

This paper examines the way various factors within the political economy lead to humanitarian emergencies, characterized by war, state violence, and refugee displacement. A major factor responsible for the increase in emergencies in the 1990s was the developing world's stagnation and protracted decline in incomes during the 1980s, which contributed to state decay and collapse. Economic decline and predatory rule that fail to provide state services lead to relative deprivation, or to a perception by influential social groups of injustice arising from a growing discrepancy between conditions they expect and those they can get. Relative deprivation spurs social dissatisfaction and political violence. Poor economic performance undermines the legitimacy of a regime, increasing the probability of regime turnover. Political elites use repression to forestall threats to the regime and capture a greater share of the population's declining surplus. Repression and economic discrimination trigger further discontent and sociopolitical mobilization on the part of the groups affected, worsening the humanitarian crisis. Protracted economic stagnation increases the probability of population displacement, hunger, and disease.

Slow or negative per-capita growth, which is often accompanied by a chronic external disequilibrium, necessitates stabilization and adjustment; those countries whose adjustment policies fail, so that they do not qualify for the IMF "Good Housekeeping seal," are more vulnerable to humanitarian disaster.

Another factor, high inequality in income, contributes to regional, ethnic, and class discrepancies that engender crises. In addition, the competition for mineral resources by warlords and traders in weak states increases vulnerability to war and state violence. Authoritarianism is related to emergencies but not in a linear fashion; instead, emergencies first increase with authoritarian repression, then decrease along an inverted U-curve. Another explanation for emergencies is military centrality, found more frequently in decaying states. Military centrality can spur conflicts as well as increase poverty. Furthermore, a tradition of violent conflict, in which violence becomes normatively justifiable in a society, increases the risk of a humanitarian emergency. Contrary to a commonly held view, ethnicity is not usually a source of conflict and state violence but often emerges during conflict, sometimes as an invention or construction of politicians.

Since low average income, slow economic growth, high income inequality, and a decaying state are important contributors to emergencies, Third World states, with the support of the international community, must strengthen and restructure the political economy of their own poor, inegalitarian, and weak states. The major changes governments of less developed countries need to make are economic and political institutional changes—the development of a legal system, enhanced financial institutions, increased taxing capacity, greater investment in basic education and other forms of social capital, well-functioning resource and exchange markets, programs to help weaker segments of the population, and democratic institutions that accommodate and coopt the country's various ethnic and regional communities. Institutional and infrastructural development increases the productivity of private investment and public spending and enhances the effectiveness of governance.

Industrialized countries and international agencies bear a substantial responsibility to help developing nations by modifying the international economic order to enhance those nations' economic growth and adjustment. Developing regions, for their part, must demand greater consideration of their economic interests within present international economic and political institutions. The interests of the Third World can generally be served by the following means: the enhancing of its flexibility and self-determination in designing paths toward adjustment and liberalization; a shift in the goals and openness of the IMF and World Bank; the restructuring of the international economic system for trade and capital flows; the opening of rich countries' markets; more technological transfer by foreign companies, bilateral donors, and international agencies; a greater coherence of aid programs; and increased international funding to reduce food crises, directly help the poor, ameliorate external shocks, and write down debt burdens.

A number of countries vulnerable to humanitarian emergencies are not amenable to political economy solutions. Policies of governing elites are indeed at the root of most emergencies, and usually some powerful faction of society benefits from them. Yet a large number of countries vulnerable to emergencies have the will to change. Thus there is a substantial scope for international, national, and nongovernmental economic and political actors to coordinate their long-term policies to reduce the developing world's vulnerability to humanitarian emergencies.[17]

Notes

1. A weakening or decaying state is one experiencing a decline in the basic functions of the state, such as possessing authority and legitimacy, making laws, preserving order, and providing basic social services. A complete breakdown in these functions indicates a failing or collapsing state (Holsti 2000, pp. 246–50; Zartman 1995, pp. 1–7).
2. Regression models include ordinary least squares (OLS), generalized least squares (GLS or Prais-Winsten), two-stage least squares, fixed and random effects, tobit, and probit models. See Tables 3A.1–3A.4 for the results of a few of these regressions.
3. Queen Elizabeth House is the University of Oxford's center for development studies.
4. This study is more applicable to preventing terrorism by the state or by warlords, the most frequent contributor to deaths from humanitarian emergencies, than to preventing terrorism by those trying to undermine the state. Falk (2002, p. 11) indicates that the word terrorism initially "describe[d] political violence derive[d] from the government excesses that spun out of control during the French Revolution." He deplores "the regressive narrowing of the concept of terrorism to apply only to violence by nonstate movements and organizations, thereby exempting state violence against civilians from the prohibition on terrorism . . . Such a usage is ethically unacceptable, politically manipulative and decidedly unhistorical."
5. Nafziger and Auvinen (2003, p. 201) found, like Collier and Hoeffler (1999, 2000), that the incidence of armed conflict in Africa exceeded the incidence in other developing regions in the 1990s. If Africa's economic performance had been as high as that of non-African LDCs, Africa's incidence of conflict would have been similar to that of other developing regions (ibid.). Collier and Hoeffler's finding is similar to ours. Stewart, Huang, and Wang (2001) indicate that

Africa had by far the greatest number of deaths (direct and indirect) from conflict during 1960–1995 as a proportion of the 1995 population—1.5 percent, compared to 0.5 percent in the Middle East, 0.3 percent in Asia, and 0.1 percent in Latin America.

6. Auvinen and Nafziger (1999, p. 278) found that there was an inverse relationship between IMF credits, as a percentage of GNP, and emergencies. Some of the explanation may stem from the IMF's refraining from funding "basket cases" devastated by war and displacement. In that case, the negative coefficient would be picking up a reverse causal relationship. Indeed, our two-stage least squares results, using the IMF credits/GNP variable, confirmed this reverse causality. Moreover, when the IMF variable was used as a predictor for lagged values of dependent variables, its coefficients were larger than for the OLS regression, indicating that perhaps emergencies keep away the IMF rather than vice versa (Auvinen and Nafziger 1999, pp. 280–281). Thus, a potential emergency reduces the likelihood of receiving IMF and other international support for adjustment programs.

   A major contributor to nonadjustment is the distortion from an overvalued domestic currency. Nafziger (1988, pp. 150–160) argues that African governments resist adjustments to market prices and exchange rates that interfere with state leaders' ability to build political support, especially in cities.
7. Berdal and Malone (2000) ask whether greed or grievance drives contemporary civil wars. Our answer is that *both* greed and grievance (from deprivation and inequality) are consistent with most of their contributors. This view is at odds with that of the World Bank's Collier, who holds that "the only result that supports the grievance approach to conflict is that a prior period of rapid economic decline increases the risk of conflict" (2000a, p. 97). But Collier, who apparently did not use Deininger and Squire's dataset, finds that inequality "has no effect on the risk of conflict according to the data . . . The grievance theory of conflict thus finds surprisingly little empirical support" (Collier 2000a, pp. 97–98). Can we really argue that the East Timorans, the Kashmir mujahidin, Chechnyans, Palestinians, the Hutu, Nuba, and southern Sudanese, to name just a few, are motivated only by greed and not also by grievance?
8. The International Federation of Red Cross and Red Crescent Societies (1994) indicates that 3,750 people were killed in internal repression and resistance in South Africa in 1993. Moreover, Wallensteen and Sollenberg (1996, 1997, 1998) classify South Africa from 1991 to 1993 as a war.
9. This thesis was introduced by Buss (1961, p. 58) and was developed in Gurr's relative deprivation model (1970), where "utilitarian and normative justifications"—views on the utility and appropriateness of collective violence—affected the likelihood of political violence. Utilitarian and normative justifications were secondary to relative deprivation, which was a necessary condition for political violence. A squared term has been used to capture the curvilinearity of the relationship (see, e.g., Boswell and Dixon (1990).
10. Whereas in resource mobilization/rational actor theories the inverted U-curve relationship relates to the opportunities for resource mobilization and to the calcula-

tion of costs and benefits by rational individuals, in frustration-aggression/relative deprivation theories it is viewed as being analogous to the concept of punishment in psychological theories (see Markus and Nesvold 1972, p. 235).

11. On difficulties related to Cutright's index, see Bollen (1980).
12. The sample consisted of 83 developing and developed countries in 1958–1960; African countries are not included in the analyses.
13. "Their [the dictatorships'] legitimacy often rests largely on their purported ability to provide economic efficiency and social order. Depression and debt disaster severely undermine those capabilities . . . More significant . . . may be the advantages of democracies. One virtue is that they have other sources of legitimacy. They can claim to be elected, representative, popular, and fair. They can convey a more equitable image of the distribution of sacrifices. In the absence of 'economic goods,' democracies can distribute 'political goods,' such as freedom of speech and assembly, which also provide safety valves for discontent" (Drake 1989, 53–54).
14. For more detail on how authoritarianism and democracy have affected emergencies, especially in the 1990s, see Nafziger and Auvinen 2003, pp. 114–131.
15. Auvinen and Nafziger (1999, pp. 278–279, 286) find a direct association between the number of deaths from intrastate violence in the 1960s and 1970s and humanitarian emergencies in the 1980s and 1990s.
16. This view marks a departure from Collier and Hoeffler (1998, p. 567), in which one variable explaining civil war and its duration is the extent of ethno-linguistic fractionalization.
17. Nafziger and Väyrynen (2002) provide detail on policies to prevent humanitarian emergencies.

Appendix 3A

Results of Regression Analyses

Table 3A.1 Humanitarian Emergencies: OLS Regression Models

Explanatory variables	LDEATREF	LHUMEMER	LCOHE
Constant	7.31*** (2.67)	4.27** (1.85)	15.07*** (2.51)
LGDPGRO[−1]	−1.83*** (0.55)	−1.16*** (0.38)	−2.54*** (0.52)
LGINI[−1]	0.29** (0.12)	0.18** (0.08)	0.36*** (0.11)
LGNPCAP[−1]	−0.15*** (0.03)	−0.07*** (0.02)	−0.19*** (0.03)
LIMFGNP[−1]	−0.10*** (0.03)	−0.05*** (0.02)	−0.06** (0.03)
LCPIDIFF[−1]	0.26*** (0.06)	0.20*** (0.04)	0.27*** (0.05)
LMILCENT[−1]	0.18*** (0.03)	0.16*** (0.02)	0.15*** (0.03)
LDEATRAD	0.04*** (0.01)	a	0.02* (0.01)
R square	0.18	0.16	0.19
N	663	663	663
DW	0.34	0.31	0.38

NOTE: The figures are parameter estimates and, in parentheses, standard errors. OLS stands for ordinary least squares. LGDPGRO = ln real GDP growth; LGINI = ln Gini index; LGNPCAP = ln GNP per capita; LIMFGNP = ln use of IMF credit/GNP; LCPIDIFF = ln consumer price index, annual change; LMILCENT = ln military expenditures/GNP; LDEATRAD = ln deaths from domestic violence 1963–77. Except for LDEATRAD, all explanatory variables are lagged one year [−1]. Coefficient significance: * significant at the 0.10 level (two-tailed test); ** significant at the 0.05 level (two-tailed test); *** significant at the 0.01 level (two-tailed test); a = not significant. DW = Durbin-Watson test statistic for serial correlation.
SOURCE: Nafziger and Auvinen (2003), p. 23.

Table 3A.2 Humanitarian Emergencies: GLS (Prais-Winsten) Regression Models

Explanatory variables	LDEATREF	LHUMEMER	LCOHE
Constant	−2.69*** (0.81)	1.18a(0.73)	2.82*** (0.58)
LGDPGRO[−1]	b	−0.29**(0.14)	a
LFOODGRO [−1]	−0.19* (0.12)	a	b
LGINI[−1]	0.97*** (0.16)	0.14* (0.08)	0.56*** (0.14)
LGNPCAP[−1]	−0.14*** (0.04)	−0.07*** (0.02)	−0.21*** (0.03)
LIMFGNP[−1]	a	a	a
LCPIDIFF[−1]	0.16*** (0.04)	a	0.19*** (0.04)
LMILCENT[−1]	0.19*** (0.04)	0.10*** (0.02)	0.19*** (0.03)
LDEATRAD	0.05*** (0.01)	0.02*** (0.007)	0.03*** (0.01)
Rho	0.86***(0.02)	0.88***(0.02)	0.83***(0.02)
N	600	753	732
DW	1.93	1.64	1.98

NOTE: The figures are parameter estimates and in parentheses, standard errors. GLS stands for generalized least squares. LGDPGRO = ln real GDP growth; LFOODGRO = ln growth of food production per capita; LGINI = ln Gini index; LGNPCAP = ln GNP per capita; LIMFGNP = ln use of IMF credit/GNP; LCPIDIFF = ln consumer price index, annual change; LMILCENT = ln military expenditures/GNP; LDEATRAD = ln deaths from domestic violence, 1963–77. Except for LDEATRAD, all explanatory variables are lagged one year [−1]. Rho = coefficient of autocorrelation. Coefficient significance: * significant at the 0.10 level (two-tailed test); ** significant at the 0.05 level (two-tailed test); *** significant at the 0.01 level (two-tailed test); a = not significant; b = not included in the equation. DW = Durbin-Watson test statistic for serial correlation.

SOURCE: Nafziger and Auvinen (2003), p. 24.

Table 3A.3 Humanitarian Emergencies: Fixed (LSDV) and Random Effects (GLS) Models

Explanatory variables	LDEATREF		LHUMEMER		LCOHE	
	Fixed	Random	Fixed	Random	Fixed	Random
Constant	3.52*** (0.85)	3.68** (1.46)	0.69** (0.32)	0.11a (0.27)	11.10*** (1.56)	8.61*** (1.19)
LGDPGRO[−1]	a	−0.45* (0.27)	a	a	−0.72*** (0.26)	−0.53** (0.25)
LGINI[−1]	−0.90*** (0.23)	−0.44** (0.19)	a	a	−0.50** (0.23)	a
LGNPCAP[−1]	a	a	−0.11** (0.05)	−0.07** (0.03)	−0.19*** (0.05)	−0.22*** (0.04)
LCPIDIFF[−1]	a	a	a	0.07** (0.03)	a	a
LMILCENT[−1]	0.23*** (0.03)	0.20*** (0.03)	0.17*** (0.03)	0.17*** (0.03)	0.24*** (0.03)	0.23*** (0.03)
LDEATRAD	a	0.05** (0.02)	a	a	a	a
No. of units	69	62	91	77	61	83
R square	0.08	0.07	0.04	0.10	0.10	0.18
N	885	775	1,102	933	752	996

NOTE: The figures are parameter estimates and, in parentheses, standard errors. LSDV stands for least square dummy variable. GLS stands for generalized least squares. LGDPGRO = ln real GDP growth; LGINI = ln Gini index; LGNPCAP = ln GNP per capita; LCPIDIFF = ln consumer price index, annual change; LMILCENT = ln military expenditures/GNP; LDEATRAD = ln deaths from domestic violence, 1963–77. Except for LDEATRAD, all explanatory variables are lagged one year [−1]. Coefficient significance: * significant at the 0.10 level (two-tailed test); ** significant at the 0.05 level (two-tailed test); *** significant at the 0.01 level (two-tailed test); a = not significant. R square is for "within effects" in the fixed effects model and for "overall effects" in the random effects model. Number of units = number of cross-sectional units taken into account by the analysis.

SOURCE: Nafziger and Auvinen (2003), p. 25.

Table 3A.4 Probabilities of Humanitarian Emergencies: Probit Models

Explanatory variables	LDEATREF	LHUMEMER
LGDPGRO[−1]	−0.82* (0.45)	−0.41** (0.20)
LGINI[−1]	0.25*** (0.10)	0.12** (0.05)
LGNPCAP[−1]	−0.13*** (0.03)	−0.03** (0.01)
LIMFGNP[−1]	−0.07*** (0.03)	−0.014 (0.011)
LCPIDIFF[−1]	0.05 (0.04)	−0.01 (0.02)
LMILCENT[−1]	0.05* (0.028)	0.02* (0.01)
LDEATRAD	0.04*** (0.01)	0.01*** (0.003)
Obs. P	0.33	0.08
Pred. P	0.30	0.05
Log likelihood	−309.79	−136.60
Chi squared	95.40	35.42
N	562	562

NOTE: The figures are changes in probabilities and, in parentheses, standard errors. LGDPGRO = ln real GDP growth; LGINI = ln Gini index; LGNPCAP = ln GNP per capita; LIMFGNP = ln use of IMF credit/GNP; LCPIDIFF = ln consumer price index, annual change; LMILCENT = ln military expenditures/GNP; LDEATRAD = ln deaths from domestic violence, 1963–77. Except for LDEATRAD, all explanatory variables are lagged one year [−1]. Coefficient significance: * significant at the 0.10 level (two-tailed test); ** significant at the 0.05 level (two-tailed test); *** significant at the 0.01 level (two-tailed test). Obs. P = observed probability; Pred. P = predicted probability at the mean of the dependent variable. The statistical significance of the model is tested against the value of Chi squared with 7 degrees of freedom.

SOURCE: Nafziger and Auvinen (2003), p. 26.

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4
Productivity Growth in World Agriculture

Sources and Constraints

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Before the twentieth century, almost all increases in crop and animal production occurred as a result of enlarging the area cultivated. By the end of that century, almost all increases were coming from increases in land productivity—in output per acre or per hectare. This was an exceedingly short period in which to make a transition from a natural resource–based to a science-based system of agricultural production. In the presently developed countries, this transition began in the latter half of the nineteenth century. In most developing countries, the transition did not begin until well into the second half of the twentieth century. For some of the poorest countries in the world, the transition has not yet begun.

During the second half of the twentieth century world population more than doubled—from approximately 2.5 billion in 1950 to 6.0 billion in 2000. The demands placed on global agricultural production arising out of population and income growth almost tripled. By 2050, world population is projected to grow to between 9 and 10 billion people. Most of the growth is expected to occur in poor countries where the income elasticity of demand for food remains high. Even moderately high income growth, combined with projected population growth, could result in nearly doubling the demands placed on the world's farmers by 2050 (Johnson 2000; United Nations 2001).

The most difficult challenges will occur during the next two or three decades as both population and income in many of the world's poorest countries continue to grow rapidly. But rapid decline in the rate of population growth in such populous countries as India and China lends credence to United Nations projections that by mid-century the global rate of population growth will slow substantially. The demand for food arising out of income growth is also expected to slow as incomes rise and the income elasticity of demand for food declines. In the interim, very substantial increases in scientific and technical effort will be required, particularly in the world's poorest countries, if growth in food production is to keep pace with growth in demand.

AGRICULTURE IN DEVELOPMENT THOUGHT

Economic understanding of the process of agricultural development has made substantial advances over the last half century. In the early post–World War II literature, agriculture, along with other natural resource–based industries, was viewed as a sector from which resources could be extracted to fund development in the industrial sector (Lewis 1954, p. 139; Ranis and Fei 1961; Rostow 1956). Growth in agricultural production was viewed as an essential condition, or even a precondition, for growth in the rest of the economy. But the process by which agricultural growth was generated remained outside the concern of most development economists.

By the early 1960s a new perspective, more fully informed by both agricultural science and economics, was beginning to emerge. It had become increasingly clear that much of agricultural technology was location specific. Techniques developed in advanced countries were not generally directly transferable to less developed countries with different climates and resource endowments. Evidence had also accumulated that only limited productivity gains were to be had by the reallocation of resources within traditional peasant agriculture.

In his iconoclastic book *Transforming Traditional Agriculture*, Theodore W. Schultz (1964) insists that peasants in traditional agrarian societies are rational allocators of available resources and that they have remained poor because most poor countries provide them with only limited technical and economic opportunities to which they can respond—that is, they are "poor but efficient." If given the inputs and know-how of their modern counterparts, they too could succeed, Schultz maintains:

> The principal sources of the high productivity of modern agriculture are reproducible sources. They consist of particular material inputs and of skills and other capabilities required to use such inputs successfully . . .
>
> But these modern material inputs are seldom ready-made . . .
>
> In general, what is available is a body of useful knowledge which has made it possible for the advanced countries to produce for their own use factors that are technically superior to those employed elsewhere. This body of knowledge can be used to develop similar, and as a rule superior, new factors appropriate to the biological and other conditions that are specific to the agriculture of poor countries. (pp. 146–147)

This thesis implies three types of relatively high-payoff investments for agricultural development: 1) the capacity of agricultural research institutions to generate new location-specific technical knowledge; 2) the capacity of the technology supply industries to develop, produce, and market new technical inputs; and 3) the schooling and nonformal (extension) education of rural people to enable them to use the new knowledge and technology effectively. The enthusiasm with which this high-payoff input model was accepted and transformed into doctrine was due at least as much to the success of plant breeders and agronomists in developing fertilizer and management-responsive green revolution crop varieties for the tropics as to the power of Schultz's ideas.[1]

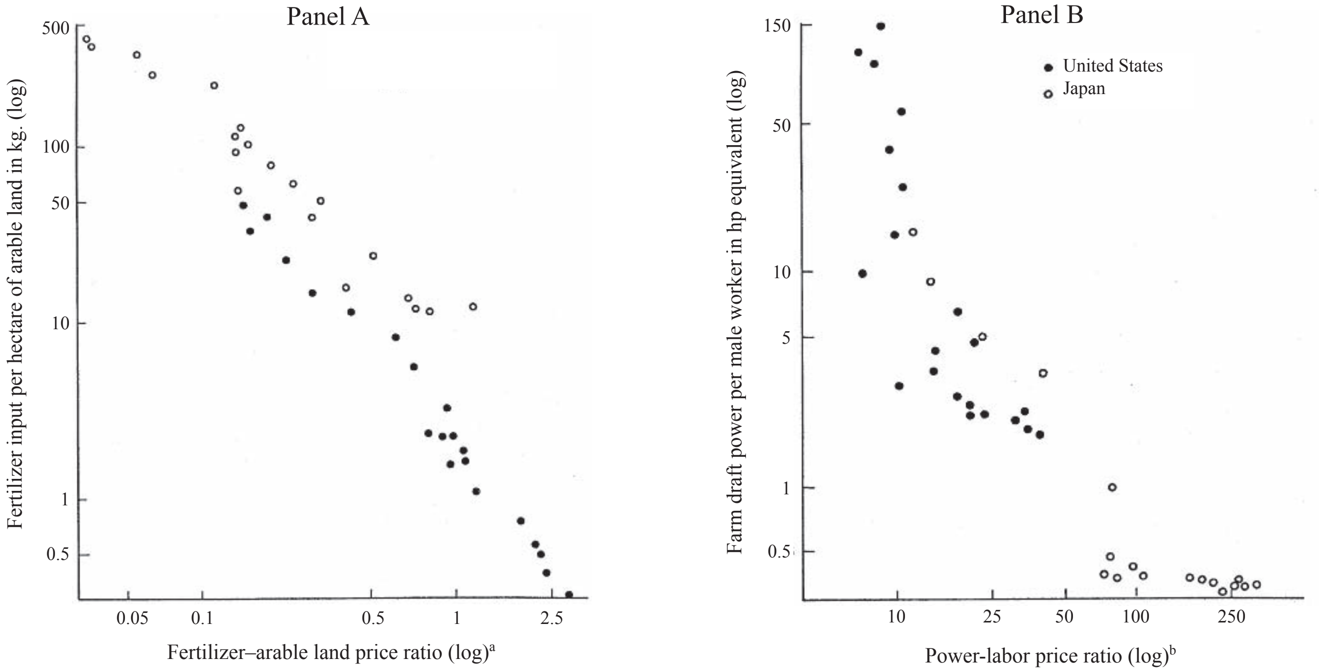
The Schultz "high-payoff input model" remained incomplete, however, even as a model of technical change in agriculture. It did not attempt to explain how economic conditions induce an efficient path of technical change for the agricultural sector of a particular society. Nor does the high-payoff input model attempt to explain how economic conditions induce the development of new institutions, such as public sector agricultural experiment stations, that become the suppliers of location-specific new knowledge and technology.

Beginning in the early 1970s, Hayami and Ruttan (1971, 1985) and Binswanger and Ruttan (1978) formulated a model of induced technical change in which the development and application of new technology is endogenous to the economic system. Building on the Hicksian model of factor-saving technical change and their own experience in southeast Asia, they proposed a model in which the direction of technical change in agriculture was induced by changes (or differences) in relative resource endowments and factor prices. In this model, alternative agricultural technologies are developed to facilitate the substitution of relatively abundant (hence cheap) factors for relatively scarce (hence expensive) factors. Two kinds of technology generally correspond to this taxonomy. Mechanical technology is labor saving, designed to substitute power and machinery for labor. Biological and chemical technology is land saving, designed to substitute labor-intensive production practices and industrial inputs such as fertilizer and plant- and animal-protection chemicals for land. Both the technical conditions of production and historical experience suggest that changes in land productivity and labor productivity are relatively independent (Griliches 1968).

