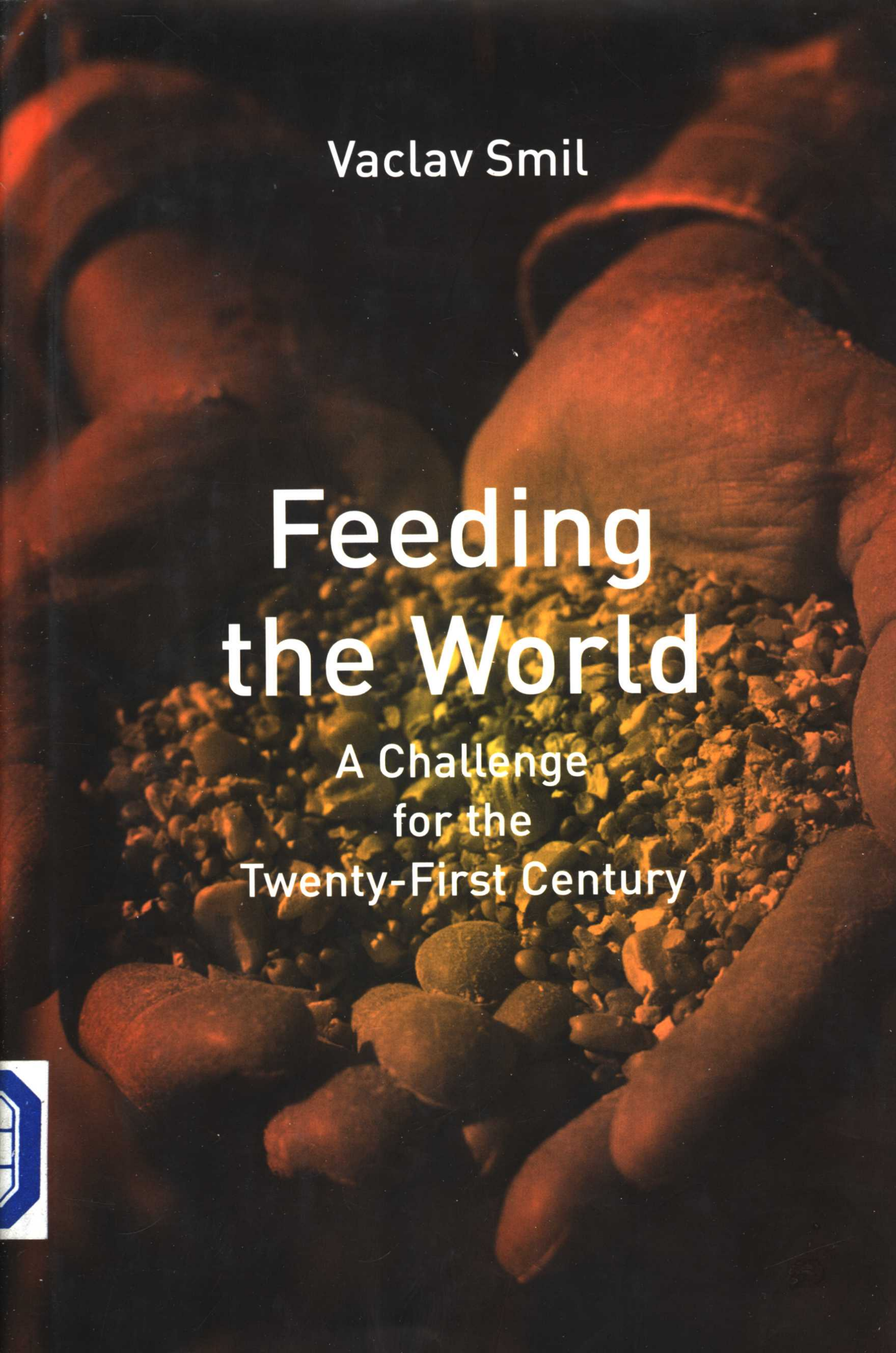

Vaclav Smil

Feeding the World

A Challenge for the Twenty-First Century

Feeding the World

A Challenge for the Twenty-First Century

Vaclav Smil

The MIT Press
Cambridge, Massachusetts
London, England

Acknowledgments

Most of this book was written during a leave of absence paid for by a grant from the Canadian Donner Foundation, which also covered the cost of research trips to Rome and Beijing.

My debt to hundreds of experts on whose work I relied in writing this book is obvious. The following individuals provided particularly useful advice, help or inspiration: Nicholas Alexandratos (FAO), Dennis Avery (Hudson Institute), Ken Cassman (University of Nebraska), Giuseppe Celestini (FAO), Tim Dyson (London School of Economics), Jacques de Guerney (FAO), Walter Burgos Leon (FAO), Patrick Luciani (Canadian Donner Foundation), François Mazaud (FAO), Per Pinstrup-Andersen (International Food Policy Research Institute), Amitava Roy (International Fertilizer Development Center), Albert Tacon (FAO), and Mao Yushi (Unirule Institute of Economics).

Marjorie Halmarson and Theresa Nichols prepared the illustrations; Greg McNamee and Deborah Cantor-Adams edited the book, and Ori Kometani designed the cover.

Introduction

"To produce a mighty book, you must choose a mighty theme," wrote Herman Melville, the author of my favorite American novel, *Moby-Dick* (Melville 1851). Naturally, I do not interpret Melville's admonition as a matter of simple *sequitur*. After more than two decades of writing books I do not have any illusions about the ease with which one can produce a mighty opus. I am, however, certain that the theme of this volume—how can we best feed some ten billion people who will likely inhabit the Earth by the middle of the twenty-first century—is sufficiently mighty.

Why am I not trying to answer, in the first place, a grander and more fascinating question of how many people the Earth can feed? Because this question has no single answer today, and it will not have one tomorrow (Smil 1994a; Cohen 1995). No complex models are needed in order to demonstrate a large range of plausible outcomes. We would not even have to increase the existing agricultural inputs in order to feed many more than ten billion people in a global economy guided by concerns about consumption equity and offering everybody frugal, largely vegetarian but nutritionally adequate diets. On the other hand, even today's six billion people could not be fed if North America's current average per capita food supply (of which about 40 percent is wasted!) were to become the global norm in a world that would be using much higher agricultural inputs with no better efficiencies than we do today.

The question of how many people the Earth could eventually feed will be asked again and again, but answering it in a definite manner is futile and counterproductive. Futile because it takes only a very short time before many requisite assumptions of detailed scenarios become either completely indefensible or highly questionable. Counterproductive because human population will cease growing for reasons unrelated to food supply. There is a very high probability that humanity will not double in number again, and that its 2050 total of around ten billion people may be very close to (or perhaps even a bit above) its long-term maximum. A more practical, and a more meaningful, inquiry is thus to look into the best means of securing the requisite nutrition for ten billion people. Or, more precisely, it is to ask: Can human ingenuity produce enough food to support healthy and vigorous life for all those people without irreparably damaging the integrity of the biosphere?

A systematic attempt to answer this question should be guided by three important principles: it requires an appreciation of complex realities whose adequate understanding is essential to tackle these questions; it demands a consideration of the entire food chain, from the fundamentals of field cropping to food intakes; and, if rational solutions are to prevail, it must concentrate on improving chainwide efficiencies of production and consumption. Without appreciating this complexity of food supply and demand it is easy to succumb either to catastrophist fears or to cornucopian dismissal—in short, to Ehrlichian doom or to Simonian giddiness.

Catastrophists and Cornucopians

During the early 1960s Paul Ehrlich's specialty was butterflies. Then came a well-publicized vasectomy and *The Population Bomb*, which refashioned him into a principal guru of global catastrophism (Ehrlich 1968). He concluded that "the battle to feed all humanity is over" and that "at this late date nothing can prevent a substantial increase in the world death rate." Not content with this prophecy, Ehrlich darkened his vision a year later by forecasting the end of all important animal life in the ocean by the summer of 1979. This event was to bring "almost instantaneous starvation in Japan and China" and force the Chinese armies to attack Russia "on a broad front on 13 October." Ehrlich's bottom line was suitably apocalyptic: "Most of the people who are going to die in the greatest cataclysm in the history of man have already been born" (Ehrlich 1969).

Obviously, Ehrlich's global population maximum would have to be well below the 1970 total of about 3.7 billion people. The only way to achieve this optimum would be by eliminating about half of humanity. The other leading catastrophist, Lester Brown of the Worldwatch Institute in Washington, has been wholesaling doom almost as long as Ehrlich. Since the mid-1970s he has been promising steadily rising food prices and a new era of permanent global food crises, if not one of a global famine.