The process of induced technical change can be illustrated from the historical experience of Japan and the United States, illustrated in Figure 4.1. In Panel A of Figure 4.1, the horizontal axis is the price of fertilizer relative to the price of land and the vertical axis the amount of fertilizer per hectare of agricultural land. In Panel B of Figure 4.1, the horizontal axis is the price of draft power—both animal and mechanical—relative to the price of labor and the vertical axis the amount of draft power per worker. Reading from right (1880) to left (1980), as the price of fertilizer declined relative to the price of land, fertilizer use per hectare rose in both countries (Panel A). Similarly, as the price of draft power declined relative to the price of labor, the use of power per worker rose in both countries (Panel B).

Throughout the period 1880–1980, Japanese farmers used more fertilizer per hectare than U.S. farmers, and U.S. farmers used more power per worker than Japanese farmers. These differences in use of fertilizer per unit of land and of draft power per worker between the two countries, and the changes in each country between 1880 and 1980, were not the result of simple factor substitution in response to relative price changes. The large changes in factor ratios were made possible only by the very substantial advances in biological and mechanical technology that facilitated the substitution of fertilizer for land and draft power for labor. These technical changes were induced by the differences and changes in relative factor price ratios (Hayami and Ruttan 1985, pp. 176–197).[2] Over time, particularly since World War II, there has been some convergence in relative factor prices and in relative intensity of factor use in the two countries.

Figure 4.1 Induced Technical Change in Fertilizer and Draft Power, the United States and Japan (quinquennial observations for 1880–1980)



[a] Relation between fertilizer input per hectare of arable land and the fertilizer–arable land price ratio: hectares of arable land that can be purchased by one ton of $N + P_2O_5 + K_2O$, contained in commercial fertilizers.

[b] Relation between farm draft power per male worker and power labor price ratio: hectares of work days that can be purchased by one horsepower (hp) of tractor or draft animal.

SOURCE: Hayami and Ruttan (1985, pp. 179–180).

Advances in mechanical technology in agriculture have been intimately associated with the industrial revolution. But the mechanization of agriculture cannot be treated as simply the adaptation of industrial methods of production to agriculture. The spatial dimension of crop production requires that the machines suitable for agricultural mechanization be mobile—they must move across or through materials that are immobile (Brewster 1950). The seasonal characteristic of agricultural production requires a series of specialized machines—for land preparation, planting, pest and pathogen control, and harvesting—designed for sequential operations, each of which is carried out for only a few days or weeks in each season. One result is that a fully mechanized agriculture is typically very capital intensive. Advances in biological technology in crop production involve one or more of the following three elements: 1) land and water resource development to provide a more favorable environment for plant growth; 2) the addition of organic and inorganic sources of plant nutrition to the soil to stimulate plant growth and the use of biological and chemical means to protect plants from pests and pathogens; and 3) selection and breeding of new, biologically efficient crop varieties specifically adapted to respond to those elements in the environment that are subject to management.

Advances in mechanical technology are a primary source of growth in labor productivity; advances in biological technology are a primary source of growth in land productivity. There are, of course, exceptions to this analytical distinction. For example, in nineteenth-century Japan, horse plowing was developed as a technology to cultivate more deeply to enhance yield (Hayami and Ruttan 1985, p. 75).[3] In the United States, the replacement of horses by tractors released land from animal feed to food production (Olmstead and Rhode 2001; White 2000). At the most sophisticated level, technical change often involves complementary advances in both mechanical and biological technology. For most countries, the research resource allocation issue is the relative emphasis that should be given to advancing biological and mechanical technology.

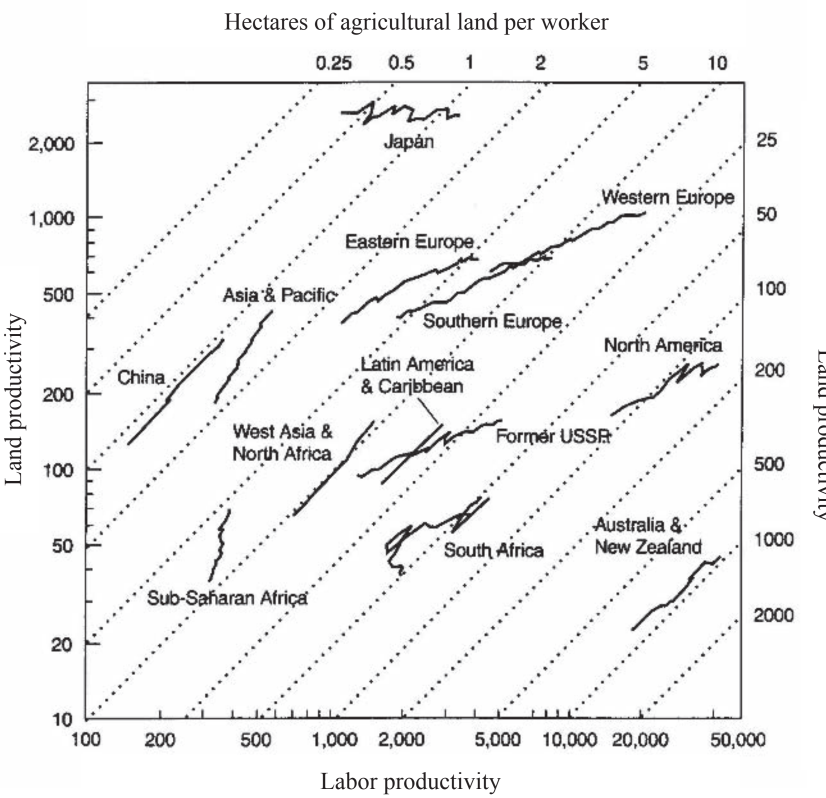
The model of induced technical change has important implications for resource allocation in agricultural research. In labor-abundant and land-constrained developing countries, like China and India, research resources are most productively directed to advancing yield-enhancing biological technology. In contrast, land-abundant Brazil has realized very high returns from research directed to releasing the productivity constraints on its problem soils. Discovery of the yield-enhancing effects of heavy lime application on acidic aluminum-containing soils has opened its *Campos Cerrados* (great plains) region to extensive mechanized production of maize and soybeans.

MEASURING THE RATE AND DIRECTION OF PRODUCTIVITY GROWTH

Comparative research on the rate and direction of productivity growth in agriculture has gone through three stages. Initially, efforts were directed to the measurement of partial productivity ratios and indexes, such as output per worker and per hectare. Intercountry cross-section and time-series comparisons of output per unit of land and labor were first assembled by Collin Clark in his pioneering study, *The Conditions of Economic Progress* (1940/1957). In the late 1960s, Clark's intercountry comparisons were revived and updated by Yujiro Hayami and associates (Hayami 1969; Hayami and Inagi 1969; Hayami, Miller, Wade, and Yamashita 1971). These early partial productivity studies identified exceedingly wide differences in land and labor productivity both among countries and among major world regions. Recent trends in land and labor productivity indicate that these wide differences have persisted.

In Figure 4.2, labor productivity (output per worker) is measured on the horizontal axis. Land productivity (output per hectare) is measured on the vertical axis. The dashed diagonal lines, with the units appearing across the top and down the right-hand side of the figure, trace the land-labor factor ratios (hectares of agricultural land per worker). The country and regional lines indicate land-labor trajectories for specific countries or regions. The partial productivity growth patterns of Figure 4.2 are displayed in much greater detail in the work of Hayami and Ruttan (1985, pp. 117–129). The several country and regional growth paths fall broadly into three groups: 1) a land-constrained path in which output per hectare has risen faster than output per worker, 2) a land-abundant path in which output per worker has risen more rapidly than output per hectare, and 3) an intermediate growth path in which output per worker and per hectare have grown at somewhat comparable rates. During the later stages of development, as the price of labor begins

Figure 4.2 International Comparison of Land and Labor Productivities by Region: 1961–1990.



SOURCE: Craig, Pardey, and Roseboom (1997, p. 1066).

to rise relative to the price of land, the growth path tends to shift in a labor saving direction. If land and labor productivity grow at the same rate, as in west Asia and North Africa, historical productivity follows a diagonal path. Partial productivity ratios such as those plotted in Figure 4.2 were employed by Hayami and Ruttan (1970, 1971, pp. 163–205) in their initial tests of the induced technical change hypothesis.

A second stage of the research on technical change in agriculture involved the estimation of cross-country production functions and the construction of multifactor productivity estimates. In these studies, factor inputs—typically land, labor, livestock, capital equipment (machinery), and current inputs (fertilizer)—were aggregated using either factor shares or statistical estimates as the weights for factor aggregation in multifactor productivity estimates or as elasticity coefficients in Cobb-Douglas type production functions.[4] Over time, improvements in data availability and estimation methods have contributed to greater reliability in the estimates.

The Hayami and Ruttan (1970) and the Kawagoe, Hayami, and Ruttan (1985) cross-country metaproduction functions (Lau and Yotopoulos 1989) have been used in growth accounting exercises to partition the sources of differences in agricultural labor and land productivity between developed and developing countries and among individual countries. The results indicated that internal resource endowments (land and livestock), modern technical inputs (machinery and fertilizer), and human capital (general and technical education) each accounted for approximately one-fourth of the differences in labor productivity between developed countries and less developed countries as groups. Scale economies, present in developed countries but not in less developed countries, accounted for about 15 percent of the difference.[5]

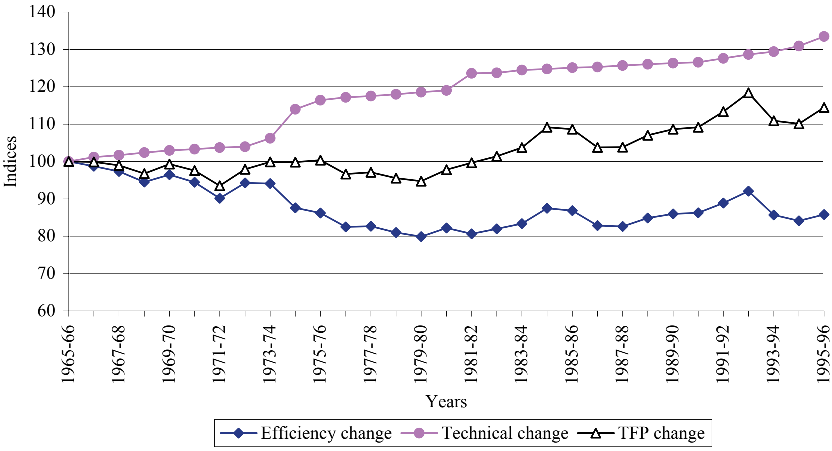
The implications of these results for potential growth of labor productivity in the agricultural production of less developed countries were encouraging. The pressure of population against land resources was not a binding constraint on agricultural production. Scale diseconomies were not an immediate constraint on labor productivity. Labor productivity could be increased by several multiples—to levels approximating the levels in Western Europe in the early 1960s—by investment in human capital and in agricultural research, and by more intensive use of technical inputs. The historical experience of Japan and the more recent experience of Korea and Taiwan did suggest, however, that as demand for labor, associated with rapid urban-industrial development, draws substantial labor from agriculture, small farm size could become a more serious constraint. As the agricultural labor force declines, farm consolidation results in a rise in the land/labor ratio and a rise in labor productivity.

A third stage in agricultural productivity analysis has involved efforts to test for the convergence of growth rates and levels of multifactor productivity between and among developing and less developed countries. Most of these studies have employed the Malmquist or frontier productivity approach. The basic idea of the Malmquist approach is to construct the best-practice, or frontier, production function and to measure the distance of each country in the sample from the frontier by applying a linear programming method known as data envelopment analysis. The combination of inputs is allowed to vary along an efficient frontier, rather than the fixed coefficient production functions employed in the second-stage studies, to partition changes in multifactor productivity into technical change and efficiency change components.[6] Technical change measures the shift in the best-practice or frontier production functions; efficiency change measures change in the difference between average practice and the best-practice productivity frontier.

These studies generally indicate a widening of the agricultural productivity gap between developed and developing countries between the early 1960s and the early 1990s. Within the group of developed countries, except for continuing divergence between northern and southern Europe, productivity levels have converged modestly. Developing countries as a group experienced declining total factor productivity relative to the frontier countries. There is, however, some evidence of convergence toward the still relatively low frontier productivity levels within African agriculture (Arnade 1998; Ball et al. 2001; Chavas 2001; Fulginiti and Perrin 1997, 1998; Suhariyanto, Lusigi, and Thirtle 2001; Thirtle, Hadley, and Townsend 1995; Trueblood and Coggins 2001).

The partitioning of total factor productivity into technical efficiency and technical change in Asian agriculture is illustrated in Figure 4.3. During the period from 1965–66 to 1995–96 the gap between average practice, as measured by technical *efficiency change*, and best practice, as measured by *technical change*, widened. As a result, average *total factor productivity change* (TFP) advanced more slowly than the rate of technical change in the countries on the efficiency frontier. Another way of making the same point is to say that technical efficiency has lagged behind technical change associated with the rapid adoption of green revolution seed-fertilizer technology in the frontier countries (Rosegrant and Hazell 2000, pp. 123–60). The results are not inconsistent with a technical trajectory implied by the induced technical change hypothesis. Technical change in Asia has been strongly biased in a land-saving direction, in response to the relatively severe constraints on land resources. This bias is reflected in both a land-saving shift in the pro-

Figure 4.3 Efficiency Change, Technical Change, and TFP Change in Asian Agriculture



SOURCE: Suhariyanto, Lusigi, and Thirtle (2001, p. 11).

duction function and the substitution of technical inputs, particularly fertilizer and pest and pathogen control chemicals, for land (Murgai 2001; Murgai, Ali, and Byerlee 2001). Similar trends have taken place in some of the more land-constrained, labor-intensive agricultural systems in Africa and Latin America.

TRANSITION TO SUSTAINABILITY

Growth in total factor productivity in agriculture, arising out of technical change and improvements in efficiency, has made an exceedingly important contribution to economic growth. Within rural areas, growth of land and labor productivity has led to substantial poverty reduction. Productivity growth has also released substantial resources to the rest of the economy and contributed to reductions in the price of food in both rural and urban areas (Irz et al. 2001; Shane, Roe, and Gopinath 1998). The decline in the price of food, which in many parts of the world is the single most important factor determining the buying power of wages, has been particularly important in reducing the cost of industrial development in a number of important emerging economies. These price declines have also meant that, in countries or regions that have not experienced such gains in agricultural productivity, farmers have lost competitive advantage in world markets and consumers have failed to share fully in the gains from economic growth. But what about the future? In the next two sections I will first address the environmental and resource constraints and then the scientific and the technical constraints that will confront the world's farmers as they attempt to respond to the demands that will be placed on them.[7]

RESOURCE AND ENVIRONMENTAL CONSTRAINTS

The leading resource and environmental constraints faced by the world's farmers include soil loss and degradation; waterlogging and salinity of soil; the coevolution of pests, pathogens, and hosts; and the impact of climate change. Part of my concern is with the feedback of the environmental impacts of agricultural intensification on agricultural production itself (Tilman et al. 2001).

Soil. Soil degradation and erosion have been widely regarded as major threats to sustainable growth in agricultural production in both developed and developing countries. It has been suggested, for example, that by 2050 it may be necessary to feed "twice as many people with half as much topsoil" (Harris 1990, p. 115). However, attempts to assess the implications of soil erosion and degradation confront serious difficulties. Water and wind erosion estimates are measures of the amount of soil moved from one place to another rather than of soil actually lost. Relatively few studies provide the information necessary to estimate yield loss from erosion and degradation. Studies in the United States by the Natural Resources Conservation Service have been interpreted to indicate that if 1992 erosion rates continued for 100 years the yield loss at the end of the period would amount to only 2–3 percent (Crosson 1995a). An exceedingly careful review of the long term relationship between soil erosion, degradation, and crop productivity in China and Indonesia concludes that there has been little loss of organic matter or mineral nutrients and that use of fertilizer has been able to compensate for loss of nitrogen (Lindert 2000). A careful review of the international literature suggests that yield losses at the global level might be roughly double the rates estimated for the United States (Crosson 1995b).

At the global level, soil loss and degradation are not likely to represent a serious constraint on agricultural production over the next half century. But soil loss and degradation could become a serious constraint at the local or regional level in some fragile resource areas. For example, yield constraints due to soil erosion and degradation seem especially severe in the arid and semiarid regions of sub-Saharan Africa. A slowing of agricultural productivity growth in robust resource areas could also lead to intensification or expansion of crop and animal production that would put pressure on soil in fragile resource areas—like tropical rain forests, arid and semiarid regions, and high mountain areas. In some such areas, the possibility of sustainable growth in production can be enhanced by irrigation, terracing, careful soil management, and changes in commodity mix and farming systems (Lal 1995; Niemeijer and Mazzucato 2002; Smil 2000).

Water. During the last half-century, water has become a resource of high and increasing value in many countries. In the arid and semiarid areas of the world, water scarcity is becoming an increasingly serious constraint on growth of agricultural production (Gleick 2000; Raskin et al. 1997; Seckler, Molden, and Barker 1999). During the last half century, irrigated area in developing countries more than doubled, from less than 100 million hectares to more than 200 million hectares. About half of developing-country grain production is grown on irrigated land. The International Water Management Institute has projected that by 2025 most regions or countries in a broad sweep from north China across East Asia to North Africa and northern sub-Saharan Africa will experience either absolute or severe water scarcity.[8]

Irrigation systems can be a double-edged answer to water scarcity, since they may have substantial externalities that affect agricultural production directly. Common problems of surface water irrigation systems include waterlogging and salinity resulting from excessive water use and poorly designed drainage systems (Murgai, Ali, and Byerlee 2001). In the Aral Sea Basin in central Asia, the effects of excessive water withdrawal for cotton and rice production, combined with inadequate drainage facilities, have resulted in such extensive waterlogging and salinity, as well as contraction of the Aral Sea, that the economic viability of the entire region is threatened (Glazovsky 1995). Another common externality results from the extraction of water from underground aquifers in excess of the rate at which the aquifers are naturally recharged, resulting in a falling groundwater level and rising pumping costs. In some countries, like Pakistan and India, these externalities have in some cases been sufficient to offset the contribution of expansion of irrigated area to agricultural production.

However, the lack of water resources is unlikely to become a severe constraint on global agricultural production in the next half century. The scientific and technical efforts devoted to improvement in water productivity have been much more limited than efforts to enhance land productivity (Molden, Amarasinghe, and Hussain 2001), so significant productivity improvements in water use are surely possible. Institutional innovations will be required to create incentives to enhance water productivity (Saleth and Dinar 2000). But in 50 to 60 of the world's most arid countries, plus major regions in several other countries, competition from household, industrial, and environmental demands will reallocate water away from agricultural irrigation. In many of these countries, increases in water productivity and changes in farming systems will permit continued increases in agricultural production. In other countries, the reduction in irrigated area will cause a significant constraint on agricultural production. Since these countries are among the world's poorest, some will have great difficulty in meeting food security needs from either domestic production or food imports.

Pests. Pest control has become an increasingly serious constraint on agricultural production in spite of dramatic advances in pest control technology. In the United States, pesticides have been the most rapidly growing input in agricultural production over the last half century. Major pests include pathogens, insects, and weeds. For much of the post–World War II era, pest control has meant application of chemicals. Pesticidal activity of dichlorodiphenyl-trichloroethane (DDT) was discovered by scientists in the late 1930s. It was used in World War II to protect American troops against typhus and malaria. Early tests found DDT to be effective against almost all insect species and relatively harmless to humans, animals, and plants. It was relatively inexpensive and effective at low application levels. Chemical companies rapidly introduced a series of other synthetic organic pesticides in the 1950s

(Ruttan 1982; Palladino 1996). The initial effectiveness of DDT and other synthetic organic chemicals for crop and animal pest control after World War II led to the neglect of other pest control strategies.

By the early 1960s, an increasing body of evidence suggested that the benefits of the synthetic organic chemical pesticides introduced in the 1940s and 1950s were obtained at substantial cost. One set of costs included the direct and indirect health effects on wildlife populations and on humans (Carson 1962; Pingali and Roger 1995). A second set of costs involved the destruction of beneficial insects and the emergence of pesticide resistance in target populations. A fundamental problem in efforts to develop methods of control for pests and pathogens is that the control results in evolutionary selection pressure for the emergence of organisms that are resistant to the control technology (Palumbi 2001). When DDT was introduced in California to control the cottony cushion scale, its predator the vedalia beetle turned out to be more susceptible to DDT than the scale. In 1947, just one year after the introduction of DDT, citrus growers were confronted with a resurgence of the scale population. In Peru, the cotton bollworm quickly built up resistance to DDT and to the even more effective—and more toxic to humans—organophosphate insecticides that were adopted to replace DDT (Palladino 1996, pp. 36–41).

The solution to the pesticide crisis offered by the entomological community was integrated pest management (IPM). IPM involved the integrated use of an array of pest control strategies: making hosts more resistant to pests, finding biological controls for pests, cultivation practices, and also chemical control if needed. At the time integrated pest management began to be promoted in the 1960s, it represented little more than a rhetorical device. But by the 1970s, a number of important IPM programs had been designed and implemented. However, exaggerated expectations that dramatic reductions in chemical pesticide use could be achieved without significant decline in crop yields as a result of IPM have yet only been partially realized (Gianessi 1991; Lewis et al. 1997).

My own judgment is that the problem of pest and pathogen control will represent a more serious constraint on sustainable growth in agricultural production at a global level than either land or water constraints.[9] In part, this is because the development of pest- and pathogen-resistant crop varieties and chemical methods of control both tend to induce the evolution of more resistant pests or pathogens. In addition, international travel and trade are spreading the newly resistant pests and pathogens to new environments. As a result, pest control technologies must constantly be replaced and updated. The coevolution of pathogens, insect pests, and weeds in response to control efforts will continue to represent a major factor in directing the allocation of agricultural research resources to assure that agricultural output can be maintained at present levels or continue to grow.[10]

Climate. Measurements taken in Hawaii in the late 1950s indicated that carbon dioxide (CO_2) was increasing in the atmosphere. Beginning in the late 1960s, computer model simulations indicated possible changes in temperature and precipitation that could occur because of human-induced emission of CO_2 and other greenhouse gases into the atmosphere. By the early 1980s a fairly broad consensus had emerged in the climate change research community that energy production and consumption from fossil fuels could, by 2050, result in a doubling of the atmospheric concentration of CO_2, a rise in global average temperature by 2.5°C–4.5°C (2.7°F–8.0°F) and a complex pattern of worldwide climate change (Ruttan 2001, pp. 515–520).

Since the mid-1980s, a succession of studies has attempted to assess how an increase in the atmospheric concentration of greenhouse gases could affect agricultural production through three channels: 1) higher CO_2 concentrations in the atmosphere may have a positive "fertilizer effect" on some crop plants (and weeds); 2) higher temperatures could result in a rise in the sea level, resulting in inundation of coastal areas and intrusion of saltwater into groundwater aquifers; and 3) changes in temperature, rainfall, and sunlight may also alter agricultural production, although the effects will vary greatly across regions. Early assessments of the impact of climate change on global agriculture suggested a negative annual impact in the 2–4 percent range by the third decade of this century (Parry 1990). More recent projections are more optimistic (Mendelsohn, Nordhaus, and Shaw 1994; Rosenzweig and Hillel 1998). The early models have been criticized for a "dumb farmer" assumption—they did not incorporate how farmers would respond to climate change with different crops and growing methods. Efforts to incorporate how public and private suppliers of knowledge and technology might adjust to climate change are just beginning (Evenson

1988). But even the more sophisticated models have been unable to incorporate the synergistic interactions among climate change, soil loss and degradation, ground and surface water storage, and the incidence of pests and pathogens. These interactive effects could combine into a significantly larger burden on growth in agricultural production than the effects of each constraint considered separately. One thing that is certain is that a country or region that has not acquired substantial agricultural research capacity will have great difficulty in responding to anticipated climate change impacts.

SCIENTIFIC AND TECHNICAL CONSTRAINTS

The achievement of sustained growth in agricultural production over the next half century represents at least as difficult a challenge to science and technology development as the transition to a science-based system of agricultural production during the twentieth century did. In assessing the role of advances in science and technology in releasing the several constraints on growth of agricultural production and productivity, the induced technical change hypothesis is useful. To the extent that technical change in agriculture is endogenous, scientific and technical resources will be directed to sustaining or enhancing the productivity of those factors that are relatively scarce and expensive. Farmers in those countries that have not yet acquired the capacity to invent or adapt technology specific to their resource endowments will continue to find it difficult to respond to the growth of domestic or international demand.

In the 1950s and 1960s, it was not difficult to anticipate the likely sources of increase in agricultural production over the next several decades (Millikan and Hapgood 1967; Ruttan 1956; Schultz 1964). Advances in crop production would come from expansion in area irrigated, from more intensive application of improved fertilizer and crop protection chemicals, and from the development of crop varieties that would be more responsive to technical inputs and management. Advances in animal production would come from genetic improvements and advances in animal nutrition. At a more fundamental level, increases in crop yields would come from genetic advances that would change plant architecture to make possible higher plant populations per hectare and would increase the ratio of grain to straw in individual plants. Increases in production of animals and animal products would come about by genetic and management changes that would decrease the proportion of feed devoted to animal maintenance and increase the proportion used to produce usable animal products.

I find it much more difficult to tell a convincing story about the likely sources of increase in crop and animal production over the next half century than I did a half century ago. The ratio of grain to straw is already high in many crops, and severe physiological constraints arise in trying to increase it further. There are also physiological limits to increasing the efficiency with which animal feed produces animal products. These constraints will impinge most severely in areas that have already achieved the highest levels of output per hectare or per animal unit—in Western Europe, North America and East Asia. Indeed, the constraints are already evident. The yield increases from incremental fertilizer application are falling. The reductions in labor input from the use of larger and more powerful mechanical equipment are declining as well. As average grain yields have risen from 1–2 metric tons per hectare to 6–8 metric tons per hectare over the last half century in the most favored areas, the share of research budgets devoted to maintenance research—the research needed to maintain existing crop and animal productivity levels—has risen relative to total research budgets (Plucknett and Smith 1986). Cost per scientist year has been rising faster than the general price level (Huffman and Evenson 1993; Pardey, Craig, and Hallaway 1989). I find it difficult to escape a conclusion that both public and private sector agricultural research, in those countries that have achieved the highest levels of agricultural productivity, have begun to experience diminishing returns.

Perhaps advances in molecular biology and genetic engineering will relieve the scientific and technical constraints on the growth of agricultural production. In the past, advances in fundamental knowledge have often initiated new cycles of research productivity (Evenson and Kislev 1975). Transgenetically modified crops, particularly maize, soybeans, and cotton, have diffused rapidly since they were first introduced in the mid-1990s. Four countries—the United States, Argentina, Canada, and China—accounted for 99 percent of the 109 million acres of transgenic crop area in 2000 (James 2000). The applications that are presently available in the field are primarily in the area of plant protection and animal health. Among the more dramatic examples is the development of cotton varieties that incorporate resistance to the cotton bollworm. The effect has been to reduce the application of chemical control from 8–10 to 1–2 spray applications per season (Falck-Zepeda, Traxler, and Nelson 2000). These advances are enabling producers to push crop and animal yields closer to their genetically determined biological potential. But they have not yet raised biological yield ceilings above the levels that have been achieved by researchers employing the older methods based on Mendelian genetics (Ruttan 1999).

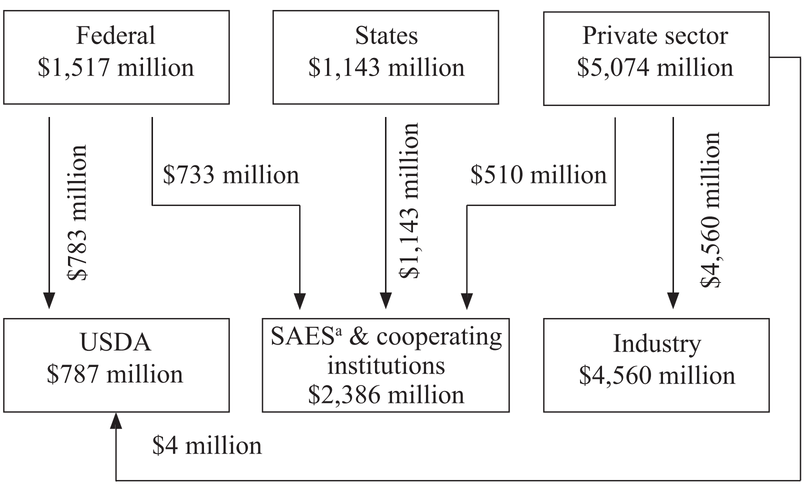
Advances in agricultural applications of genetic engineering in developed countries will almost certainly be slowed by developed country concerns about the possible environmental and health impacts of transgenetically modified plants and foods. One effect of these concerns has been to shift the attention of biotechnology research away from agricultural applications in favor of industrial and pharmaceutical applications (Committee on Environmental Impacts 2002, pp. 221–229). This shift will delay the development of productivity-enhancing biotechnology applications and agricultural development in less developed economies.

I find it somewhat surprising that it is difficult for me to share the current optimism about the dramatic gains to be realized from the application of molecular genetics and genetic engineering. One of my first professional papers was devoted to refuting the pessimistic projections for agricultural productivity and production that were common in the early 1950s (Ruttan 1956). Other students of this subject have presented more optimistic perspectives (Runge et al. 2003; Waggoner 1997). But I have not yet seen evidence that the new genetics technologies, although undoubtedly powerful, will or can overcome the long-term prospect of diminishing returns to research on agricultural productivity.

AGRICULTURAL RESEARCH SYSTEMS

To this point, I have given major attention to the role of agricultural research as a source of technical change and productivity growth. In this section I sketch the evolution and structure of national and international agricultural research systems.[11] The institutional arrangements for the support of agricultural research began in the middle of the nineteenth century. In 1843 John Bennet Lawes (subsequently knighted) established, and later endowed, an agricultural experiment station on his family estate of Rothamsted, in Hertfordshire, England. In Germany, the introduction by Justus von Liebig of the laboratory method of training in organic chemistry at Giessen led directly to the establishment of the first publicly supported agricultural experiment station at Mockern, Saxony, in 1852. The German method of public-sector agricultural research became the model for agricultural research in the United States. A number of American students who studied with Liebig were responsible for establishing the research program of the U.S. Department of Agriculture and the agricultural experiment stations at the new land-grant public universities in the late 1800s (Ruttan 1982). The basic structure of the U.S. agricultural research system has become increasingly complex, with the federal government, individual states, and the private sector each playing an important role. The sources and flows of funding for 1998 are shown in Figure 4.4.

Figure 4.4 Sources and Flows of Funding for Agricultural Research: 1998



[a] SAES stands for State Agricultural Experiment Station.

SOURCE: Adapted from Fuglie, Ballenger, Day, Klotz, Ollinger, Reilly, Vasavada, and Lee (1996, p. 9).

Substantial progress was made in the first several decades of the twentieth century in initiating public sector agricultural research capacity in Latin America and in the colonial economies of Asia and Africa. Research efforts were focused primarily on tropical export crops such as sugar, rubber, cotton, bananas, coffee, and tea. The disruption of international trade during the Great Depression of the 1930s and during World War II, followed by the breakup of colonial empires, aborted or severely weakened many of these efforts.

By the early 1960s, the U.S. development assistance agency and the assistance agencies of the former colonial powers were beginning to channel substantial resources into strengthening agricultural education and research institutions, with a stronger focus on domestic food crops in developing countries. The Ford and Rockefeller foundations collaborated in the establishment of four international agricultural research institutes: the International Rice Research Institute (IRRI) in the Philippines, the International Center for the Improvement of Maize and Wheat (CIMMYT) in Mexico, the International Institute of Tropical Agriculture (IITA) in Nigeria, and the International Center for Tropical Agriculture (CIAT) in Colombia. In 1971, the two foundations, joined by the World Bank, the Food and Agricultural Organization of the United Nations (FAO), the United Nations Development Program (UNDP), and a number of bilateral donor agencies, formed the Consultative Group on International Agricultural Research (CGIAR). By the early 1990s the CGIAR systems had expanded to 18 centers or institutes.

From the 1950s through the 1980s, the resources available to the new national and international research institutions from national and international sources expanded rapidly. Both the national and the international systems achieved dramatic success in the development of higher yielding, "green revolution" wheat, rice, and maize varieties (Alston et al. 2000; Ruttan 2001, pp. 203–223). Several developing countries—India, China, Brazil, Argentina, and South Africa—achieved world class agricultural research capacity. During the 1990s, however, growth of public sector support for both national and international agricultural research slowed substantially. Support for private sector agricultural research, which remains concentrated primarily in developed countries, has continued to grow rapidly.[12]

An active and vibrant global agricultural research system will be needed to sustain growth in agricultural productivity into the twenty-first century. But the system itself is still incomplete. When it is completed, it will include strong public national research institutions, linked to higher education, that can work effectively with the international system and other national systems. This network will be complemented by a scientifically sophisticated technology supply industry, composed of both national and multinational firms. The research systems in most developing countries have yet to establish sufficient capacity to make effective use of the existing advances in knowledge and technology. The private sector agricultural technology supply industry, although growing rapidly, still remains poorly represented in the poorest developing countries.

PERSPECTIVE

What are the implications of the resource and environmental constraints, the scientific and technical constraints, and the institutional constraints on agricultural productivity growth over the next half century? In those countries and regions in which land and labor productivity are already at or approaching scientific and technical frontiers, it will be difficult to achieve growth in agricultural productivity comparable to the rates achieved over the last half century (Pingali and Heisey 2001; Pingali, Moya, and Velasco 1990; Reilly and Fuglie 1998). But in most of these countries at the technological frontier, the demand for food will rise only slowly. As a result, these countries, except perhaps those that are most land-constrained, will have little difficulty in achieving rates of growth in agricultural production that will keep up with the slowly rising demand for food. Several of the countries near the technological frontier, particularly in east Asia, will find it economically advantageous to continue to import substantial quantities of animal feed and food grains (Rosegrant and Hazell 2000).

For those countries in which land and labor productivity levels are furthest from frontier levels, particularly those in sub-Saharan Africa, opportunities exist to enhance agricultural productivity substantially. Countries that are land-constrained, such as India, can be expected to follow a productivity growth path that places primary emphasis on biological technology. In contrast, Brazil, which is still involved in expanding its agricultural land frontier while confronting crop yield constraints in its older agricultural regions, can be expected to follow a more balanced productivity growth path. Most of the poor countries or regions that find it advantageous to follow a biological technology path will have to invest substantially more than in the past to acquire a capacity for agricultural research and technology transfer. These investments will include general and technical education, rural physical infrastructure, and appropriate research and technology transfer institutions. Moreover, gains in labor productivity will depend on the rate of growth in demand for labor in the nonfarm sectors of the economy, which in turn will create the incentives for substituting mechanical technology for labor in agricultural production. If relatively land-abundant countries, in sub-Saharan Africa for example, fail to develop a strong intersector labor market in which workers can move from rural agricultural jobs to urban manufacturing and service jobs, they will end up following an East Asian land-saving biological technology path.

I find it more difficult to anticipate the productivity paths that will be followed by several other regions. The countries of the former Union of Soviet Socialist Republics (USSR) have in the past followed a trajectory somewhat similar to North America (as shown in Figure 4.2). If they recover from recent stagnation, these countries may resume their historical trajectory.[13] The trajectories that will be followed by west Asia, North Africa, and other arid regions are highly uncertain. Very substantial gains in water productivity will be required to realize gains in land productivity in these areas, and very substantial growth in nonagricultural demand for labor will be required to realize the substantial gains in labor productivity that would enable them to continue along the intermediate technology trajectory that has characterized the countries of southern Europe. The major oil-producing countries will continue to expand their imports of food and feed grains. If the world should move toward more open trading arrangements, a number of tropical or semitropical developing countries would find it advantageous to expand their exports of commodities in which their climate and other resources give them a comparative advantage and import larger quantities of food and feed grains.

While many of the constraints on agricultural productivity discussed in this paper are unlikely to represent a threat to global food security over the next half century, they will, either individually or collectively, become a threat to growth of agricultural production at the regional and local level in a number of the world's poorest countries. A primary defense against the uncertainty about resource and environmental constraints is agricultural research capacity. The erosion of capacity of the international research system will have to be reversed, capacity in the presently developed countries will have to be at least maintained, and capacity in the developing countries will have to be substantially strengthened. Smaller countries will need, at the very least, to strengthen their capacity to borrow, adapt, and diffuse technology from countries in comparable agroclimatic regions. It also means that more secure bridges must be built between the research systems of what have been termed the "island empires" of the agricultural, environmental, and health sciences (Mayer and Mayer 1974).

If the world fails to meet its food demands over the next half century, the failure will be at least as much in the area of institutional innovation as in the area of technical change. This conclusion is not an optimistic one. The design of institutions capable of achieving compatibility between individual, organizational, and social objectives remains an art rather than a science. At our present stage of knowledge, institutional design is analogous to driving down a four-lane highway while looking only at the rear-view mirror. We are better at making course corrections when we start to run off the highway than at using foresight to navigate the transition to sustainable growth in agriculture output and productivity.

Notes

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1. The Schultz "poor but efficient" hypothesis was received skeptically by development economists who had posited a "backward bending" labor supply curve in developing countries' agriculture. See, for example, Lipton (1968). For a particularly vicious review of *Transforming Traditional Agriculture*, see Balogh (1964). Schultz was the recipient of the 1979 Nobel Prize in Economics, along with W. Arthur Lewis, for his contribution to development economics.

2. Hayami and Ruttan's (1985) induced innovation interpretation of technical change has been criticized on both theoretical and empirical grounds. See, for example, Olmstead and Rhode (1993) and Koppel (1995). For a response to these criticisms, see Ruttan and Hayami (1995).
3. Before that time, Japanese farmers prepared the soil by hand with shovels and hoes, or by using plows pulled by cattle, which were not as strong as horses and so could not plow as deep.
4. Multifactor productivity estimates for agriculture in the United States were first constructed in the late 1940s and early 1950s (Barton and Cooper 1948; Schultz 1953; Ruttan 1956). For a comparative review and analysis of the sources of differences in the several aggregate agricultural production functions that have been estimated for U.S. agriculture, see Trueblood and Ruttan (1995). Note that from the beginning agricultural economists were using what, in the recent literature, have been termed "augmented" neoclassical production functions rather than Solow-type, two-factor production functions. For a review of total factor productivity estimates in developing countries, see Pingali and Heisey (2001).
5. In cross-country growth accounting, it has not been possible to account directly for improvement in the quality of inputs. Attempts are made to capture improvements in the quality of labor input by including education and for improvements in the quality of capital and intermediate inputs by including investment in technical education or research and development in the cross-country production functions. Jorgenson and Gollop (1995) have estimated that during 1947–85, when total factor productivity in U.S. agriculture grew at an annual rate of 1.58 percent, input quality change accounted for about one-third of the total factor productivity growth. Using a somewhat different approach, Shane, Roe, and Gopinath (1998) estimated that private research and development embodied in factor input quality accounted for about 25 percent of total factor productivity between 1949 and 1991.
6. The advantages of the Malmquist or frontier productivity index, in addition to the decomposition of total factor productivity into efficiency change and technical change, are twofold: 1) it is nonparametric and does not require a specification of the functional form of the production technology, and 2) it does not require an economic behavior assumption such as cost minimization or revenue maximization (Färe, Grosskopf, and Knox Lovell 1994; Färe et al. 1994). The contemporaneous Malmquist approach employed by Trueblood and Coggins (2001) identifies the best-practice countries in each period and measures the change in each country's performance relative to the change in the frontier. A country that shows a positive growth in total factor productivity may show negative Malmquist productivity change because it may lag relative to the best-practice frontier. The sequential Malmquist approach that has been employed by Suhariyanto, Lusigi, and Thirtle (2001) does not permit negative technology shifts.
7. The issues discussed in this section are addressed in greater detail in Ruttan (1999).
8. Countries characterized by "absolute water scarcity" do not have sufficient water resources to maintain 1990 levels of per capita food production from irrigated

agriculture, even at high levels of irrigation efficiency, and also meet reasonable water demands for domestic, environmental and industrial purposes. Countries characterized by "severe water scarcity" are in regions in which the potential water resources are sufficient to meet reasonable water needs by 2025, but only if they make very substantial improvements in water use efficiency and water development (Seckler, Molden, and Barker 1999).

9. Estimates of losses in crop and animal production due to pests vary greatly by commodity, location, and year. However, estimates by reputable investigators run upwards of 33 percent of global food crop production. Losses represent a higher percentage of output in less developed countries than in developed countries. Among major commodities, the highest losses are experienced by rice (Yudelman, Ratta, and Nygaard 1998).
10. I have not in this paper discussed the potential impacts of health constraints on agricultural production. The increase in use of insecticides and herbicides associated with agricultural intensification have had important negative health effects on agricultural workers. The health effects of the resurgence of older diseases such as malaria and tuberculosis, are greatest in rural communities in developing countries. It is not too difficult to visualize situations in particular villages in which the coincidence of several health factors, including AIDS, could result in serious constraints on agricultural production (Pingali and Roger 1995; Bell, Clark, and Ruttan 1994; Haddad and Gillespie 2001).
11. For a more detailed discussion of the evolution and structure of national and international agricultural research, see Ruttan (1982) and Huffman and Evenson (1993).
12. In 1995 it was estimated that global agricultural research expenditures amounted to $33 billion (in 1993 dollars). Of this amount public sector expenditures amounted to $12.2 billion in developed countries and $11.5 billion in developing countries. Private sector expenditures for agricultural research amounted to $10.8 billion in developed and $0.7 billion in developing countries. Support for the CGIAR system declined from $334 million in 1990 to $305 million (1993 prices) in 2000 (Pardey and Beintema 2001).
13. Between 1962 and 1990, crop yields in the former Soviet Union experienced modest gains relative to the world's leaders. From the early 1990s, however, yield growth rates became negative, and by 1997 the yield gap between the countries of the former Soviet Union and the world leaders exceeded the levels of 1962 (Trueblood and Arnade 2001).

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5
How the World Survived the Population Bomb

An Economic Perspective

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The population of the world doubled between 1960 and 2000, growing from 3 billion to 6 billion people. This is by far the largest increase in world population over a period of two generations in human history, measured in either absolute numbers or percentage increase. In terms of the world's ability to meet increasing demands on resources, the second half of the twentieth century offered an experiment unlike anything seen before. As we think about issues of sustainable development facing the world today, it is instructive to look back on the lessons of this unique period of human history.

It is entirely appropriate to think of the rapid growth of world population between 1950 and 2000 as a "population explosion." Viewed from the perspective of the 1960s, when the rate of growth reached its peak, it is not surprising that there were concerns that this population explosion would put enormous pressure on the world's economic resources. Many predicted mass starvation, large increases in poverty, and depletion of key resources in the decades to follow. We now have accumulated more than three decades' worth of data since many of these predictions were made, and more than four decades' worth since the population growth rate reached its peak. This chapter will survey several key economic indicators related to some of the worst fears about the impact of population growth on humans. The data on economic variables, including food production, commodity prices, and poverty, suggest that the world not only survived the population explosion but was in better condition by most of these indicators in 2000 than it was in 1960. The past four decades have been a period of rising per capita food consumption, with significant declines in both the percentage and the absolute number of people in poverty. While poverty rates remain unacceptably high in many countries, with especially disappointing progress having been made in Africa, the global picture of the latter half of the twentieth century presents the surprising combination of an unprecedented population explosion occurring at the same time as rapid declines in poverty.

If we have the hindsight to say the world survived the population bomb, it follows that the population explosion is over. In addition to looking at trends in key economic indicators, this chapter examines the demography of the population explosion. As demographers have long pointed out, the population explosion resulted from rapid declines in mortality that produced a relatively short period of extremely high growth. While the world's population continues to grow, fueled in part by the inertia of rapid growth during the peak of the population explosion, rapidly declining birth rates imply that growth rates will continue to fall in coming decades, moving the world into a period of much slower growth. Growth has already dropped below the rate of 1950. With the growth rate in 2000 returning to roughly the level of 1950, it seems appropriate to consider 1950 and 2000 as convenient bookends for the population explosion in examining both its demography and its economics. An economic perspective helps us understand how the world avoided mass starvation; it also helps explain why birth rates have fallen so rapidly throughout the developing world.

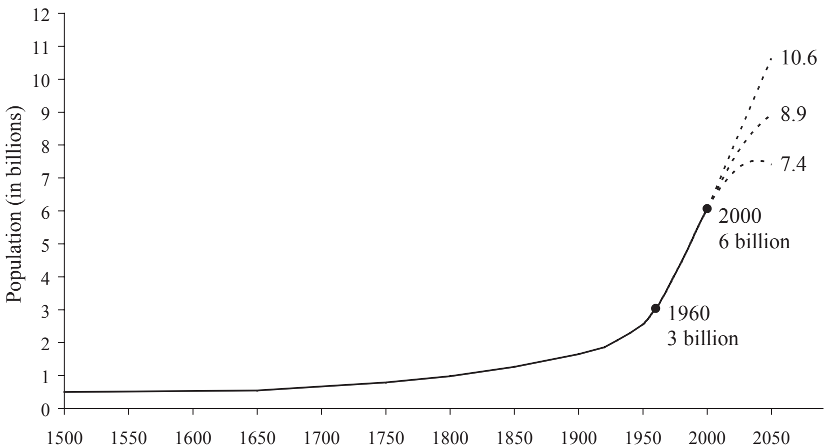
This chapter will take a broad look at the world, with examples from many different countries, but in addition, its last part will look in detail at fertility decline in Brazil. Brazil is an interesting case study because it had a rapid decline in birth rates in the absence of a significant national family planning effort. The fertility rate in Brazil is now about the same as the fertility rate in the United States. This chapter argues that the response of parents to falling infant mortality and the impact of rising parental education levels played an important role in Brazil's incredible fertility decline. An economic model of optimizing behavior based on tradeoffs between the quality and quantity of children (the former term refers to the quality of their lives and the investments made in them) provides a framework for explaining these responses at the household level.

THE HISTORY OF WORLD POPULATION GROWTH

We begin with a historical overview of world population growth. Figure 5.1 shows estimates of the total population of the world from 1500 to 2000, along with projections from 2000 to 2050.[1] It demonstrates that the population growth of the twentieth century, and especially of the second half of the twentieth century, skyrocketed. The world did not reach 1 billion population until 1800, reached 2 billion around 1930, and then added another 4 billion people in the next 70 years.

If we work backward from the 2000 population of 6 billion, an interesting benchmark would be the time when the world population was $^1/_{32}$ (2^{-5}) this size, or 187.5 million, meaning that the world has subsequently doubled in population five times. A common estimate for the population of the world in 1 AD is 300 million, although estimates range from 170 million to 400 million (U.S. Census Bureau 2003). The estimates reported by the Census Bureau suggest that a population of 187.5 million might have existed around 300 BC. A population twice this large, 375 million, may have been reached around 1200 AD, a doubling time

Figure 5.1 Total World Population from 1500 to 2000 and U.N. High, Medium, and Low Variant Projections to 2050



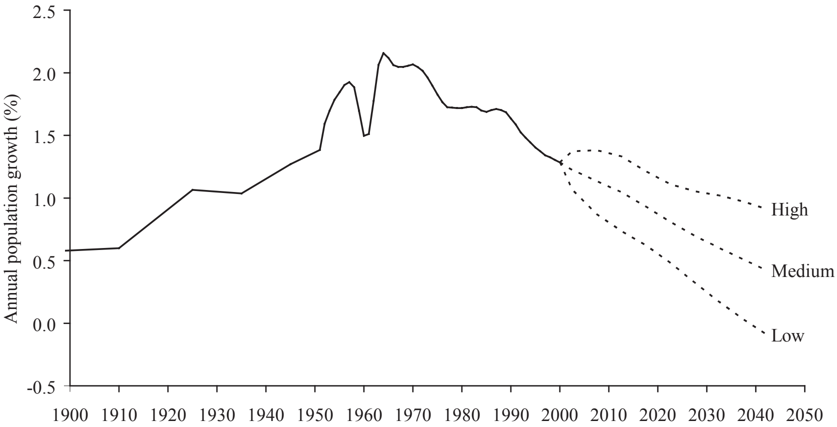
SOURCE: Estimates for 1500–1950 are from U.S. Census Bureau (2003); estimates for 1950–2000 and high, medium, and low variant projections for 2000–2050 are from United Nations Population Division (2003). See Note 1.

of 1,500 years. Continuing with subsequent doublings of population, the world reached 750 million around 1700, 1.5 billion around 1860, and 3 billion around 1960. In round numbers, then, the sequence of five doubling times since the world was $1/32$ of its 2000 population is roughly 1500 years, 500 years, 150 years, 100 years, and 40 years.

Given this sequence of doubling times, it is natural to ask what the next doubling time will be—that is, when will world population reach 12 billion? While the answer obviously requires conjecture, it is virtually impossible that the next doubling time would be less than 40 years, and very unlikely that it would be less than 100 years. Figure 5.1 shows three population projections from 2000 to 2050 made by the United Nations Populations Division. Even the high variant projection only reaches 10.6 billion by 2050, a rate of increase far short of the previous doubling (although it would be a larger absolute increase than took place between 1960 and 2000). The medium variant projection does not even reach 9 billion by 2050. In fact, many forecasts predict that world population will never again double. The United Nations Population Division (1999, p. 5) has projected that world population will reach about 9.5 billion in 2100, 9.75 billion in 2150, and will stabilize sometime after 2200 at just above 10 billion. Lutz, Sanderson, and Scherbov (2001) use a model of probabilistic population projections in which their median forecast predicts that world population will peak in 2070 at 9 billion. They estimate that there is an 85 percent chance that the world will reach population stability by 2100.

While it is obviously difficult to forecast world population, there is nonetheless quite a bit of information to use for such forecasts, given current age distribution, trends in fertility and mortality, and past experience (Bongaarts and Bulatao 2000). The picture of population growth becomes clearer if we look at growth rates rather than totals. Figure 5.2 shows the annual rate of population growth from 1900 to 2000, with United Nations projections to 2050.[2] The annual growth rate of 0.6 percent at the beginning of the twentieth century was already quite high by historical standards. From there, we see that growth rates rise to a level of 1 percent a year around 1930. They then increase dramatically in the 1950s, reaching about 1.4 percent in 1950 and rising to 1.9 percent by 1958. The sharp short-term drop around 1960 and 1961 is due to the Great Famine in China, which killed more than 18 million Chinese, causing such a jump in death rates that it dropped the world

Figure 5.2 Annual World Population Growth Rate, Actual and Projected, 1900 to 2050[a]



[a] Rates to 2000 are three-year moving averages; rates after 2000 are based on five-year projections (see Note 2).

SOURCE: Estimates for 1900–1950 are from U.S. Census Bureau (2003); estimates for 1950–2000 and high, medium, and low variant projections for 2000–2050 are from U.N. Population Division (2003).

population growth rate by almost half a percentage point. The world reached its peak growth rate according to these estimates in 1964, at 2.16 percent a year (implying a doubling time of about 32 years if the rate remained constant). The growth rate declined fairly rapidly in the 1970s, remained fairly stable in the 1980s, and has been falling steadily since around 1990. The world's growth rate in 2000 was about 1.3 percent, lower than in 1950. Even the high variant U.N. projection shows steadily falling growth rates from 2000 to 2050. The medium variant projection has the growth rate dropping below 1 percent by 2015, dropping below 0.5 percent by 2040, and continuing to fall after that.

WHAT CAUSED THE POPULATION EXPLOSION?

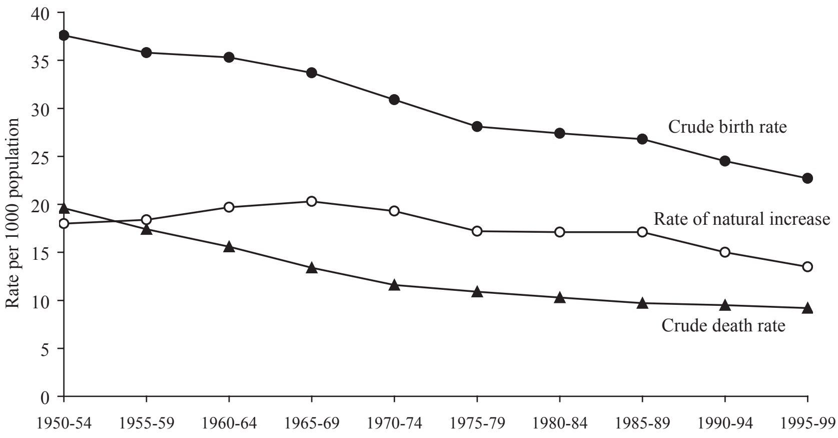
These figures suggest that the world will almost surely never again see population growth of the magnitude experienced in the past half-century. In order to understand how the world survived this population explosion and why it is unlikely to ever be repeated, it is necessary to understand what caused it in the first place. The demographic explanations for the dramatic increase in the world population growth rate in the 1950s and 1960s are well understood. The annual percentage increase in world population in a given year (the measure shown in Figure 5.2) is entirely determined by the difference between birth rates and death rates. Demographers define the crude birth rate (CBR) as the number of births in a year per 1000 population, and the crude death rate (CDR) as the number of deaths per 1000 population. The crude rate of natural increase (CRNI) is simply the difference between these. If the CRNI is 10 per 1000, the population growth rate is 1 percent a year. Given these standard measures, we can analyze the extent to which either changes in the crude birth rate or changes in the crude death rate were responsible for producing the increase in the population growth rate in the 1950s and 1960s.

The Demographic Transition

Figure 5.3 shows the crude birth rate, crude death rate, and crude rate of natural increase for the world between 1950 and 1999, based on United Nations Population Division estimates (2003). These are five-year averages, in contrast to the single-year estimates shown in Figure 5.2. The peak growth rate occurs at just above 2 percent a year in the 1965–1969 period. (Since these data are averaged over five years, they do not show the sharp drop associated with China's Great Famine that was seen in the annual estimates in Figure 5.2.) One of the striking features of Figure 5.3 is that both the crude birth rate and the crude death rate fall over the entire period shown. The reason the population growth rate increased between the periods of 1950–1954 and 1965–1969 is that the death rate fell faster than the birth rate. Falling infant and child mortality played a major role in the falling death rate. Not only did the birth rate not increase during this period, it was already falling in the 1950s and continued falling throughout the period that population growth rates were increasing.

Statistics are not available, but if we extended Figure 5.3 back several decades, we would find that crude birth rates were probably in the range of 40–45 per 1000, not significantly higher than observed around 1950. Crude death rates, on the other hand, would have been considerably higher than the 20 per 1000 level observed in 1950. We know that

Figure 5.3 Crude Birth Rate, Crude Death Rate, and Rate of Natural Increase for the World, 1950–1999



SOURCE: U.N. Population Division (2003).

crude death rates must have been close to crude birth rates earlier in the twentieth century since the population growth rate was close to 0.5 percent (5 per 1000). Death rates had already fallen substantially by 1950, producing the growth rates of over 1.5 percent shown in Figure 5.3.

The pattern shown for the world as a whole would have been broadly similar to the pattern observed in most developing countries. Beginning from a regime with high birth rates, high death rates, and relatively low population growth, developing countries saw their death rates decline during the first half of the twentieth century. Birth rates initially remained at their previous level, generating a gap between birth rates and death rates that caused increased population growth. The population growth rate continued to increase until birth rates began to fall fast enough to offset falling death rates. This occurred in the 1965–1969 period for the world (Figure 5.3), beginning a period of declining population growth rates. About this time, death rates stabilized at a low level of around 10 per 1000, with further declines in birth rates leading to further declines in the rate of population growth. This process, known as the demographic transition, has played out in similar fashion throughout the developing world, with variations in the timing and pace of the transition. A century earlier, the demographic transition had occurred in similar fashion in most of the countries that currently have high incomes. The difference was that death rates fell much more gradually, with the result that peak growth rates during the transition were typically lower than those observed in developing countries 100 years later.

Population Momentum

The other dynamic is population momentum. Since childbearing is concentrated in the 20–35 age range, a large increase in births in a given period will lead to a corresponding increase in the size of the childbearing population 20–35 years later. This creates a powerful mechanism for population momentum, implying that even though there were sharp reductions in fertility in the 1970s and 1980s, the numbers of births in many countries will continue to grow for several decades, the result of increasing numbers of women of childbearing age. This holds true even for countries that have already reached replacement fertility. This dynamic also helps explain why we can predict the path of population growth with some precision. One reason we can be certain the world population growth rate will decline steadily between now and 2050 is that the current growth rate is only as high as it is because of population momentum. The size of the childbearing population can be fairly easily projected for the next 20 years, since many of those women have already been born. While the number of women of childbearing age will continue to increase for several decades, the growth rate of that population is falling rapidly. This must translate into falling population growth rates, even if fertility rates were to stop falling.

THE IMPACT OF THE POPULATION EXPLOSION

Given the unprecedented rates of population growth that appeared in the 1950s and 1960s, it is understandable that there were concerns about the potential social and economic consequences of this rapid growth. Paul Ehrlich's *The Population Bomb*, which came out in 1968, was one of the best-known books expressing alarm over the high rates of population growth. Ehrlich focused particularly on the challenge of feeding the increasing numbers of people in developing countries. He wrote, "The world, especially the developing world, is rapidly running out of food . . . In fact, the battle to feed humanity is already lost, in the sense that we will not be able to prevent large-scale famines in the next decade or so" (1968, p. 36). Lester Brown struck a similar note when he wrote in a 1967 article in *Science* that "conventional agriculture now provides an adequate and assured supply of food for one-third of the human race. But assuring an adequate supply of food for the remaining two-thirds, in parts of the world where population is increasing at the rate of 1 million weekly, poses one of the most nearly insoluble problems confronting man" (1967, p. 604). The computer simulations of the Club of Rome's well-known *The Limits to Growth* (Meadows et al. 1972) focused attention on depletion of nonrenewable resources and resulting increases in commodity prices.

Trends in Economic Indicators

There have been extensive debates about trends in economic, social, and environmental indicators in recent decades. It is far beyond the scope of this chapter to provide an exhaustive review of those debates, or to propose resolutions to the complex issues involved. Some of these debates have been closely tied to discussions about the impact of rapid population growth, with many going back to the predictions made by Ehrlich and others who gave early warnings. In this section, I provide a broad description of trends in several key economic indicators during recent decades. These include food production, commodity prices, and poverty.

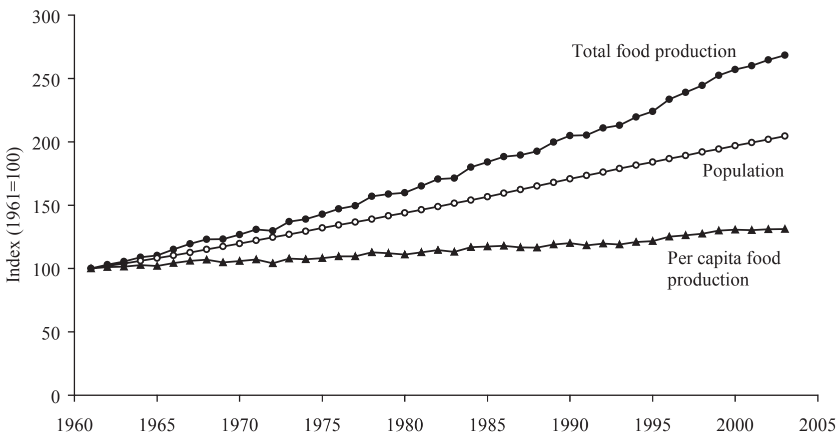
These variables go to the heart of many of the worst fears about the potential impact of rapid population growth. Mass starvation, exhaustion of nonrenewable resources, and increased poverty were certainly some of the major concerns among a wide variety of observers who considered the impact of rapid population growth during the 1960s. It is hard to imagine a more challenging test of the world's capacity to absorb population than for it to double its population in 40 years, especially when this doubling means the addition of 3 billion people. As Lester Brown wrote in his 1967 *Science* article, in which he (accurately) predicted the addition of at least 1 billion people by 1980, "The world has never before added 1 billion people in 15 years."

Trends in Food Production

In the 1960s, there was probably no more daunting challenge associated with rapid population growth than that of feeding the growing population. The prologue to *The Population Bomb* began, "The battle to feed all of humanity is over. In the 1970s the world will undergo famines—hundreds of millions of people are going to starve to death in spite of any crash programs embarked upon now" (Ehrlich 1968).

Data on agricultural production are provided by the Food and Agriculture Organization of the United Nations (FAO) and are readily available on that organization's Web site (FAO 2004). Figure 5.4 presents indices of total food production, per capita food production, and total population for the world from 1961 to 2003, setting the 1961 levels to 100 as a baseline for all three indices. As the figure indicates, the world has experienced steady and dramatic increases in food production since 1961. Total food production in the world roughly doubled between 1961 and 1990, and by 2003 it had reached a level 2.7 times the amount in 1961. The average rate of growth of food production between 1961 and 2003 was 2.4 percent a year. Significantly, Figure 5.4 shows that the line for total food production is always above the line for total population,

Figure 5.4 Indices of World Food Production and Population, 1961–2003 (1961=100)



SOURCE: Food and Agriculture Organization (FAO) of the United Nations (2004).

even during the period of the most rapid population growth, the 1960s. Thus, at any point between 1961 and 2003, food production increased faster than world population relative to the 1961 baseline. The average growth rate of world population from 1961 to 2003 was 1.7 percent a year, yet per capita food production grew at an average annual rate of 0.7 percent. Per capita food production in 2003 was 31 percent higher than it was in 1961.

One reason for the world's remarkable increase in agricultural output since the 1960s has been the green revolution's technological advances in developing new high yield crops. While we cannot assume that the growth rates of the past 40 years in food production can be maintained, it is interesting to look at forecasts of food production made at various points between the 1960s and today. Lester Brown concluded in a 1975 article in *Science* that "the scarcity of basic resources required to expand food output, the negative ecological trends that are gaining momentum year by year in the poor countries, and the diminishing returns on the use of energy and fertilizer in agriculture . . . lead me to conclude that a world of cheap, abundant food with surplus stocks and a large reserve of idled cropland may now be history. In the future, scarcity may be more or less persistent, relieved only by sporadic surpluses, of a local and short-lived nature" (1975, p. 1059). In addition to his dire prediction about overall food production, Brown expressed concern that the world was becoming increasingly dependent on North America as its food producer. In fact, however, FAO data indicate that between 1965 and 1975, food production increased at an annual rate of 2.9 percent in developing countries, compared to a rate of 2.4 percent in North America.

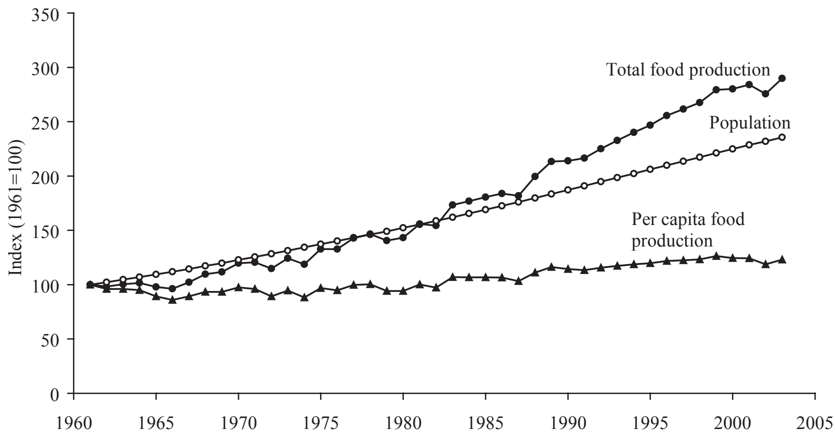
Although impressive growth in food production continued through the late 1970s, Brown (1981) again expressed concern in another *Science* article: "As the 1980s begin, the growth in world production is losing momentum and its excess over population growth is narrowing" (p. 1001). But in fact the annual growth rate of world food production in the 1980s turned out to be 2.5 percent, slightly higher than the growth rate between 1965 and 1980 and a full percentage point greater than the growth rate of world population. Additional concerns were raised at the end of the 1980s. Paul and Anne Ehrlich (1990) wrote in *The Population Explosion*, a follow-up to *The Population Bomb*, that "world grain production peaked in 1986 and then—for the first time in forty years—

dropped for two consecutive years . . . Global food production peaked in 1984 and has slid downward since then" (p. 15).

A couple of years after the Ehlichs' book, Robert McNamara (1992) wrote that "The early gains of the Green Revolution have nearly run their course. Since the mid-1980s, increases in worldwide food production have lagged behind population growth." It is not clear exactly what data the Ehrlichs and McNamara were referring to, although it is possible that their comments were consistent with the data available at the time they wrote. The FAO data shown in Figure 5.4 clearly tell a much different story. Figure 5.4 shows that both total and per capita food production for the world increased throughout the 1980s, although there are occasional years when per capita food production declined, such as a 1 percent decline between 1986 and 1987. The record after these prognostications is even more positive, with food production growing significantly faster than population in the 1990s. While it is easy to find observers in the 1970s, 1980s, and today warning that the success of the green revolution cannot last forever, the data indicate remarkable and sustained success in food production for more than four decades, with no evidence that future food production will not keep pace with population growth, especially given the declining rate of growth.

While the experience of the world as a whole is one important summary statistic, it is also interesting to look at the experience of individual countries. India was singled out by Ehrlich for particular attention in *The Population Bomb*. Ehrlich quoted one expert on Indian agriculture who predicted that India had reached its maximum level of food production in 1967–1968. At that time, India's population was growing at more than 3 percent a year (implying a doubling time of less than 25 years), and it was one of the places where Ehrlich and many others predicted mass starvation. Figure 5.5 shows food production in India from 1961 to 2003 based on the same FAO data used for Figure 5.4, once again using 1961=100 as the baseline. India's food production over the period actually grew faster than food production for the world as a whole, and 2003 production was 2.9 times greater than the level in 1961. Even so, the line for per capita food production in Figure 5.5 indicates that India's food production did not grow fast enough to keep up with its population during some periods in the 1960s and 1970s—per capita food production fell by about 10 percent between 1961 and 1966. These were temporary shortfalls, however, and per capita food produc-

Figure 5.5 Indices of Food Production and Population in India, 1961–2003 (1961=100)



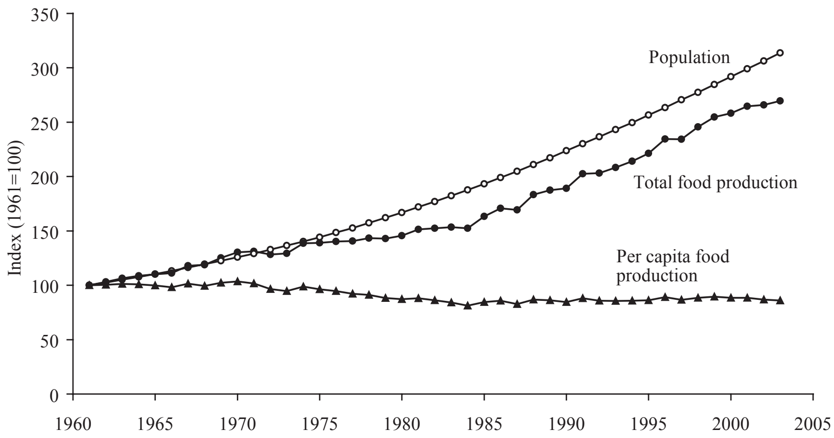
SOURCE: FAO (2004).

tion returned to its 1961 level by 1970. It fell again slightly in the mid-1970s, returned to its 1961 level in 1980, and then remained above its 1961 level in the 1980s and 1990s.

As with the world data, India's impressive increases in food output in the late 1960s and the 1970s were followed by numerous predictions that the success could not be sustained. Ehrlich and Ehrlich (1990) acknowledged India's "dramatic increases in wheat production between 1965 and 1983" but noted that "since 1983, India's rising grain production has lost momentum" and warned that "the country appears to be facing a catastrophic problem in the 1990s, if not earlier" (pp. 70–72). The FAO data indicate that food production in India actually grew by 2.3 percent a year between 1990 and 2003, 0.5 percent faster than the growth rate of the population. By 2003 India's per capita food production was 23 percent above its 1961 level (and 43 percent above the low observed in 1966), even though the Indian population in 2003 was 2.4 times larger than in 1961.

While India has done much better at producing food than almost any observer could have predicted in the 1960s, as has the world as a whole, not all regions of the world have done so well. Sub-Saharan Africa has been much less successful at feeding itself over this period. Figure 5.6 shows total food production, per capita food production, and population

Figure 5.6 Indices of Food Production and Population in sub-Saharan Africa, 1961–2003 (1961=100)



SOURCE: FAO (2004).

for sub-Saharan Africa from 1961 to 2003. Total food production for sub-Saharan Africa in 2003 was 2.7 times the level of 1961. This is in many respects an impressive increase, but it was not sufficient to keep pace with Africa's rapid population growth: per capita food production in sub-Saharan Africa in 2003 was 14 percent below the level of 1961. Most economists looking at the disappointing performance of agriculture in Africa agree that the problems are not fundamentally related to resource constraints or rapid population growth.

"In the case of sub-Saharan Africa," writes Gale Johnson (1999), "the failure to achieve a significant increase in per capita food supplies has been due, not primarily to limitations of natural resources, but to wholly inappropriate national policies that exploited agriculture in the name of promoting economic development as well as by ethnic and civil strife in several countries" (p. 5915). As an example of the policies that have discouraged food production in Africa, Johnson mentions the World Bank study of agricultural pricing policy, which estimated that effective returns to African farmers declined by 51.6 percent between 1960 and 1984 as a result of governmental interventions in agricultural markets (Krueger, Schiff, and Valdes 1988).

While the decline in per capita food production in Africa shown in Figure 5.6 is a very serious problem, it does not negate the relatively optimistic picture of global food capacity provided by the evidence from other regions. The disappointing African experience also points to some of the reasons for the positive experience of the past 40 years in the rest of the world. The rapid increases in global food production are not simply the result of technological innovation in agriculture. As frequently pointed out by agricultural economists, getting economic incentives right in agricultural sectors within countries and liberalizing agricultural trade across countries are key factors in generating world agricultural output. It is also important to recognize the role played by increased human capital. As Johnson (2000) posed the question in his presidential address to the 2000 meeting of the American Economic Association (AEA), "What made it possible for the world to escape from what could be called the Malthusian trap? The answer is simple: the creation of knowledge" (p. 2).

Leaving aside regional imbalances in food production in recent decades, we must recognize that even increased per capita food production within a particular country does not necessarily translate into reductions in hunger in that country. Distribution of food, like distribution of income, is very unequal both within and across countries. Examining the distribution of resources within countries requires household level data. Below I will look at estimates of trends in poverty for the world as a whole and for specific regions and countries. Since these estimates are usually based on measures of consumption at the household level, they are the best evidence regarding trends in hunger in the world.

Trends in Commodity Prices

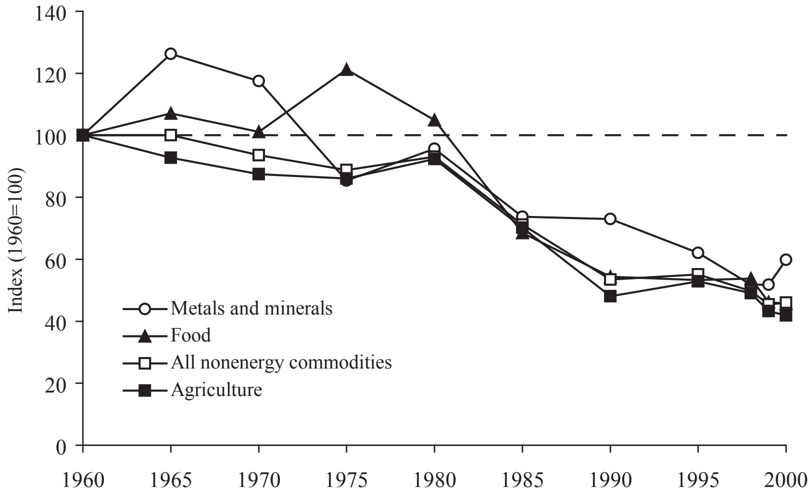
The impressive story of how world food production kept pace with world population during the population explosion might be considered a story of remarkably good luck, in that green revolution innovations came along at just the right time to keep up with the population explosion. Concerns about the impact of the population explosion were not limited to food, however. Rapid population growth was also predicted to cause scarcity with many other types of commodities. In order to investigate these issues we can look at data on a wide range of other commodities, both renewable (like food) and nonrenewable. This was one of the points made by Julian Simon in his book *The Ultimate Resource* (1981). Simon upheld the standard notion of economists that one of the best indicators of whether the world is running out of a resource is whether the price of that resource is increasing. While various nonmarket forces, such as the Organization of the Petroleum Exporting Countries (OPEC) cartel, might create distortions between price and resource supply, it would be difficult to have a situation in which a commodity is nearing depletion at the same time that the price of the resource is declining.

Simon's emphasis on the tendency of most commodity prices to decrease over time led to a famous bet between himself and Paul Ehrlich (Tierney 1990). Simon challenged any taker to pick any natural resource and any future date, and he would bet that the real price of the resource would decline. Ehrlich and a group of colleagues selected five metals—chrome, copper, nickel, tin, and tungsten—for the period from October 1980 to October 1990. The outcome was that the real price of each of these five commodities declined between 1980 and 1990, and the bundle of five metals that cost $1000 in 1980 (in quantities that cost $200 each) could be bought for $618 in 1990 (adjusted for inflation). To settle the bet, Ehrlich sent Simon a check for $576.07, the decline in the total cost of the five metals using 1990 prices.

Data on commodity prices are relatively easy to come by, since commodities are the focus of very active and highly competitive international markets. The data presented here are taken from the World Bank's World Development Indicators (2001). Figure 5.7 shows real commodity price indices from 1960 to 2000, using 1960=100 as the baseline. All prices are adjusted for inflation. Four broad indices are shown—food, agricultural products, metals and minerals, and all nonenergy commodities. Although each index has periods of price increases over the four decades, the clear trend is downward for all four indices. The price decline between 1960 and 2000 is 40 percent for metals and minerals, 54 percent for food, 60 percent for agricultural commodities overall, and 54 percent for the combined index of all nonenergy commodities. For this last category, the combined index of all nonenergy commodities, the price is lower in every period between 1960 and 2000 than it was in 1960.

Petroleum prices, which are not shown in Figure 5.7, are the one major exception to the trend of falling commodity prices. Movements

Figure 5.7 Indices of World Commodity Prices, 1960–2000 (1960=100)



SOURCE: World Bank (2001).

in petroleum prices are driven predominantly by actions of the OPEC cartel; the highest real prices were observed in the late 1970s. According to World Bank data, the price of petroleum in 1980 was 6.7 times higher than the price in 1960. The petroleum price in 2000 was 3.6 times the 1960 price. While these higher petroleum prices have an impact on all economies in the world, they would seem to have little to do with actual resource scarcity.

The results shown in Figure 5.7 provide a powerful piece of data in support of sustainable development. During a period in which world population doubled, real commodity prices, excluding petroleum, fell by more than 50 percent. Many economic forces help explain this fairly remarkable outcome. Technological innovations have increased efficiency in the use of resources and have often produced substitutes for resources when price increases have appeared. As Johnson emphasized to the AEA in the case of agricultural production, human knowledge has been instrumental. Trade liberalization and increased efficiency in global transport and communication have also played an important role. While a separate story could be told about the price trends in every major commodity, the common theme is one of falling prices and decreasing resource pressure, in spite of the enormous increase in world population.

Trends in Poverty

It is frequently, and appropriately, pointed out that increased food production or rising per capita incomes do not improve the lives of all people equally. Some segments of the population may be excluded from economic progress completely, or may even suffer declining living standards at the same time that aggregate measures indicate improvement. The increase in food production shown above would be less reassuring if we discovered that all of the increase in consumption went to high-income consumers. One of the concerns about rapid population growth has been that it would lead to increased poverty, both because poor countries were those with the highest growth rates and because higher population growth rates might have negative distributional consequences within countries (Birdsall, Kelley, and Sinding 2001; Cassen 1994; Lam 1987, 1997).

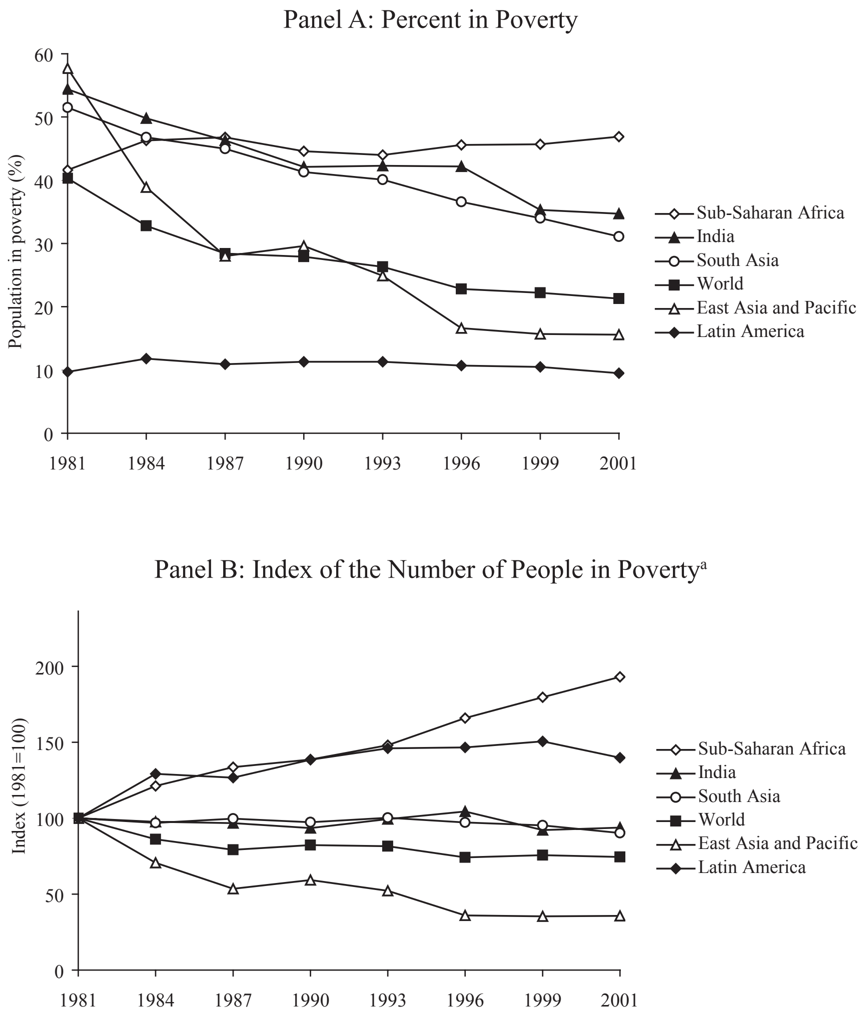
Data on poverty rates are much more difficult to come by than data on agricultural output or commodity prices, since poverty estimates require data at the level of individual households. Measuring poverty in developing countries is a complex and challenging task that has been the focus of extensive research. The absence of reliable and consistent data to estimate poverty was one of the main motivations for the World Bank's effort to collect comparable household surveys on income and consumption in a large number of countries (Grosh and Glewwe 2000).

The issue has produced extensive debate over matters of measurement, analysis, and interpretation, much of which has played out in the context of larger debates about the impact of globalization, international trade, and the actions of international agencies. The ideal way to measure trends in poverty in any country would be to have a consistent series of large, nationally representative household surveys with detailed information on income and consumption for a number of years. Very few developing countries met this ideal before the mid-1980s, and even after the launching of the World Bank's ambitious Living Standards Measurement Study (LSMS) surveys in the 1980s, many issues of incomplete coverage and data comparability remained. As is discussed by Ravallion (2003) and Deaton (2001, 2002, 2003), most estimates of poverty use a combination of household survey data and national accounts data.[3] The survey data are used to provide detailed information on the distribution of income or consumption across households, but are often only available for one or two points in time. National accounts statistics can be used to estimate changes in mean income for every year, with the combination of the survey data and national accounts being used to estimate the percentage below a given poverty line in years when complete survey data are not available. An additional key methodological issue is the comparison of incomes across countries. It is standard to use Purchasing Power Parity (PPP) indices, which are based on the cost of purchasing a comparable basket of goods in each country to compare income and consumption across countries.

The most comprehensive attempts to estimate poverty in this way have been done by researchers at the World Bank. Estimates covering the period 1981–2001 are presented in Figure 5.8, based on data taken from the World Bank's PovertyNet Web site (World Bank 2004). Methodological details and additional estimates are provided in Chen and Ravallion (2001). Figure 5.8 reports estimates of poverty based on one of the simple benchmark poverty lines that is often used—$1 a day in per capita household consumption. Note that the estimates are typically based on direct measures of consumption and therefore speak to the issue of changing trends in hunger as well. The top panel of Figure 5.8 shows the percentage in poverty (the population headcount ratio); the bottom panel shows the absolute number in poverty, using 1981=100 as a baseline for each region. For the total developing country population, the "World" line in Figure 5.8 indicates that the percentage of the population in poverty in all developing countries by the $1 a day measure declined from 40.3 percent in 1981 to 21.3 percent in 2001. Impressive declines in poverty in China play a large role in the overall trend, although the poverty rate still declines from 31.6 percent to 22.8 percent when China is excluded (not shown). This world decline was large enough to more than offset the substantial population growth in developing countries during this period, leading to a decline in the absolute number in poverty in all developing countries of about 25 percent (from 1.48 billion to 1.10 billion).

Figure 5.8 also shows poverty trends for major regions of the developing world and for the specific case of India.[4] Looking at the regional

Figure 5.8 Percentage and Absolute Number in Poverty by Region, 1981–2001 ($1 Per Day Poverty Line)



[a] The index represents the absolute number of people in poverty in each region in each year, divided by the number who were in poverty in that region in 1981. Using an index makes it possible to do a simple comparison of regions with very different population sizes.

SOURCE: World Bank (2004).

breakdowns in Figure 5.8, we see that the largest decline in poverty over this period took place in East Asia and the Pacific, where the $1 a day poverty rate plummeted from 58 percent to 16 percent between 1981 and 2001. Estimates for India indicate that the poverty headcount ratio fell from 55 percent in 1981 to 35 percent in 2001. The absolute number of poor people in India is estimated to have stayed almost constant over this 20-year period, showing small declines in the late 1990s. The declining poverty rates in India shown in Figure 5.8 are consistent with estimates of Deaton and Drèze (2002).

Latin America and sub-Saharan Africa had more disappointing performances over this period. The percentage of the population in poverty in Latin America remained roughly constant at around 10 percent, implying about a 50 percent increase in the absolute number in poverty. Africa had by far the worst experience of any region, with the percentage in poverty rising from 42 percent to 47 percent. Combined with rapid population growth, this resulted in almost a doubling of the number of people in poverty in 20 years, an increase of 150 million.

In addition to the large regional differences in both levels and trends in poverty shown in Figure 5.8, there are often large differences within a given country. A detailed examination of poverty in India by Deaton and Drèze (2002) shows significant declines in poverty in the 1990s but also shows regional differences in poverty increasing over the period, including no reduction in poverty in some of the states that already had the highest levels of poverty. A number of studies also indicate that income inequality has increased in India and China even though poverty has declined. Higher income growth occurred in the highest income deciles (Chen and Wang 2001; Deaton and Drèze 2002).

Although data on poverty rates before the 1980s are much more limited, most evidence indicates that the declines in poverty shown in Figure 5.8 for the period after 1980 were a continuation of declines in poverty over several decades. Sala-i-Martin (2002) combines national accounts data from 1970 to 1998 with the available data on individual country income distributions to estimate changes in the distribution of income in each country and for the world as a whole. Applying the $1 per day poverty line to these distributions, he estimates that there have been substantial declines in poverty rates for the developing world as a whole over the entire period. His estimates of the levels of poverty are considerably lower than those estimated by Chen and Ravallion, but the trends show a similar pattern: poverty fell rapidly in Asia, fell more slowly in Latin America, and increased substantially in Africa.

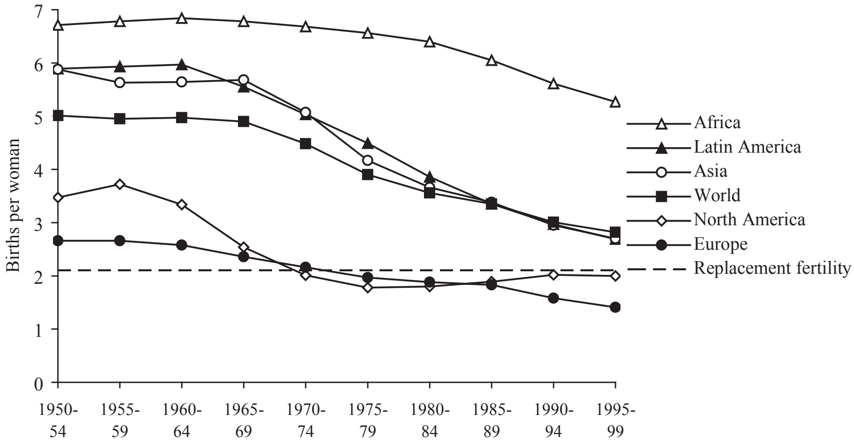
In summarizing the data on world poverty trends in recent decades, we find that the overall picture is quite positive. The evidence since 1980 indicates that the percentage of the world in extreme poverty (falling under the $1 a day measure) has been cut almost in half. The absolute number of people in poverty has declined by about 25 percent. This good news must be balanced by a couple of sources of concern. First, these estimates imply that one in five people in the world continue to live in extreme poverty. Second, the trends have varied enormously across regions, with poverty increasing rather than decreasing in Africa. The percentage of the African population in poverty has risen to almost 50 percent, and the absolute number of Africans in poverty roughly doubled between 1981 and 2001.

THE RAPID DECLINE IN FERTILITY

The impressive ability of the world economy to absorb the population growth of the last four decades is matched by equally remarkable declines in fertility rates. It is instructive to look at these declines in some detail and to consider their causes from an economic perspective. This section will pay particular attention to the case of Brazil, where fertility fell rapidly in the absence of significant family planning programs.

Figure 5.9 shows the total fertility rate (TFR) for major world regions from 1950 to 1999, based on United Nations Population Division (2003) estimates. The total fertility rate is the sum of the age-specific fertility rates in a given year and can be interpreted as the number of births a woman would have in her lifetime if she was exposed to the age-specific birth rates for that year. The total fertility rate for the world was around 5 births per woman for the five-year periods beginning in 1950–1954 and ending in 1965–1969, then began to fall rapidly in the 1970s. By the 1995–1999 period the world TFR had fallen to 2.8. Demographers use a TFR of 2.1 as a benchmark for replacement fertility, a rate that would have each couple replacing itself on average, with some additional births to compensate for those that didn't survive to childbearing age.[5] Freedman and Blanc (1992) found it useful to measure the percentage decline in fertility toward replacement level as a measure of

Figure 5.9 Total Fertility Rate for World Regions, 1950–1999



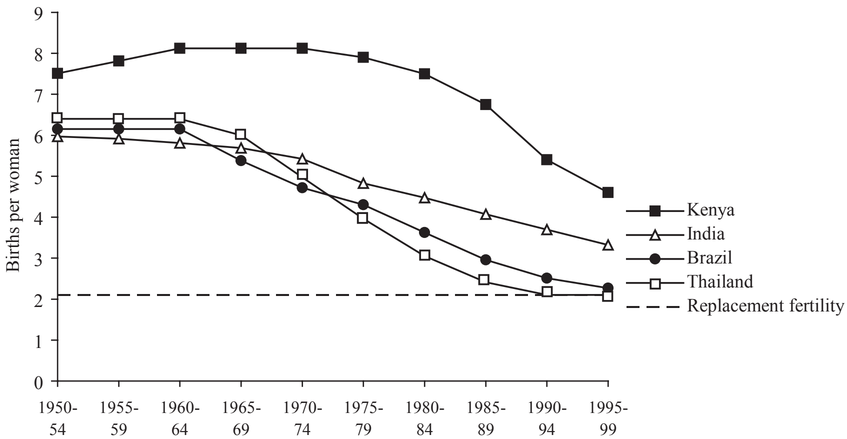
SOURCE: U.N. Population Division (2003).

fertility decline. The difference between the TFR and replacement fertility for the world fell from 2.9 to 0.7 between 1965 and 1999, meaning that fertility fell by 75 percent of the amount required to reach replacement fertility.

As shown in Figure 5.9, declines in fertility have been observed in all regions of the world. Asia and Latin America have had the fastest declines, following very similar patterns over the 50 years shown. In both regions the TFR fell from around 6.0 in 1950 to about 2.7 in 1999. This decline is 82 percent of the decline necessary to reach replacement fertility. The pace of fertility decline has been significantly slower in Africa. While the TFR has clearly been declining in Africa, especially after 1980, the TFR for the region as a whole was still 5.3 in 1995–1999, almost twice as high as for Asia and Latin America, the next-highest regions. The decline from the 1960 peak of 6.8 represents 32 percent of the decline necessary to reach replacement fertility.

Figure 5.10 shows the TFR for four specific countries for the period 1950–1999—Kenya, India, Brazil, and Thailand—based on United Nations estimates. Thailand is an example of a country experiencing rapid fertility decline, having dropped from a TFR of well over 6 in 1960–1964 to near replacement level fertility by 1990–1994. Brazil's fertil-

Figure 5.10 Total Fertility Rate for Selected Countries, 1950–1999



SOURCE: U.N. Population Division (2003).

ity decline is slightly slower, but Brazil had fallen to near replacement level fertility by 1995–1999. India began its fertility decline somewhat later than Brazil and Thailand and has had slower rates of decline. The TFR in India in 1995–1999 was about 3.3. Kenya, like most sub-Saharan African countries, continued to have high fertility into the 1980s, with a TFR of over 7.0 in the 1980–1984 period. Fertility began to fall at a rapid rate later that decade, however, reaching about 4.5 in 1995–1999.

Fertility Decline, Investments in Human Capital, and Quantity-Quality Tradeoffs

The patterns of fertility decline over the last 50 years are much clearer than are the determinants of the decline. While it is beyond the scope of this chapter to survey the vast literature that has analyzed the determinants of fertility decline in developing countries, I will address a few issues that I believe are fundamental to understanding the economics of fertility. As in the case of rising agricultural output and falling commodity prices, optimizing responses to changing incentives and tradeoffs has played an essential role in the fertility declines of the last 40 years.

Declines in fertility across the developing world have coincided with substantial increases in the health and schooling of children. The negative relationship between fertility and children's schooling is a strong empirical regularity, whether observed across populations, across time in a given population, or across families at a given point of time in a population. Not only are couples in developing countries having significantly fewer children than they were four decades ago, they are investing a great deal more in the human capital of those children. The tradeoff between the quantity and quality of children is one of the central features of economic theories of fertility (Becker and Lewis 1973; Willis 1973; Lam 2003). Since his early writings on the economics of fertility, Becker has pointed out that rising incomes lead to substitutions away from quantity of children and into quality of children, where quality is indicated by expenditures on children, including investments in schooling and health. Lam and Duryea (1999) applied the models of Becker and Lewis (1973) and Willis (1973) to the case of rising parental schooling, noting that falling infant mortality and increased parental schooling could easily lead to a similar substitution of quality in place of quantity of children. This mechanism helps explain why the fertility decline has been so universal and why it has been combined with rapid increases in schooling.

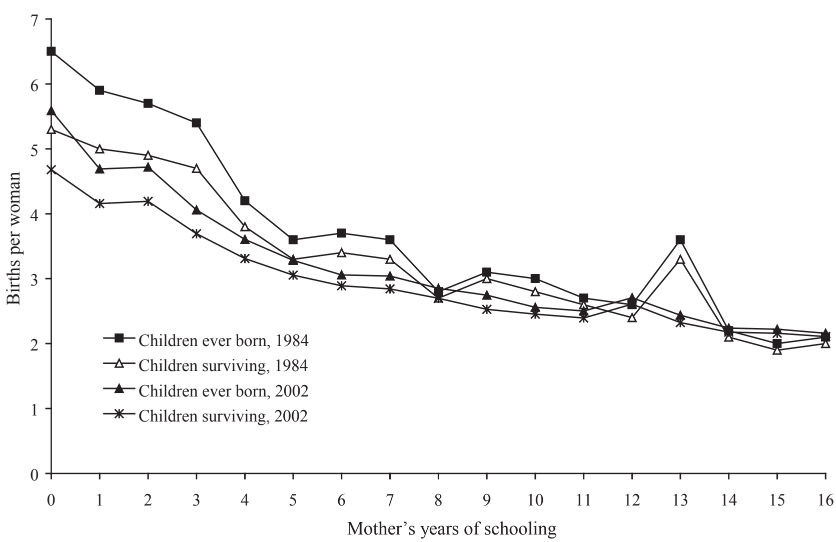
THE BRAZILIAN EXPERIENCE

Brazil's fertility decline makes for a particularly interesting case study. It is probably the best example of a developing country experiencing rapid fertility decline in the absence of a major family planning effort. Brazil is also a country for which we have excellent census and survey data going back to 1960, making it possible to analyze the fertility decline in great detail. As indicated in Figure 5.10, Brazil's fertility decline was well underway by the late 1960s, and fertility fell rapidly in the 1970s and 1980s. This was a period in which the country was ruled by a military government that gave little support to family planning programs (Merrick and Berquó 1983; Martine 1996; Potter, Schmertmann, and Cavenaghi 2002). It is also noteworthy that the fertility decline began during the rapid economic growth of the 1960s and 1970s but continued at a similar pace during the recessionary 1980s. Research suggests that increases in schooling, especially for women, played a major role in this decline (Merrick and Berquó 1983; Lam and Duryea 1999).

Lam and Duryea use the cross-sectional relationship between women's schooling and fertility to estimate the decline in fertility that would have resulted from increasing women's schooling prior to 1984. They estimate that increases in women's schooling could account for roughly 70 percent of the large decrease in fertility that occurred in the 1960s and 1970s in Brazil. Figure 5.11 shows the relationship between women's schooling and fertility in 1984 and in 2002. The 1984 relationship is taken from Lam and Duryea (1999); the pattern for 2002 is estimated using the 2002 PNAD survey, which includes roughly 10,000 women aged 45–59.[6]

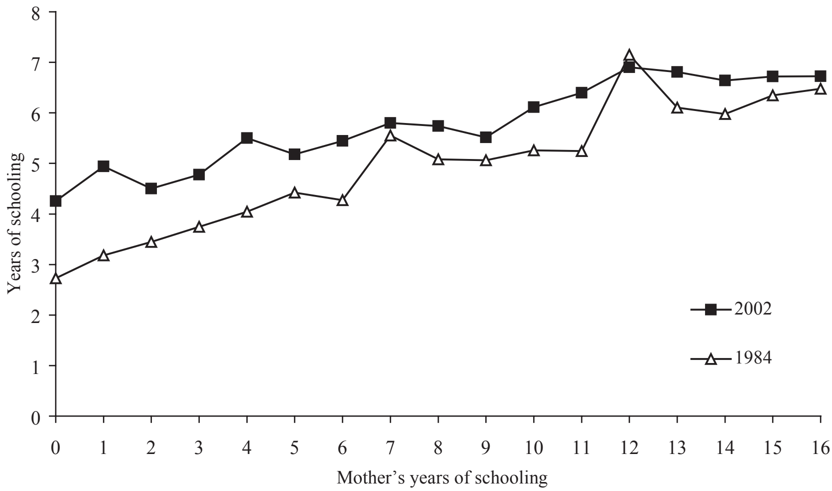
The mean number of children that had been born to women aged 45–49 fell from 5.0 in 1984 to 3.5 in 2002 (not shown).[7] This is a considerably larger gap than the varying distance between the two lines for

Figure 5.11 Number of Births by Years of Schooling, Women Ages 45–49, Brazil, 1984 and 2002



SOURCE: Author's estimates using Brazil's PNAD (National Household Survey).

Figure 5.12 Mean Schooling of 14-Year-Olds by Years of Schooling of Mother, Brazil, 1984 and 2002



SOURCE: Author's estimates using Brazil's PNAD (National Household Survey).

children ever born in 1984 and in 2002 in Figure 5.11. This indicates that the increased schooling of women, which shifts the distribution of women to the right along the horizontal axis in Figure 5.11, plays an important role in explaining the fertility decline. Mean years of schooling for women aged 45–49 rose from 3.5 in 1984 to 6.4 in 2002. Importantly, this involves a shift away from the lowest levels of schooling, the levels associated with the highest fertility.

The percentage of women aged 45–49 with zero years of schooling fell from 30 percent in 1984 to 14 percent in 2002, while the percentage going beyond the fourth grade rose from 24 percent to 53 percent. Given the strong relationship between schooling and fertility in Figure 5.11, especially at the lowest schooling levels, these shifts in the schooling distribution imply large declines in fertility.

Figure 5.11 also shows the number of surviving children by years of mother's schooling. Several features should be noted about the relationship between the number of surviving children, the number of children ever born, and years of schooling. First, there is the large gap between the number of children ever born and the number of children still alive at the time of the 1984 survey for women with low schooling. Women with zero schooling, a large part of the sample, had lost 1.2 children on average, a mortality rate of 18.5 percent. Part of the high fertility of women with low schooling levels appears to have been a response to high infant mortality. Figure 5.11 also shows the large improvement in child survival as schooling increases: women with schooling of eight years or more had very few children die. These relationships suggest that as increased schooling leads to higher infant survival, women respond by having fewer births.

As noted above, it has been an empirical regularity around the world that falling fertility has been associated with increased investments in children's human capital. Parental schooling can play an important role in this relationship, as suggested by economic theories of quantity-quality tradeoffs. Figure 5.12 shows the relationship between mother's schooling and the schooling of 14-year-olds in Brazil in 1984 and 2002, using the same household survey data as was used in Figure 5.11. Figure 5.12 shows a strong positive relationship between mother's schooling and children's schooling, with an especially strong relationship at low levels of schooling. In the 1984 data, 14-year-old children whose mothers had 15 or more years of schooling (university completion) were more than three grades ahead of 14-year-olds whose mothers had zero schooling. The 2002 relationship shows a slightly flatter slope to this curve, although there is still a gap of well over two grades between the highest and lowest schooling levels.

Although Figure 5.12 gives the impression that there has been relatively little improvement in schooling between 1984 and 2002, there was in fact a large increase in mean schooling over this period. The mean years of schooling of 14-year-olds grew from 3.5 years to 5.4 years, a 54 percent increase. As can be seen in Figure 5.12, the increase in schooling of 14-year-olds, holding mother's schooling constant, is significantly smaller than this 1.9 year overall improvement. As with the fertility relationship discussed above, this indicates that the increased schooling of women is an important factor in explaining increased schooling of their children over this period. The improvements at the bottom of the schooling distribution are once again important, since moving women from zero to four years of schooling has a big impact on the schooling of their children. Lam and Duryea show that the strong relationship between parental schooling and children's schooling continues to be observed when regressions are estimated with additional controls for variables such as region and urban or rural location, with the effect of father's schooling almost as large as the effect of mother's schooling.

While many factors, including the increased provision of family planning services, play a role in explaining the rapid declines in fertility in the last 40 years, improvements in child survival and in the schooling of parents clearly are key parts of the story. Brazil's case is particularly strong evidence of this, since there was very little increase in family planning. The fact that investments in children's schooling and health increased at the same time fertility declined is one of the most important signs of the changing behavior of parents, since it means that today's generation of young people is the best educated in human history. Given the importance that increases in human knowledge have had in helping the world survive the population explosion, it is reassuring to know that the next generation of adults will be even better educated than the generations that dealt with the challenges of the last 40 years.

CONCLUSION

The years from 1950 to 2000 form one of the most interesting periods of demographic change in history. The 1950s saw the annual growth rate of world population begin a dramatic increase that peaked at over 2 percent a year in the mid-1960s, followed by a return to the 1950 level of 1.4 at the end of the 1990s. The doubling of world population between 1960 and 2000 was by far the shortest doubling time in human history, a phenomenon that will almost surely never be seen again. This population explosion essentially played itself out within a half-century, and as it did so it presented an unprecedented challenge to the world's ability to feed itself and provide resources necessary for modern human existence.

This chapter has argued that the world has already survived the population explosion. While the demographic impact of the rapid population growth of recent decades will continue for several more decades, the population growth rate of the world will continue to fall rapidly, returning the world to the kind of growth rates seen in the early twentieth century and even earlier. During this population explosion the world managed to increase per capita food production, decrease poverty, and reduce the prices of most commodities, both renewable and nonrenewable. This is an amazing accomplishment that we should not lose sight of as we move beyond the late twentieth century.

Understanding how the world survived the population explosion requires an understanding of both the demography and the economics at work during these decades of rapid population growth. Demographically, it is important to recognize that it was rapidly falling mortality that began the population explosion and that it was unexpectedly rapid falls in fertility that brought it to an end. The economics of markets, individual responses to incentives, and returns to human capital are important aspects of the story. The fact that per capita food production was 31 percent higher in 2003 than it was in 1961 reflects both innovations in agricultural technology and responses by farmers to economic incentives. The fact that an index of nonenergy commodity prices fell 54 percent between 1960 and 2000 reflects technological advances and the impact of international trade. And the fact that the world's total fertility rate fell from 5.0 to 2.8 between 1965 and 2000 reflects the rational responses of couples to increased child survival and increased parental schooling. Parents not only chose to have fewer children but also chose to invest more in the health and schooling of those children, making this current cohort of young people the best educated in history.

In considering issues of sustainable development and the world's ability to meet increasing resource pressures, the history of the past 50 years must be a source of optimism. At the same time, challenges remain. While world poverty rates fell impressively in recent decades, with the percentage of people living on less than $1 a day being cut in half between 1980 and 2001, poverty increased substantially over this period in Africa. Nor has Africa been able to increase food production fast enough to keep pace with population. Beyond that, this chapter has not dealt with the many environmental concerns that are often raised by those who are less optimistic about the world's future. These issues are critical, especially when markets may do a poor job of creating appropriate incentives, as in the case of ocean fishing or global warming. In considering whether the world will be able to meet these challenges of the twenty-first century, however, we should not forget how bleak prospects looked in the 1960s. The world's ability to survive the population explosion may be one of the most important lessons about human adaptability that we will ever receive.

Notes

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1. Estimates before 1950 are taken from the U.S. Census Bureau's "Summary Estimates," which are based on a number of historical sources (2003). Estimates and projections from 1950 to 2050 are taken from United Nations Population Division (2003). See Bongaarts and Bulatao (2000) for discussion of projections to 2050.
2. The growth rates in Figure 5.2 are based on estimates of the total population for each single year up to 2000. The figure shows three-year moving averages of these growth rates, which serve to remove some of the short-run year-to-year volatility. The growth rates for the period after 2000 are based on United Nations population projections for every fifth year (2000, 2005, etc.). For example, the growth rate centered on 2002.5 for the medium variant is the average annual growth rate implied by the U.N. medium variant estimates for the population in 2000 and 2005.
3. National accounts data are the aggregate data on measures such as GNP and industrial output that are produced by national statistical agencies.
4. Note that India is included in the "South Asia" series, in addition to being represented separately.
5. The actual value of replacement fertility depends on mortality rates between birth and childbearing, and thus is different for every population. The figure of 2.1 is a rough benchmark.
6. PNAD stands for Pesquisa Nacional por Amostra de Domicilios, or National Household Survey.
7. Note that most of these births would have taken place when these women were 20 to 35 years old, so this decline roughly describes the decline in fertility between the 1960s and the 1980s.

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6
Property Rights and the Urgent Challenge of Environmental Sustainability

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I seek here to connect two prominent contemporary concerns—property rights and environmental sustainability. While the relation between these two ideas may not be apparent at first thought, they are most certainly linked in the realm of public policy. The linkage occurs because many actions taken by private landowners hold serious implications for parts of the natural world that are the subject of much concern for sustainability. And to the extent that public policies concerning sustainability seek to influence individual and group action so that detrimental impacts are avoided, individual landowners may find themselves in an unwelcome situation. The dominant myth in America is that the owner of land may do as she wishes with the land that she owns. When this belief is acted upon, and when such acts are detrimental to sustainability outcomes, perceptions of property rights come into direct conflict with the imperatives of sustainability.

In this chapter I will offer a brief overview of the concept of *rights* (and that of *duties*), I will explore the concept of *property*, and I will then spell out the idea and practice of *property rights* in the American political and legal system. I will next turn to a brief discussion of the issues that must be faced if we are to understand the essence of sustainability. The problem to be highlighted here is that sustainability cannot be discussed in the absence of serious thought about the evolving purposes of nature. That is, we learn about what is worth sustaining when we learn about how different people come to see what "nature is for." Since the purposes of nature are continually evolving, we can only understand concerns for sustainability if we understand the nature of this evolutionary process. Finally, I will offer some insights into the problems that arise when scientific experts (or courts of law) offer up advice (or legal findings) about sustainability or about property rights. The philosophy of pragmatism helps us to understand that, in a democracy, assertions from scientists—or decrees from courts—must be justified to those who will be affected by those assertions and decrees. I explore the important implications of having public policy flow from this fact.

PROPERTY RIGHTS

If we are to understand the role of property rights in relation to concerns for environmental sustainability, we must start with the idea of a *right*. Rights are the collective (legal) permission to be able to compel the government to come to your assistance in particular situations (Becker 1977; Bromley 1989, 1991; Christman 1994). Rights do not offer mere passive support by the state. Rather, to have rights is to have assurance of active assistance from the coercive power of the state. That is, the state stands ready to be enlisted in the cause of those to whom it has granted rights. Rights expand the capacities of the individual by indicating what one can do with the aid of the collective power. This process works because of the correlated duties on others who might wish to interfere with the individual to whom rights have been granted. Rights are not something embedded in natural law. Instead, rights emerge through the collective recognition of the legitimacy of particular interests in the eyes of the state.

With the meaning of rights in hand, we can now consider the meaning of *property*. Despite how we talk—"I just bought a nice piece of property on a lake"—what the idea and practice of property convey is *not* an object (such as land). Property is, instead, a stream of values into the future (Macpherson 1973, 1978). When one buys a piece of land one acquires not merely a physical object but rather control over a benefit stream arising from the setting and circumstances associated with that object. That is why we spend money (one benefit stream) in order to acquire property ("ownership" of a new benefit stream arising from the fact of ownership). The price paid to acquire that new benefit stream is simply the discounted present value of all future net income flowing from ownership of the thing and its stream of values. Ownership concerns futurity—value running into the future that the owner controls (for the most part) and may now receive.

The idea of *property rights* brings these two ideas together. Property rights define the limits of the law pertaining to the income arising from the control of income-producing settings and circumstances. Trademarks, copyrights, and patents are property rights. All are forms of rights in property (the future value) and correlated duties falling on nonowners. In practical terms, the empirical content of property rights is determined when conflicting *rights claims* are brought before that legal body created to resolve conflicting claims in a democracy—the courts. As property rights disputes work their way through the court system, some of them may end up in the Supreme Court. The legal struggle, and the appeals process that keeps it moving up through ever higher layers in the judicial system, is precisely concerned with figuring out which disputant has the more compelling rights claim. We see that property rights are not some a priori concept by intuition ("this is a table"). Rather, property rights are the result of a process whose essential purpose is to determine which of the conflicting rights claims before the court seems better, at the moment, to sanctify. In other words, settings and circumstances are not protected because they are, a priori, instantiations of property rights. Rather, those settings and circumstances that gain protection from the courts acquire, by virtue of the decisions in the courts, the status of a property right.

John Locke plays a central role in the American idea of property rights. Locke worked out a theory of the *acquisition* of property, such acquisition then giving rise to several desirable outcomes, from which flow the main justifications for the *holding* of property. Locke's necessary starting point is a creation story in which a Calvinist God gives the earth to humans *in common* and admonishes them to take dominion over that commons by, among other things, mixing their labor with it (Kreuckeberg 1999). Locke is then able to argue that by having mixed their labor with the land they deserve to become its owner. This Lockean creation story occurs in a state of nature (a pre-civil society) and hence it is necessary to have some means of protecting that which has been acquired. It is here that the state enters the picture. To Locke, the purpose of the state is to protect those who have labored as God commanded, and thereby to bestow on all the beneficial effects that arise from this class of hard-working citizens. The state, having formed to protect those who have, out of nothing but hard work, created so much, is thus obligated to stand as a shield for those who now hold property. That protection works in two important directions. It works against others who may wish to prey on the industry of those who labor on their land, and it works, reflexively, against that very state. That is, the state itself is restrained, by the collective realization of the great benefit arising from the existence of an owning and laboring class, from interfering with those activities it finds so beneficial and compelling.

It is here that we come to the Lockean idea of *holding* land. If one acquires land in the Lockean way then it has been justly acquired, and its continued holding is justified on moral grounds. Equally important, this holding is justified on prudential grounds since the effect of individuals holding land is the production of benefits for the community at large. The key justification for the continued holding of land finds its expression in the idea that this grant is the essential assurance of liberty for those who hold land. They are assured of liberty because the state agrees to protect them from the predations of others, and they are assured of liberty because the state itself agrees to refrain from its own form of predation on the private property of its citizens (unless compensation is offered in return).

Locke recognized that as the earth filled up, and as less and less of God's Commons (to use Kreuckeberg's phrase) was available for appropriation, it was inevitable that conflicts would arise (Kreuckeberg 1999). As Locke put the matter, his theory of justified acquisition and subsequent justified holding worked only so long as there was "enough and as good" for others. This Lockean proviso brings us to Immanuel Kant. The views of Kant are important in discussions of sustainability because it was Kant who first offered a way out of the trap set by the static nature of Locke's concept of property rights.

Kant's innovation was to recognize that rights (and therefore property rights) are not tangible empirical realities but are, instead, mental constructs. The word he used is *noumena*. Those things that cannot be apprehended by the senses but are knowable only by reason constitute noumena. Kant motivates his inquiry on rights by asking what conditions are necessary for an individual to make internal something that is, by its very nature, external? Something external to an individual is made internal by understanding the idea of belonging to. And how is it decided that something external *belongs to* an individual? The individual may declare that some particular object or situation belongs to her. Notice that this is a claim against all others to whom the object or situation might otherwise belong. Such claims are asserted by those who wish to make the point that the speaker is the rightful (justified) possessor and controller ("owner") of the thing under discussion. The speaker is making something internal that is, quite clearly, external.

Kant recognized that such claims represent negations of the interests of others within the same community. And he suggested that while one individual may indeed announce and display physical *possession* of something external, this was not the same as having a socially sanctioned authority to make that declaration binding on others who might wish to make internal that very same thing. That is, unilateral declarations of "belonging to" are inherently unstable and therefore cannot be expected to settle the matter once and for all. Kant noticed that it is only from the consent of others that one can make internal that which is clearly external. For if that external thing can belong to *anyone* within the community, what justification can be mounted to assert that it belongs to any *particular* member of that community? Why should others willingly accept binding duties on nothing more compelling than the self-serving assertions of those already in possession of something of potential value to others?

Kant said that such assertions are nothing but the affirmation of *empirical possession*. And by being based on mere possession they confuse physical control with something much more profound. That more profound circumstance is one that Kant called *intelligible possession*. Intelligible possession comes into play when a community of sentient beings reaches agreement that indeed it is both right (moral) and good (prudential) that someone among them should be able to make internal something that has hitherto been external. The essence of empirical possession is a dog with a bone. There is not, nor can there be, recognition among the community of dogs—all of whom covet the bone—that it "belongs to" the one currently in possession of the bone. The most one can say is that they acknowledge possession. It takes Kantian reason to transcend empirical possession. In human society, what is mine depends *not* on what I say about it being mine. Rather, what is mine *becomes* mine by virtue of the assertions of all others who, by their declaration, acquiesce in their own disenfranchisement from the benefits associated with that object or circumstance. Others grant me *possessio noumenon*, or socially justified possession—I cannot take it for myself.

We see that Locke gave us a basis for justified acquisition and holding of land (property) as long as there is "enough and as good" for others. But Locke stopped short of a complete theory of what is to be done when there is *not* enough and as good for others. That is, Locke developed a theory of acquisition and holding that works best when it is needed least. Kant helped us to see that the continued holding of land in the face of scarcity requires something very special. For scarcity raises the specter of deprivation and exclusion if Lockean acquisition and holding works against the interests of others in the community who—by virtue of coming late—find that all of God's Commons has already been justly acquired. How are we to justify the continued holding of land once there is no more of it to be justly acquired? Or what are we do about those who hold (own) land yet insist on using it in ways inimical to environmental sustainability?

Contemporary Lockeans have a ready answer to this question: let the latecomers buy it from those who have justly acquired it (who have previously purchased it). Or, if the current owner is to be restrained from using land in destructive ways the government must offer compensation in order to induce the owner to stop such practices. Notice that once the initial acquisition has been transferred to another for a particular price, the logic seems compelling and without end—all future acquisitions must be mediated by due consideration to the extant holder of land (property). And what is transferred in this way is—and must be—precisely what earlier acquirers obtained. By this logic, the "just acquisition and holding" continues into perpetuity.

Such logic threatens the prospects for sustainability of certain components of nature adversely affected by traditional land-use practices. That is, the current holding of land and other natural resources often results in actions that are now found to be neither moral nor prudential. What if ownership results in wetlands—important breeding and nesting habitat for wildlife—being destroyed? What if ownership results in too much old growth timber being cut down? What if ownership means excessive soil erosion that fouls streams and lakes? Given these possibilities, on what grounds can payment then be justified in order to induce the current holder to stop using his land in an antisocial manner? In other words, what is to preclude one or more holders of land from engaging in social extortion? We see that land justly acquired may evolve into land unjustly held, its current use no longer being moral or prudential. Kant recognized that the community itself must determine whether land justly acquired continues to be justly held. And Kant located this determination in *acts of reason* undertaken by a civil society (Williams 1977). It is the community itself that must set the standards by which holding of justly acquired land remains justified.

Kant forced us to work out a new theory of holding land in the face of emerging collective disapproval of the actions of the current owner. Such a theory must offer an explanation (justification) for difficult decisions about what to do with just and prudential holdings into the future. In more practical terms, this theory must address the issue of what is to be done when current land holdings—or particular uses of land—are no longer socially acceptable. Must payment to the offensive owner always be forthcoming? This is the essential "takings" question in land-use regulations (Bromley 1993, 1997).

One school of thought holds that there are no circumstances in which actions on land that has been justly acquired can be circumscribed or precluded—say through regulations—without those restrictions being accompanied by compensation (Epstein 1985). In reality, however, there are many land-use conflicts in the American experience in which particular uses of land have been prohibited and no compensation has been forthcoming. One classic case is *Penn Central Transportation Co. v. City of New York*, in which the Penn Central wanted to construct an enormous skyscraper on stilts above New York's Grand Central Terminal, which it owns. The New York City Landmarks Commission had declared it a historic site, preventing this plan. Penn Central sued the City of New York for compensation under the takings clause and was denied. Other cases involve wetland drainage and timber harvests under the Endangered Species Act. The courts have sometimes found in the interests of a restrained land owner, and they have sometimes found in favor of governments seeking to protect natural habitats in the interest of sustainability. Why have the courts varied?

An answer to this apparent contradiction is found in the work of Charles Sanders Peirce, said to be one of the most creative and profound philosophers America has ever produced. Peirce would have us imagine the idea of property rights in the American experience as the benediction applied to those settings and circumstances that, when the dust of consideration by various levels of jurisprudence has finally settled, are found worthy of indemnification by the state (Peirce 1934). Notice that the term *property rights* is not something known axiomatically—something whose essence is clear to us by intuition or introspection *before* a particular legal struggle is joined and its specifics emerge. Rather, the idea of property rights is worked out—created—in the process of resolving mutually exclusive rights claims before the courts. This means that the American judicial system does not seek to discover where the a priori property right lies. Instead, the courts offer a necessary forum to which, from time to time, conflicting rights claims will be brought. When the more compelling rights claim has been determined, the court will issue a decree to that effect. We see that property rights are made, not discovered.

This idea that the courts create, not discover, property rights as they dig into conflicting rights claims can be attributed to the celebrated Supreme Court justice Oliver Wendell Holmes. Louis Menand says that "it was Holmes's genius as a philosopher to see that the law has no essential aspect" (Menand 2001). Indeed, Holmes had written in 1870 that the merit of common law is that it leads judges to decisions on the merits of the cases before them and it then allows them to determine the guiding principle secondarily. Menand describes the process thus:

> A case comes to court as a unique fact situation. It immediately enters a kind of vortex of discursive imperatives. There is the imperative to find the just result in this particular case. There is the imperative to find the result that will be consistent with the results reached in analogous cases in the past. There is the imperative to find the result that, generalized across many similar cases, will be most beneficial to society as a whole—the result that will send the most useful behavioral message. There are also, though less explicitly acknowledged, the desire to secure the outcome most congenial to the judge's own politics; the desire to use the case to bend legal doctrine so that it will conform better with changes in social standards and conditions; and the desire to punish the wicked and excuse the good, and to redistribute costs from parties who can't afford them (like accident victims) to parties who can (like manufacturers and insurance companies).
>
> Hovering over this whole unpredictable weather pattern—all of which is already in motion, as it were, before the particular case at hand ever arises—is a single meta-imperative. This is the im-

> perative not to let it appear as though any one of these lesser imperatives has decided the case at the blatant expense of the others. A result that seems just intuitively but is admittedly incompatible with legal precedent is taboo; so is a result that is formally consistent with precedent but appears unjust on its face (Menand 2001, p. 339).

It would seem that pragmatism is a central reality of American jurisprudence. This pragmatism is particularly suited to property rights cases, which are concerned with figuring out where the most compelling property interests lie. The problem here is to blend moral and prudential arguments in search of the *best* thing to do. That best thing will comprise the "truth" in that particular setting. In fact, one way to paraphrase the courts' approach is to say that truth is merely that which it is better, at the moment, to believe. Truth is the special benediction we bestow on our settled deliberations (Rorty 1982, 1999).

It would also seem that conventional efforts to divine the idea—the a priori essence—of property rights are flawed and prevent clear thought about environmental policy and sustainability. When property disputes arrive in the courts, justices are forced to consider and imagine possible futures and then figure out which of the claimants has the more compelling claim in light of those imagined futures. Their legal findings, or decrees, reflect this new recognition.

SUSTAINABILITY

With this necessary background on the legal side of land-use issues, let us turn directly to the matter of sustainability. The central issue concerning environmental sustainability is to recognize that individual and collective ideas concerning the purposes of nature are undergoing constant change. Thus the problem of sustainability concerns the need to understand and to come to grips with the continual evolution in human conceptions about what nature is for. And the present-day challenge of sustainability involves the ongoing evolutionary process whereby a particular type of land cover—a particular plant and animal community—has come to be seen as much more complex, interesting, and dependent on other distant ecotypes (as well as much more important to the well-being of other ecotypes and to us as humans) than had been previously thought.

At one level, not much about the forest has changed in a fundamental way over the past several decades. Despite dwindling in the area they cover worldwide, forests are still an evolving complex of chemical and physical properties and attributes. However, while the forest has not changed very much, the precise social *meaning* of the forest has changed profoundly. It is not the forest on the ground that we address and fuss over when we undertake management activities. It is the forest *in our minds* that we are working on and seeking to manage. Indeed it is the forest in our minds that we use when we are in it, and it is the forest in our minds that we covet and recall when we are away from it.

Modernism, grounded on Cartesian radical doubt, brought us the odd idea that the mind is—to use Richard Rorty's phrase—simply a "mirror of nature." That is, we are led to believe that there is a unique, tangible, and knowable reality out there (in the world) that would become available to us if we would but first, as good Cartesians, purge our minds of all existing ideas and thoughts about that reality. With this newly emptied receptacle, we could then immediately grasp and comprehend that extant reality, and then we would—at last—have an accurate and irrefutable description of it (Rorty 1979). Our knowledge of it, and about it, would be complete and irrefutable. With that durable knowledge in hand, we would then be getting very close indeed to the "truth" about that particular reality—the "thing in itself," as Kant and his followers might put it. Some refer to this as the *representational* model of knowing. Those whose essential burden in life is to produce true descriptions of and stories about that reality are called scientists. And, as modernism drills into us at every opportunity, scientists pursue the truth.

Pragmatists are not so sure about this search-for-truth claim. Pragmatism suggests that when the collective determination of what is out there converges into a consensus and comes to be adopted by the epistemic community (the scientific discipline) whose task it is to investigate some particular aspect of the world, then this consensus becomes the accepted story—the "truth"—about that observed and apprehended "reality." Scientific debates are not about some knowable reality. They are debates about *stories* about that reality. In other words, there is no plausible, reliable, complete, irrefutable, comprehensive, true, and accurate account of a "forest" or an "ecotype" or an "ecosystem." Indeed, that Holy Grail of environmental policy, *species*, is itself an artificial construct. To be sure, the creations of the early classifiers and categorizers have some plausible attributes. But the only thing that recommends them to us now is that these categories and their members serve to order our world—they are useful for the purposes that motivated their creation.

I hope it is now easier to comprehend my earlier assertion that what matters about forests, ecotypes, and ecosystems is nothing more than the categories, meanings, and purposes that humans attach to them. Each of these environmental assets and the species in them *become* for us what we have made of them. We will see, understand, use, manage, and revere them in ways that evolve as we figure out new ways to think about them. To put the finishing touches on this line of thought, the forest is *for us* the sum of its effects *on us*. Human interaction with forests and ecosystems can only be understood in terms of the effects those forests and ecosystems have on us. We do not manage forests and ecosystems. We manage and redefine the effects that forests and ecosystems have on us, and we manage and redefine the effects we have on them.

We know and understand a stunning sunset, a high mountain meadow, or the boreal forest, not by anything inherent in those physical settings, but rather by the effects those settings and circumstances have on us. Our conception of the effects of a sunset, a forest, or an ecosystem is the *whole* of our conception of a sunset, a forest, or an ecosystem. That is all there is (Peirce 1934). The mind is not a mirror of nature. Rather, the mind creates our conception of nature in the light of our current embeddedness in particular social, economic, and cultural settings and circumstances. An adult from an urban area sees a very different forest than does an adult from a small town surrounded by forest. She sees the forest differently because she learned about it differently, and she most certainly uses it differently. When those settings and circumstances change for us, then the construction project in our mind recreates nature in keeping with the emergent futures we think we see before us. This recreation of nature is always undertaken in light of our imagined purposes for the future.

The way in which we see nature cannot be distinguished from the way in which we imagine the purposes of nature—what nature is *for*. Indeed it is our vision of what nature is for that prefigures how we see and regard nature. Debates about sustainability will, inevitably, bring into the discussion the testimony of scientific experts. And the use of scientific knowledge for improved decision making necessarily starts with the requirement that the scientific knowledge offered up must be pertinent to the disparate purposes for nature held by the many individuals and groups who claim to speak on behalf of nature. There is no single decision maker, and this multitude of audiences reminds us that there cannot possibly be a single bundle of scientific knowledge that will, upon presentation by the experts, be found to be decisive with respect to what shall be done about particular environmental challenges.

In the face of this multitude of audiences for scientific knowledge, we must recognize that there are two general categories of knowledge that are pertinent. The first concerns scientific knowledge that presumes to be informative, while the second concerns information that pertains to what we call *agency*. Consider the problem of global climate change. When we think of scientific knowledge that presumes to inform, we usually think of the natural sciences—paleobiology, oceanography, climatology, forestry, atmospheric chemistry, and the like. The point here is that distinct epistemic communities undertake research to gather data that, with sufficient interpretation and elaboration, will provide pertinent information about processes of interest to the rest of us. Notice that data are not information. Rather, information is purposefully reconfigured data. We will be shown long-run trends in global mean temperatures, we will be shown fossil records and maps of vegetation change. We will see photographs and maps and charts. We are being informed. Or are we? Some individuals, with different perspectives on the issue, and with different interests at stake, may well be suspicious. In other words, we must never presume that all individuals are equally open to what the rest of us might consider to be useful information.

Consider now the second category of scientific knowledge—what I above referred to as the problem of agency. Regardless of what one happens to believe about global climate change, the interesting issue is whether or not human activity—say the burning of fossil fuels—is plausibly related to this matter. That is, one can accept the natural scientific evidence that, yes, it would seem that the earth is indeed getting warmer. But admitting a warming trend and accepting human culpability in that trend are two distinct mental processes. Perhaps the trend is caused by increased activity on the surface of the sun. Or perhaps Planet

Earth is going a bit wobbly on its axis. We see that many individuals—again for a purpose that may be subconscious—draw a distinction between fate (so-called acts of God) and outcomes in which the hand of humans is seen as decisive. For many individuals, corrective action to address acts of fate is pointless; they are of the belief that only if humans can be found culpable must we confront and seek to change those implicated behaviors.

Suddenly global climate change, a matter of such overwhelming simplicity and certitude in the minds of some individuals, is seen to be multilayered and deeply confusing. In addition to this complexity, we have multiple audiences, each of which brings its own created imagining about necessity and purpose and its own particular receptivity to what the rest of us regard as informative evidence.

WHAT TO BELIEVE?

I now turn to the process whereby individuals come to hold particular beliefs, and how they might be induced to alter firmly held convictions. I shall approach these questions from the perspective of what I call *volitional pragmatism*—the human will in action, looking to the future, trying to figure out how that future ought to unfold for us (Bromley 2004, 2005).

The central challenge in public policy for environmental sustainability is to understand the process whereby information from a community of scientists is regarded as definitive and pertinent to the problem under consideration. There are two issues here. The first is the authority with which scientists speak on a particular matter. This problem has to do with the veracity and coherence of pronouncements emanating from a particular community of scientists. The second problem involves the receptivity of the larger public to scientific pronouncements and declarations. The first problem concerns what I call *warranted assertions*; the second, what I call *valuable assertions*.

Warranted assertions are those that can be justified to most members of the discipline out of which the assertions emerge. Most economists who advise on environmental policy feel quite comfortable telling us how environmental choices ought to be considered—and that is usually in terms of benefit-cost analysis. The issue here is the extent to which a subset of the discipline of economics has a conceptual and empirical sanction to issue prescriptive assertions, and to have those claims stand as the truth as seen through the eyes of the entire profession.

Pragmatism accords the status of warranted belief (or warranted assertion) *only* to the settled deliberations of an entire community of scholars (a discipline or a particular epistemic community). When an entire discipline speaks with clear consensus on a particular scientific matter, then the rest of us can safely regard these truth claims as constituting warranted assertions. On the other hand, when that disciplinary consensus is absent, or when it begins to dissipate over time, then the associated truth claims cannot be justified within the discipline and they thereby lose their warrantability and their legitimacy to the larger community to which they are addressed. The various audiences for these assertions from "science"—whether executive-branch agencies of government, legislative bodies, courts, or citizen's groups—find themselves barraged by a wide array of conceptual and empirical claims. Often, the processing of those assertions takes place in a manner that might be thought irrational by those who produce scientific assertions. Such dismissive judgments are quite unjustified, and this brings us to the demand side of information.

Consider now the idea of valuable assertions. Pragmatists insist that the adjective "valuable" can only be applied by those who are the intended consumers of particular assertions (truth claims). In other words, the consumers of those assertions stand as the definitive judges of whether or not they happen to find them valuable, useful, pertinent, informative, and dispositive. For instance, when environmental economists offer specific consequentialist prescriptions about collective choice—indicating which decisions are efficient, correct, rational, best, and socially preferred—we see truth claims from a particular subdiscipline of economics projected onto disparate considerations about what is best for the future. The pragmatist would wish to know whether or not those specific truth claims can be *justified* to all members of the particular community to whom they are directed. If that justification is possible then the truth claims are valuable. They are valuable because the community into which they are projected finds such assertions helpful, useful, edifying, and instrumental to improving the working out of what seems best to do in the current setting and circumstances. If those truth claims cannot be justified to the members of the pertinent community then such claims are unjustified. They are unjustified precisely because the community to whom they are directed finds them to be impertinent to the task they currently face.

We see that the prescriptive assertions from a community of disciplinary adherents are hardly a sufficient condition for the immediate acquiescence of the rest of us. The public may well respond, "Do not expect the rest of us to stop what we are doing and fall into line with the pronouncements from scientists just because they happen to be scientists." Indeed, the public's acquiescence in the alleged truth claims of science must rest on a separate set of arguments and reasons from those to which the members of a discipline alone are privileged. With the public lacking this information, disciplinary practitioners are not entitled to expect the general population to accept their particular truth claims on faith.

Notice that the issue here is not truth but justified claims or justified belief. The pragmatist would ask whether economistic truth claims are capable of being justified to an audience of individuals who are the objects of our interest as we seek to improve their lot with our socially preferred, or optimal, policies. The question worth asking is, "Why, exactly, are the truth claims of environmental economics more pertinent to this particular choice setting than, say, the truth claims of psychology?" We have here a debate about the *true* and the quest to justify *claims* about the true. Recall that truth is not a property of perfect correspondence between propositions (words) and particular events and objects to which those propositions refer—between language and things. Truth is not denotative. Truth is, instead, a property of the relationship between different statements about specific events and objects—that is, between contending linguistic claims. Truth is connotative (Bromley 2005).

We now have a way to view the prescriptive assertions emanating from any number of scientific disciplines. Warranted assertions are those that can be justified to the larger disciplinary community—here the keys are that warranted assertions be coherent in their concept and plausible in their empirical claims to the larger epistemic community out of which such assertions arise. Valuable assertions are those that a community of sapient agents (that is, the rest of us) find useful and reasonable to the decision now before them. The essential idea here is that human choice and action are properly characterized as *prospective volition*—the human will in action, looking to the future, trying to determine how that future ought to unfold. As this process evolves, individuals and groups bring contending expressions and imaginings to the task of choice and action (Shackle 1961). Individuals and groups do not know precisely what they want until they work out what they can have. Group action is more complicated than individual action because it requires reconciliation of disparate and contending individual expressions and imaginings until a consensus emerges—the properties of which are that this consensus is regarded as 1) feasible, and 2) the best thing to do at this particular time.

The two properties of that consensus—"feasible" and "best at this time"—represent judgments reached by those individuals who are responsible for collective action. In the realm of environmental policy, the first step in this process of working out an emergent consensus is necessarily confined to legislators, administrators, and judges. As we know, this process may be aided by input from economists and other scientific "experts." It is here that the first test of valuable assertion is encountered. In a democracy, going beyond this level entails the critical step of justifying particular decisions or decrees to the larger political community. In some cases that would include polluters, victims of pollution, and others who care about nature. In other cases, it could be those who see the purpose of the forest being the production of timber versus those who see the purpose of the forest being the provision of places of solace and emotional regeneration. In either case, these are the individuals whose separate actions will be liberated, restrained, or expanded by policies that favor one purpose over another. If policies are not justified to such disparate audiences, those policies will lack legitimacy. This justification to the larger political community necessarily entails the giving of reasons for the decision reached, and those reasons must match as closely as possible the asking for reasons that is expected from the political community to whom the collective action is directed (Brandom 1994, 2000). This activity is properly thought of as justification in the service of emergent consent.

We see that even if particular truth claims are deemed coherent by the discipline—or the court chamber or parliament—from which they spring, the projection of those truth claims to a larger audience is impertinent unless there is widespread acceptance on the part of those to whom the truth claims are directed. Individuals in contemporary life retain the authority to reject, for their own reasons, truth claims from any source (scientist or mystic). Recall that the status of *valuable belief* is a property bestowed upon prescriptive assertions (truth claims) by those to whom such claims are directed—not by those who produce the assertions. All that the producers of prescriptive assertions can justifiably affirm is that their assertions share wide agreement within the interpretive community out of which they arise—that they are warranted.

We see that the fundamental problem in much public policy is that pronouncements from scientists tend to be seen as presumptively legitimate, while the pronouncements from nonscientists are often dismissed as mere opinion, as based on emotion, as idealistic, or as predicated on sentiment. Such judgments are simply one more residue of modernist conceit.

PROPERTY RIGHTS AND SUSTAINABILITY—AGAIN

My purpose here has been to find a way to help us escape the trap in which environmental policy (and discussions of sustainability) is usually framed. That usual framing forces us to make a choice at two levels. At the first level, we must decide if we are to invoke consequentialist choice rules or ethical choice rules. Notice that much debate gets stalled here and never moves on to the second, more profound level, where substantive issues are addressed. Even assuming that we manage to reach agreement on which path to the "correct" choice is to be followed, this second-level challenge remains fatally flawed. It is flawed because it presumes that there is some a priori right way to address either the ethical issues or the consequentialist issues.

This suggests that discussions about sustainability cannot be understood as prescriptive assertions about what must be—what ought to be—saved for the future. Nor can we make much headway by advancing prescriptive assertions concerning the optimal level of something that must be preserved. Rather, coherence in such conversations will only flow from a continual conversation—a political process—in which we work out what seems worth saving as we struggle with figuring out what we revere now and what we hope our descendants will revere as well. This conversation addresses fundamental issues about the sustainability side of our story.

While such considerations are going on, it is to be expected that owners of private land may well experience the unwelcome scrutiny of the larger community, which happens to be affected by particular land-use decisions. In response to this scrutiny landowners may well appeal to the community's understanding of what it means to have a property right. They would, it seems, be well advised not to play this card too aggressively. They might find, to their despair, that others are holding a trump card.

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7
Too Poor to Be Stewards?

Rural Poverty and Sustainable Natural Resource Management

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Sustaining natural resource stocks, especially those underpinning the capacity to produce food, is key to most definitions of sustainable development. Yet troubling evidence has surfaced of instances where the rural poor were forced to sacrifice long-term sustainability for the sake of near-term survival (Mink 1993; Figueroa 1998). Are such cases special ones, or is rural poverty a driving factor in causing soil erosion, overgrazing, deforestation, and degradation of other natural resources? This chapter argues that natural resource sustainability in developing countries is not the result of a direct cause-effect relationship, but rather is engendered by a web of causal factors. Untangling that web entails separating out strands for poverty from those for location-specific natural resources, human institutions, technology, and population. This chapter will review the history of the poverty-environment debate, examine three case studies that shed light on key relationships, and, finally, propose policy interventions to promote the sustainability of the natural resources that underpin agricultural productivity.

POPULATION AND FOOD PRODUCTION: IDEAS AND TRENDS

The poverty-environment debate has grown from a seed planted by the English clergyman Thomas Malthus 200 years ago. Having studied the historical growth rates of population and food production, Malthus

(1798) wrote an essay, published anonymously by Joseph Johnson, a radical publisher at St. Paul's Churchyard in London, in which he laid out his famous scenario for disaster: "The power of population is indefinitely greater than the power in the earth to produce subsistence for man. Population, when unchecked, increases in a geometrical ratio. Subsistence increases only in an arithmetical ratio." Throughout human history, war and pestilence have reined in population before the food supply became a constraint. But by the mid-nineteenth century, when a potato blight spread famine among the Irish population, killing one million inhabitants, current events seemed to support Malthus' grim observation that food production lacked the potential to keep up with population.

As population growth rates took off during the period of relative peace after World War II, Malthusian fears again reared up. Could the world possibly provide for a rapidly growing population? Two affirmative answers emerged during the 1960s. Based on her sweeping review of agricultural development worldwide, Esther Boserup (1965) found that rising population tended to trigger an intensification of agriculture, leading to higher food production from the same land. She argued that this was so because rising population increased demand for food, raising food prices and creating incentives for farmers to invest in boosting the productivity of the land by adding productive inputs, such as fertilizers and irrigation.

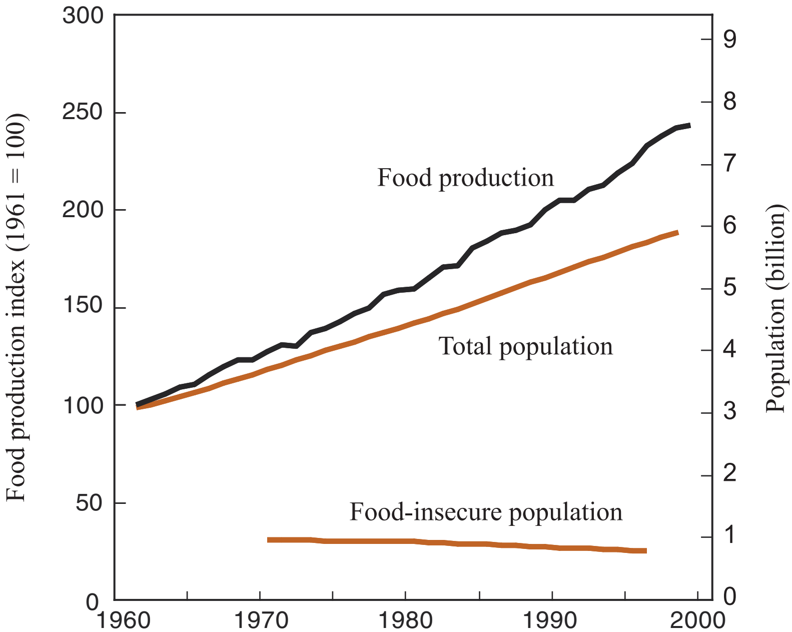
At the same time, the Rockefeller and Ford foundations were investing in new agricultural research centers in Mexico and the Philippines. By the end of the 1960s, Norman Borlaug and fellow agricultural researchers at these locations had bred new, high-yielding varieties of wheat and rice, whose advent became known as the green revolution. Developed by traditional methods of crossing plant varieties that had different desired characteristics, these new varieties possessed resistance to debilitating diseases like wheat rust, as well as reengineered plant architectures that shifted more biomass from stems and leaves into grain formation. In regions like the Punjab, where irrigation and fertilization were available, these varieties delivered spectacular yields. The success of the early varieties triggered a generation of investment in a network of publicly funded international agricultural research centers. The goal of the network was to bring productivity gains comparable to those in the Punjab to crop and livestock farmers working under diverse conditions around the globe.

By the 1980s the euphoria of the boom-boom days of the green revolution had begun to wear off. Replicating the yield gains achieved in developing countries in wheat, rice, and hybrid maize had proven more difficult to do for other crops and livestock. Moreover, even those more successful crops had turned out to yield significantly less when fertilizer and water inputs were lacking. Despite major investments in agronomic and socioeconomic research to understand and improve farm management practices, yield gains were not keeping up. To make matters worse, by the 1990s many developing country governments had cut back sharply on their agricultural research and extension services in response to fiscal discipline imposed by the International Monetary Fund.

Today, a stark contrast has emerged between food production trends worldwide and food production trends in the poorest regions. Viewed globally, Malthus' fears now look groundless: Food production outstripped population growth by 50 percent during the period 1960–2000. As shown in Figure 7.1, food available per capita has grown significantly (Wiebe 2003). Indeed, the percentage of the world population that is food-insecure has fallen steadily. Viewed regionally, however, food production in the poorest parts of the developing world has not kept up. A Malthusian trend apparent in several disadvantaged regions has been most noted in sub-Saharan Africa. There, food production per capita eroded by 15–20 percent during the last 40 years of the century (Figure 7.2). Indeed, despite a shrinking percentage of food-insecure population globally, the absolute number of people who are at risk of hunger worldwide has remained troublingly stable (Figure 7.1).

How are we to reconcile persistent localized hunger with growing global bounty? In a world increasingly integrated by trade and communication, the crux of the problem is no longer the quantity of food produced, but rather access to it (Runge et al. 2003). Almost a billion people are still too poor to acquire the food they need. Worse, they may feel the need to sacrifice future natural resource productivity for current consumption. The task of this chapter is to examine why poverty endures in many rural regions of the tropics, and particularly how poverty is linked to natural resource degradation.

Figure 7.1 Rise in World Food Production Compared to Population Growth, 1960–2000



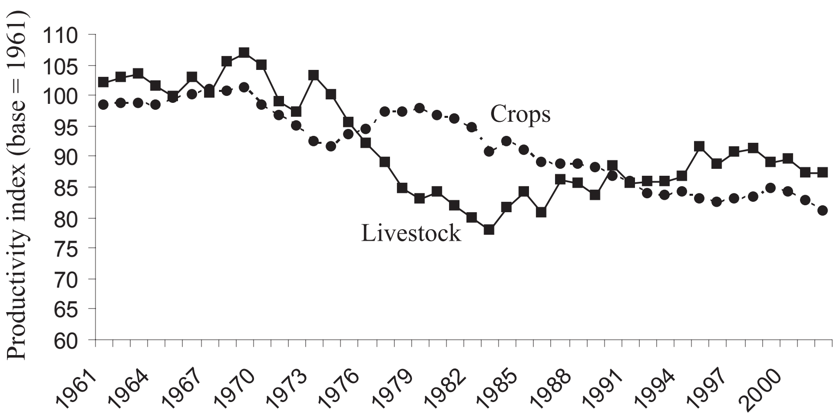
NOTE: Food insecurity is indicated here by chronic undernourishment.
SOURCE: Wiebe (2003), based on data from the Food and Agriculture Organization of the United Nations (FAO).

DESPITE TECHNOLOGICAL CHANGE, WHY DOES MALTHUS STILL LOOK PARTLY CORRECT?

The persistence of pockets of extreme poverty raises questions about the population–food production relationship. Why was Malthus wrong at a global level yet seemingly right in some regions of the globe? And, are the trends we observe inevitable?

The place to begin is the fundamental ratio of food productivity: the rate of change in food production divided by the rate of change in population. Malthus clearly failed to anticipate the sensitivity of the numerator (rate of change in food production) to technological change.

Figure 7.2 Food Production Per Capita in sub-Saharan Africa, 1960–2000



SOURCE: FAOSTAT (2004).

Not only has technological change proven able to augment food production dramatically, it has also proven highly responsive to relative prices. The powerful dynamic that Ruttan and Hayami dubbed induced innovation describes how technological change is driven by shifts in relative prices of inputs and outputs (Hayami and Ruttan 1985). In particular, this dynamic has meant that when land becomes relatively scarce (e.g., because of rising population), technological change tends to increase its productivity disproportionately. Indeed, the green revolution was all about technological changes in plant genetics, irrigation, and fertilization; these three areas had the combined effect of sharply increasing crop yield per unit of land.

But technological change is by no means automatic. First, agricultural research is not automatically triggered by relative factor prices. This mechanism can work effectively where markets permit the intellectual property from research to produce marketable products. For example, Hayami and Ruttan (1985) document the spread of tractors in North America in response to the high cost of labor relative to land and the spread of fertilizer in Japan in response to the high cost of land relative to labor. But certain types of agricultural research do not generate marketable products. Private seed companies have done much to advance the genetics of hybrid corn, for which newly hybridized seed must be purchased for planting each year, thus ensuring that the research will be profitable. But the same companies have shown little interest in improving open-pollinated cereal crops, like rice and wheat, because the seed can be multiplied on-farm, so that seed is only sold once. Hence, public sector investment in agricultural research was crucial to the original green revolution breakthroughs in rice and wheat.

Second, overcoming the scientific hurdles is only the first step toward technological change. Breakthroughs at the level of basic research typically then require adaptive research that will tailor them to the conditions of farmers who might take up the new practices. Adult education and extension efforts are needed to inform farmers about the existence of new technologies. Then, once aware of the new possibilities, farmers must be willing and able to adopt them (Nowak 1992). Technological change ultimately occurs because farmers decide to do things differently.

From Macro to Micro: What Drives Farmer Behavior?

Given the pivotal role of individual farmers in determining how much food is produced, it helps to look at the world from a farmer's point of view. Farmers face many choices: whether to farm at all or to engage in nonfarm employment; whether to grow food or a cash crop, like cotton or tobacco; how much land, labor, and other inputs to devote to each crop or animal enterprise; and what practices (technologies) to follow.

The choices that farmers make are shaped by their objectives and the resources at their command. Objectives might include being able to feed, clothe, and house the family, or avoiding the risk of failing to meet subsistence needs in case weather or pests should be bad. Defined narrowly, productive resources typically include the labor and knowledge of family members and employees (human resources); land, water, climate, and biodiversity (natural resources); and equipment, buildings, and the means to buy or produce feed, fertilizers, pesticides, and other inputs (financial and manufactured resources). Some would add to this list the networks of social relationships and cultural-legal institutions that enable farmers to obtain access to needed resources (social capital).

Two important environmental factors affect the quality of these productive resources. Access to economic infrastructure—notably roads, communications, banks, and markets that supply inputs and buy products—strongly affects the costs of inputs and the earnings possible from selling products. The biogeophysical environment—notably climate, soil quality, access to water, and topography—strongly affects the need for agricultural inputs, the potential productivity of the land, and the ease of selling the crops produced.

So if technological change was responsible for increasing per capita food production for the world on average, why have certain regions been left out? Several answers fit the question. The first is that while technological change may be driven by relative prices (which reflect the relative scarcity of specific production inputs), it is equally driven by scientific feasibility. Raising land productivity is most feasible where the land is fertile, well watered, and well drained. A few fortunate places in the world meet these criteria naturally. In many others, they require investment in mineral fertilizers, irrigation, and drainage.

The regions of the world that have lagged farthest behind in food production are those where the economic infrastructure and the biogeophysical environment are least favorable. The semiarid tropics and highland areas, like South America's altiplano, Africa's Sahel and highland regions, and parts of Asia, face formidable geophysical constraints. Steep slopes in highland areas exacerbate soil erosion; they may also aggravate seasonal drought if sudden tropical deluges run off before soaking into the earth. Semiarid zones, by definition, have scant rainfall, less surface water, and higher risk of drought.

The underdeveloped economic infrastructure in these same regions adds up to sparser, lower quality roads that make transportation more expensive. Poor communication networks render communication slower and more expensive as well. Less developed financial institutions mean that credit for purchasing inputs tends to be costlier. Distant, poorly equipped markets mean that more farmers have farther to go to buy inputs and sell products. Expensive transportation, communication, and credit make production inputs on the farm costlier (e.g., fertilizers, improved seed, irrigation, drainage); they also reduce the farm-level value of food produced. Farm income is reduced both by transportation costs and by the risk of weak market prices inherent when poor communications deprive the farmer of information on where and when to market the crop.

Due in large part to these biogeophysical and infrastructural disadvantages, not only has food productivity lagged in the semiarid tropics and highland regions of the world, but these regions also account for large numbers of impoverished people. Global malnutrition is highest in regions where public infrastructure is most deficient and where the natural endowment of biogeophysical resources is least generous. In these zones, farmers face severe capacity constraints to the natural and infrastructural resources at their command.[1]

TOO POOR TO BE STEWARDS?

More troubling than the failure to expand food production faster than population in these poor regions is evidence of diminishing incomes, when one considers that incomes are critical to maintaining or raising per-capita food consumption. Worse yet, projections 25 and 50 years into the future using the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) suggest that regions like sub-Saharan Africa are likely to see significant percentage increases in the number of hungry people (Runge et al. 2003, p. 31).

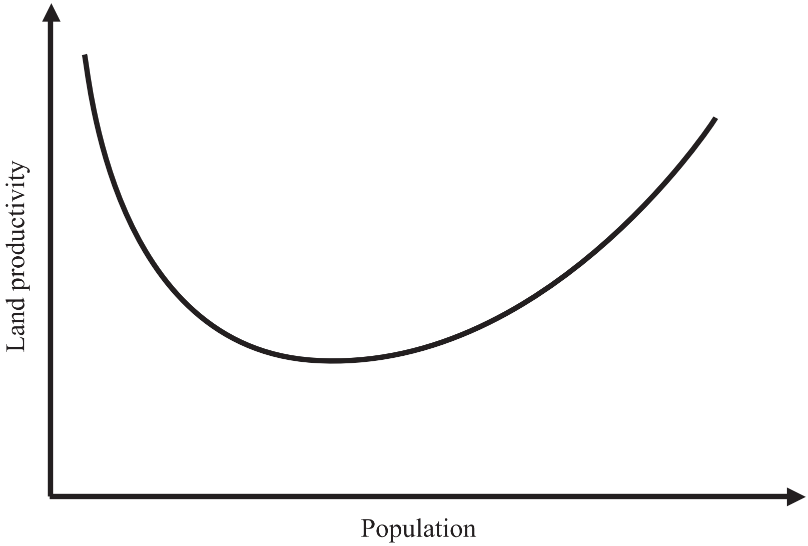
For large numbers of the rural poor, agriculture offers the principal means to put food on the table, whether it be food that was produced on the farm or food bought with earnings from the farm. Farmers can respond to the imperative to increase food production to meet rising household needs with two alternative strategies: extensification or intensification. Extensification refers to expansion onto new lands. Usually uncultivated lands are less suited for agricultural production than those lands that farmers chose to cultivate earlier. They may be less fertile, steeper, more susceptible to drought, or more prone to waterlogging than other lands. Hence, crop yields on such marginal lands tend to be lower than average. Examples of extensification include felling the forest to open new lands or expanding from fertile valleys up onto less productive hillsides. While extending farming onto marginal lands may reduce average yield per unit of land and may also increase the riskiness of output, it does not undermine the productivity of lands already in production.

Intensification of agricultural production can also raise food production per capita, as documented by Boserup. Subsequent authors have chronicled the virtuous cycle by which initial acceleration of soil erosion in Machakos, Kenya, was reversed over a period of three generations, as rising food and coffee prices led farmers to invest in land terracing and other soil conservation measures, enabling environmental recovery and increasing food production per hectare (Tiffen, Mortimore, and Gichuki 1994).

Unfortunately, the "more people, less erosion" story from Machakos is countered by others where productivity has continued to decline. If access to increased income or other sources of investment capital is unavailable, farmers may have no alternative but to work harder to scrounge more food from the same land. In their study of agricultural intensification in highland Rwanda, Clay, Reardon, and Kangasniemi (1998) distinguish between labor-led and capital-led intensification. Labor-led intensification occurs when farmers work the land harder to extract more food. In Rwanda, farmers would cease to leave fields fallow, cropping them continuously but without fertilization. The process does intensify output per hectare of land in the short term, but at the cost of undermining the land's long-term productive potential by mining the nutrient supply in the soil. Similar patterns of shortening fallow periods linked to declining crop yields have been observed in other parts of the semiarid and highland tropics (Swinton and Quiroz 2003b).

The distinction between labor-led and capital-led intensification offers one explanation for how decline and increase of agricultural land productivity can coexist in the world. Basing their work on a broad review of literature on agricultural land productivity in hilly regions, Templeton and Scherr offer a unified theory for how these effects are linked to population, as shown in Figure 7.3 (Templeton and Scherr 1999). They contend that at first, population increases are linked to declining productivity. For example, bush fallow cultivation systems, where the land goes unplanted by the farmer except for once every five or more years, tend to shift to long-cycle crop rotations of three to five years and then to shorter rotations, but all relying on fallow to restore soil fertility. As the annual output gains from such labor-led intensification diminish, rising populations in largely autarkic regions trigger increases in the cost of food and of the land that can produce it. These changes, in turn, spur capital investment in the land, which gradually

Figure 7.3 Hypothetical Relationship between Population and Land Productivity



SOURCE: Templeton and Scherr (1999).

increases land productivity from a low point. The U-shape of this population–land productivity relationship can thus encompass both the labor-led (Malthus effect) and capital-led (Boserup effect) intensification explanations with a common population driver (Templeton and Scherr 1999).

In a world with migration and trade, opportunities exist for people and goods to move about. Many poorly endowed areas with rising populations can receive goods produced elsewhere, often at lower costs of production than local costs. There also exist opportunities for inhabitants to migrate elsewhere for work. Migration offers an alternative to intensification as a means for rising populations to meet their subsistence needs. But how migration affects land productivity depends on the specific situation: migration reduces the labor available for farming, which can cause low-productivity systems to stagnate at the bottom of the population-productivity U-curve. On the other hand, if migrant remittances are reinvested in the land, then capital-led intensification may cause land productivity to rise. The upshot of migration patterns is that certain regions can find themselves trapped at the bottom of the U-curve when migrants move out but households choose not to invest in agricultural productivity (García-Barrios and García-Barrios 1990; Zimmerer 1993; Wiegers et al. 1999).

Where the means for investment are not available, impoverished farmers face a stark choice between meeting current subsistence needs and preserving the future productive potential of the natural resource base (Mink 1993). Adolfo Figueroa (1998) succinctly summed up their dilemma: "Given the options of producing less today . . . in exchange for producing more in the future, or less in the future and more in the present, the small farmer will choose the second option." Such a Faustian bargain between survival and land stewardship directly contravenes the goal of sustainable development, defined by the Brundtland Commission as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development 1987).

If the poor are undermining their own future survival, not to mention the natural resource base shared by the rest of humanity, what does this mean for development policy? Should we revive Sir Arthur Lewis's dictum of the 1950s that the key to economic development is to transfer surplus labor from unproductive agricultural employment to the productive industrial sector (Lewis 1955; Fei and Ranis 1964)? Should agricultural development efforts be targeted only at less poor regions or poor areas endowed with abundant biogeophysical resources? Such policy remedies would represent an abrupt change in direction. Is there conclusive evidence of circumstances where there is a causal link between poverty and natural resource degradation?

THE EVIDENCE

A number of recent studies have examined the evidence of links between poverty and natural resource degradation (Wunder 2001; Barrett, Place, and Aboud 2002; Swinton, Escobar, and Reardon 2003). The great academic challenge to these studies is to control for the natural resource setting and the level of political-economic infrastructure. Put differently, does poverty affect natural resource outcomes differently in the rain forest than, say, in the savanna? Does the same level of poverty cause different environmental outcomes in a setting with good roads and communications, as opposed to a more remote location? The plethora of different agricultural natural resources complicates comparisons even more. The quantity and quality of soils, natural forages for livestock, surface and ground water, and forests are just the most evident of the natural resource characteristics that interact closely with farming. In order to parse the poverty-environment puzzle more carefully, we examine illustrative cases for three agriculturally related natural resource degradation processes: soil erosion, overgrazing of natural rangeland, and soil nutrient depletion.

Soil Conservation with Terraces

Of the many natural resource management technologies that farmers in developing countries have considered, terracing to conserve soil and runoff water offers researchers the advantage of paired cases under similar geophysical and socioeconomic environments. Recent case studies from Peru and Ethiopia present nuanced complexity. In Peru, terraces have existed for over 600 years, since before the time of the Incan empire. Many of these terraces are maintained to this day, yet others have been allowed to decay, despite the fact that terrace maintenance requires far less work than new construction. Remarkably, elsewhere in Peru, farmers are constructing new terraces. How can we explain this conundrum that in similar topographic conditions in the same country, farmers would display such different attitudes toward soil conservation? Efraín Gonzales de Olarte and Carolina Trivelli (1999) point out that the returns to investment in terracing differ markedly from one part of Peru to another. In more remote parts of the country like the south-central Andes, where low-value crops like potato and forage are raised, the payoff to investments in terrace construction—or even terrace maintenance—are unattractive. But in the Pacific valleys, where cash crops can be raised for export or sale in coastal cities like Lima, farmers have been actively building new terraces because they see an appealing payoff and can obtain the resources to do it (Wiegers et al. 1999). What is the effect of poverty? The poorest farmers are the ones in the remote areas who have been allowing terraces to decay. Many of them have been opting to invest in migration to the cities rather than invest in agricultural land productivity.

A continent away, Ethiopia offers a similar internal contrast. Terraces that were built by local workers under food-for-work projects have been destroyed by some landowners, allegedly because the value of their soil and water conservation services could not justify the forgone productivity of the amount of land they took up (Shiferaw and Holden 1999). Yet at the same time, other terraces were being built voluntarily in similar parts of the country. In the areas where terraces were being torn down, it seems that on the steepest slopes, farmers felt that the benefits of terraces were too modest, whereas on the most gently sloped land, soil bunds offered comparable benefits at lower cost of construction and lower opportunity cost of land unproductively occupied. But perhaps the biggest reason for destroying terraces had to do with land tenure security. Where farmers felt confident of passing fields on to their children, they were much more prone to build or preserve terraces than when they expected to control the fields for five years or less (Gebremedhin and Swinton 2003). The effect of poverty is not apparent here, although households with more members are more likely to build terraces.

Native Forage Protection from Overgrazing

Conservation of native range forage species offers another case in contrasts. In Chile's arid Region IV—the north-central part of the country—impoverished farmers grazed goats on native scrub in a common pool grazing area, all the while watching the digestible native vegetation slowly disappear. Because of the growth of off-farm jobs in the grape industry during the 1990s and a government policy of subsidizing small-scale irrigation, many families earned enough income to invest in irrigation to raise alfalfa for cattle feed. As a result, the livestock population of these communities increased, and there also was a resurgence in the native forage species (Bahamondes 2003). Farmers were able to capitalize on attractive cattle prices because of the off-farm income available for investment and the government cost-sharing policy, which proved to be critical contributors to this success story. Although the protagonists began the decade of the 1990s as poor people and ended it the same, the Chilean economy had created considerable wealth at many levels in the meantime. Some of that wealth allowed investments that relieved the population pressure on the rangeland resource base.

In contrast, both the total biomass and the biodiversity of native forage species in the Peruvian altiplano have declined precipitously in the upland villages that relied upon communal grazing. Increasingly, the only species available are ones that are indigestible to the sheep, alpacas, and llamas grazed there. Yet the livestock owners most at fault turn out not to be the poorest in the area, who own few animals, but the relatively well off, who own many (Swinton and Quiroz 2003a). Yet indirectly, this story still traces its causes back to a poverty root. Over three-quarters of the people in the altiplano lack what the Peruvian government defines as basic human needs. Even the relatively less poor in the altiplano are still poorer than the peasant farmers of Chile's Region IV, whose off-farm earnings have allowed investment in irrigated forages. While livestock farmers in both areas have communal grazing lands at hand, the herders in Peru's altiplano are far more distant from major urban markets than their Chilean counterparts.

Maintenance of Soil Nutrient Levels

One additional case study of maintaining soil quality provides a nuanced perspective on the role of property rights. In a set of eight villages in the Peruvian altiplano, farmers reported declining crop yields and soil fertility, compared with their recollection of 20 years earlier. Very few used mineral fertilizers or manure amendments to restore fertility, because of a shortage of cash and the need to use dried manure for cooking fuel. Regression analysis highlighted the primary importance of fallow cycles in their crop rotation. A second stage analysis pointed to the importance of a cultural institution known as *aynoca* for influencing farmers to include fallow in crop rotations. Aynoca is the Aymara word for a community-level cropping pattern, whereby fields in a certain part of the village are all sown to the same crop. While the aynoca system originated to make it easier for villagers to take turns protecting maturing crops from predators and thieves, the system has had the side effect of enforcing a community-level crop rotation (even though the individual fields are privately owned). Farmers in communities that had abandoned the aynoca system conceded that the system had helped them to maintain soil fertility, although they reported having given up the aynoca system in order to have more land to plant, thus boosting short-term production to meet household needs (Swinton and Quiroz 2003a).

WHY DO THE POOR SOMETIMES SUCCEED AS STEWARDS?

The evidence can be interpreted at two levels. Certainly the clearest environmental success story presented here comes from Chile, where capital-led intensification was made possible by off-farm earnings. Likewise, terrace construction in Peru responded to capital-led intensification stimulated by agricultural income-earning opportunities. When income is available to poor farmers, whether by cross-subsidy from other sources or by increased income from farm sales, capital-led intensification is possible and may have dramatic results.

But successful natural resource stewardship also occurred among poor farmers without capital-led intensification. Land tenure security made it worthwhile for poor Ethiopian farmers to achieve largely labor-led intensification for stone terrace construction, even though benefits from soil conservation would only accrue slowly over time. Likewise, there was evidence that the poorest do not necessarily cause the greatest natural resource degradation, as shown by the overgrazing in the Peruvian altiplano by livestock owners who are relatively less poor than their neighbors. And the success of the aynoca system at checking soil fertility loss by maintaining crop rotations with fallow illustrates how a common property management institution is able to support sustainable stewardship, at least at a basic level. These examples signal possibilities for sustaining natural resource management at modest cost.

POLICY GUIDELINES

So if the poor are not necessarily bad stewards of natural resources, what factors can public policy manipulate to improve their stewardship—and ultimately to promote sustainable development? The answers will clearly vary from place to place, based on the politico-economic infrastructure and the natural resource setting. But the recurring themes consistently relate to understanding farmers' incentives and the constrained resources that limit their feasible alternatives. Policy guidelines are listed below, beginning with ones related to farmer incentives and going from least costly to most. Many are familiar recommendations for strengthening small-farm incomes, because better incomes are key to meeting the incentive and capacity needs for increased investment in sustainable natural resource management.

Incentive No. 1: Clear, Durable Property Rights

Clear, durable property rights are a sine qua non for longterm investments in conserving natural resources (Feder et al. 1988; Baland and Platteau 1996). Uncertainty about whether future benefits will accrue to the person who made the investment can sharply undermine the expected value of returns even in a riskless world, as noted in the Ethiopian stone terrace investment case above. For a risk averse, impoverished farmer, uncertainty about poverty rights undermines even further the expected utility of future benefits that will accrue in exchange for a known, up-front cost. Although, in principle, clear property rights would not seem difficult to establish, in practice the great challenge is to ensure their diffusion and consistent enforcement. Indeed, abundant evidence shows that formal land titling is not equivalent to land tenure security, particularly in countries where changes of regime have made enforcement of land titling unpredictable (Gebremedhin and Swinton 2003).[2]

Incentive No. 2: Local Institutions That Support Natural Resource Stewardship

Farmers' objectives are not limited to the consumption of goods by household members; they also include intangibles like respect earned from others. Local institutions for community-based natural resource management can be effective by using peer pressure for the common good. The Peruvian aynoca system of collective decision making over adjacent private parcels of land illustrates a mechanism by which peer pressure helps to enforce a community-level crop rotation that can maintain soil fertility at modest levels.

Incentive No. 3: Efficient Infrastructure

An efficient system of transportation, communication, and markets for agricultural inputs and products can dramatically improve the expected net benefits from investments in natural resources that support agricultural productivity. To the extent that agricultural growth alleviates poverty, which in turn alleviates natural resource degradation (e.g., soil erosion and soil nutrient depletion), this can advance the sustainability of some resources. Ready access to a transportation network can sharply reduce farm-gate input costs and increase expected prices at the farm gate for food products.[3] The same kind of effect comes from a reasonably dense network of markets, though market density and road transportation quality are substitutes. Access to roads and markets were key stimuli prompting construction of new terraces for soil conservation in Peru (Gonzales de Olarte and Trivelli 1999). Effective rural communications, not only broadcast media but also telephone systems, can markedly improve the timing of market transactions.[4] All three of these infrastructural elements contribute to the net returns of agricultural production, thereby augmenting the value of conserving the natural resources that make agricultural production possible.[5] Indeed, the continued viability of capital-led intensification methods like mineral fertilizer and improved seed requires access to markets that offer these inputs (Howard et al. 1998).

One important caveat to the call for improved infrastructure is that while better infrastructure tends to make farming more profitable (hence more likely to result in available capital to invest in resource sustainability), better infrastructure also facilitates the spread of agriculture. Where agriculture competes directly with valued natural land uses such as forests or prairies, better infrastructure may undermine the sustainability of those nonagricultural natural resources (Reardon and Vosti 1995; Angelsen and Kaimowitz 2001; Lee and Barrett 2001; Vosti et al. 2003).

Capacity No. 1: Access to Education

Human resources are the most abundant assets in poor households. Level of education is often associated with adoption of natural resource management practices, for several reasons. First, better educated farmers tend to manage their resources more efficiently, obtaining better net returns (Kelly et al. 2002). Better net returns imply higher shadow prices for the natural resources that make production possible, and higher shadow prices favor conservation of those resources. Second, household members who are literate and numerate appreciate more fully the economic benefits and costs of natural resource management. For example, research into cotton growers' pesticide management in Zimbabwe showed that farmers who could read and understand pesticide labels were less likely to suffer pesticide poisoning from overapplication (Maumbe and Swinton 2003).

By contributing to skills for off-farm work, primary and secondary education can help with natural resource management indirectly as well. Migration to find work is common in much of the developing world. Remittances from such activities can have the same salutary effects on sustainable natural resource management as the off-farm earnings of the Chilean goat owners described earlier (Bahamondes 2003).

Agricultural extension education, when effective, can rapidly affect farm management. Thirty years of research has highlighted the importance of participatory approaches to extension and applied agricultural research. One promising approach, called farmer fields schools, leads groups of farmers in conducting their own on-farm research. Farmers find such participatory research engaging, while their farming neighbors learn from the demonstration effect (van de Fliert 1993).

Capacity No. 2: Access to Knowledge about Natural Resource Conservation

Over the past 15 years, many countries have eliminated or sharply reduced their capacity for research and outreach in agriculture and natural resources. None of the case studies evaluated here involves a significant research element because most of the countries cited have sharply curtailed their research and extension activities. Yet adapting agricultural and natural resource management research results to local farmers' needs is a precondition for adoption of new methods, making participatory research approaches especially apt (Kelly et al. 2002). Research and education need not be carried out by the state: nongovernmental organizations in many parts of the globe are finding ways to meet these needs. But clearly, awareness of the benefit flows that natural resources offer and of the alternative management practices needed to maintain those benefit flows is a necessary condition for adoption of such practices.

Capacity No. 3: Access to External Sources of Income or Credit

Capital-led intensification may not represent the only means to intensify sustainably, but it has certainly proven effective again and again. The Chilean case illustrates how economic growth in other areas can create off-farm earnings by members of farm households, whose income then cross-subsidizes natural resource conservation. Research among the cotton farmers of the Office du Niger in Mali has shown that cotton farmers are more likely than nearby farmers of cereal grains to apply fertilizer and productivity-enhancing inputs to their fields. The cotton crop serves both to guarantee credit for inputs and to grant access to input markets that exist to support cotton production (Kelly et al. 2002). Research in Ethiopia to learn farmers' willingness to pay for the benefit flows from soil conservation found that the poorest farmers were willing to pay the least (Holden and Shiferaw 2002). While this is not surprising, it reemphasizes the importance of financial capital for natural resource conservation investments. Even terrace construction, which is largely labor-led, requires the means to nourish the labor force, if not to pay wages on top of that.

Capacity No. 4: Emigration to Relieve Population Pressure

Frequently unmentioned is the option of relieving population pressure on natural resources through migration. Large regions of the Appalachian Mountains in the Eastern United States were once hardscrabble farms. Putting the hillsides to the plow caused severe soil erosion while failing to generate adequate income to meet basic needs. Migration to urban jobs (sometimes paired with government buyout of farms) has returned that region largely to forest. A similar option exists for developing countries, but the policy challenge is how to generate sufficient economic growth in other areas to absorb the population of marginal farms. The risk is that migration merely serves to create irreversible natural resource degradation, as when poor farmers from populous regions that are suffering declining productivity move to the rain forest frontier. There, they convert the forest cover into fertilizer for short-lived gains before having to move on.

CONCLUSION

Poor farmers in the developing world are not necessarily bad stewards—but nor are they typically very good ones. Like the rich, the poor respond to incentives. But the poor face inherent capacity constraints: even when they earn enough to survive, they may not earn enough to invest in land productivity (Reardon and Vosti 1995). Malthus failed to foresee the potential of technological change to keep food production ahead of population growth. But for that potential to be realized, technological change typically requires investment through capital-led intensification. The most promising way to slow or reverse agricultural natural resource deterioration is to contribute to rural incomes, which enables investments in sustainable intensification. Several policy approaches with this general effect are proposed, such as incentive schemes to broaden the marketing margin (making farming inputs cheaper and products more valuable) and attempts to strengthen the capacity of farmers to earn income on or off the farm. Good stewardship can also be encouraged without capital-led intensification through suitably designed property rights and local institutions. But the low cost of these strategies is offset by their limited potential to improve natural resource sustainability.

The natural resource perspective that shapes much of this chapter focuses on resources that support agricultural productivity, notably soil and rangeland. Overexploitation of these resources can often be relieved when suitable incentives exist and when increased incomes alleviate constraints on the capacity to invest in future resource sustainability. For natural resources that are best sustained by limiting human access—as in the case of native primary forests and prairies—either carefully designed property rights must create incentives for sustainable management or else there must exist income earning opportunities from sources unrelated to the resource to be protected, such as urban employment (Escobal and Aldana 2003).

The common element among all the policy alternatives presented here is the importance of tailoring policy to the specific socioeconomic, infrastructural, and biogeophysical setting in which agricultural natural resources are managed. Ways exist to ameliorate sustainable natural resource management practices, from the nearly costless to those that make heavy demands on the public treasury. But successful policies require a tailored understanding of the human and natural environments as well as clear targeting of the natural resource objective to be met.

Notes

The author thanks Steve Vosti for helpful comments.

1. For a world map showing these regions, go to http://www.povertymap.net/maps graphics/index.cfm?data_id=23355&theme=food%20security.
2. A thoughtful literature exists on various common property management structures apt for sustaining certain types of natural resources, especially biological resources such as native forage species and forest-dwelling species (Baland and Platteau 1996; Otsuka and Place 2001).
3. "Farm gate" refers to costs and revenues as perceived from the farm. The farm-gate cost of an input is the cost to buy it at market plus the cost of transporting it to the farm. Conversely, the farm-gate unit value of a product is its market price minus the unit cost of transport to market.
4. In fact, with the rapid expansion of private contracting in the developing world, better communications and transportation can make possible access to high-margin global markets that are totally inaccessible to impoverished farmers otherwise.
5. Improved infrastructure will certainly benefit the household. The net effect on natural resources is indeterminate. As noted in the case studies above, investments in natural resource conservation depend in part on the profitability of agricultural products that may be produced from them (e.g., the case of stone terrace construction in Peru). But better infrastructure also improves access by household members to off-farm jobs, raising the opportunity cost of family labor. This is why research in Tigray, Ethiopia, found that farm households in less remote villages were less prone to construct stone terraces.

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