To dismiss these extreme claims is easy: realities have been quite different. Nearly three decades after Ehrlich declared the global food fight over and prophesied Chinese armies attacking Russia, Russian military missions are busily selling advanced fighter jets to the Chinese, whose per capita food production is higher than at any time in the country's long history, and whose average food availability is almost as high as the comfortable Japanese mean. There has been no substantial increase in the world's death rate, but just the opposite: life expectancy at birth in the world's most populous countries rose impressively, with China's mean, now at sixty-nine years, surprisingly close to the Western level.

And, contrary to Brown's undeviating forecasts of ever more costly food, the world prices of every staple foodstuff are, in inflation-adjusted terms, lower than a generation ago, many of them at their lowest level during this century or even since the beginning of systematic record-keeping began a few hundred years ago. Food self-sufficiency in the world's most populous nations and gains of five to seven years of life expectancy per decade would seem to me to be very convincing proofs that the world food situation is not unraveling even in places where one might have expected the worst. Ehrlich does not see it that way, supplanting *The Population Bomb* with *The Population Explosion* (Ehrlich and Ehrlich 1990), and Brown has raised new fears about the world's future food supply with his *Who Will Feed China?*, a work that is, as we shall see in chapter 9, based on wrong data and dubious interpretations (Brown 1995a).

Curiously, catastrophists have no closer allies in their denial of realities than their antagonists, the ebullient cornucopians. These techno-optimists revel in large population increases as the source of endless human inventiveness and they consider food scarcities or environmental decay as merely temporary aberrations. Moreover, their principal protagonist, Julian Simon, claimed that food has no long-run, physical limit (Simon 1981, 1996). Dismissing these visions is also easy, inasmuch as Simon's claim is obvious nonsense. If the global grain output were to continue growing only as fast as it has done during the 1980s (almost 2 percent a year), the annual harvest of cereals would surpass the Earth's mass in less than 1,500 years, roughly an equivalent of the time elapsed since the dissolution of the Western Roman Empire.

But dismissal of extreme claims should not mean the total rejection of either message. A close reading reveals a wealth of irrefutable facts and valuable arguments in the writings of both of these extreme camps—but these patches of sensibility are surrounded by the flood of a true-believer bias precluding recognition of vastly more complex, largely unpredictable, and repeatedly counterintuitive realities. Catastrophists believe that the Earth's true carrying capacity is merely a fraction of existing global population, and that the planet has been overpopulated for several generations; they also maintain that its food production has been an increasingly unsustainable exercise underpinned by the extraction of nonrenewable resources and resulting in a grave damage to the biosphere.

I find much to agree with in this analysis. To begin with, I am convinced that ever larger populations are not of any benefit to the biosphere—or to themselves. That does not mean I have an ideal total for humanity in mind. As a scientist I know that a multitude of natural, technical and social factors constrains the human choices about the planet's carrying capacity, that our understanding of these limits constantly evolves and changes, and that their acuteness and permanence is vigorously debated.

If one really insists on numbers, then the only sensible way out is to offer conditional estimates: *given* this combination of future choices, available resources, techniques, and social arrangements, *then* it is most likely that the Earth could support so many people. Naturally, terms of the debate change drastically if we were to be willing to live like average Bangladeshis or average Californians—and I do not advocate either choice. Nor do I call for a panicky retreat. But, given the undeniable evidence of human impact on the biosphere, I simply argue for as rapid a transition to stabilized counts as is humanely possible. To make a lasting difference, this shift would have to be combined with giving up the idea of steadily increasing material consumption.

Catastrophists also raise very valid points about long-term futures of modern agriculture. Farming increasingly dependent on unceasing inputs of fossil fuels, and hence inherently unsustainable on a civilizational timescale (10^3 years), is now a universal reality. Continuous intensive monocropping—repetitive planting of one crop species supported by high applications of synthetic chemicals—may be profitable in the short run and in narrow monetary terms, but it is surely not the best way to promote longevity and stability of agroecosystems. Signs of worrisome soil degradation—ranging from obviously severe erosion to subtle deterioration of soil structure—are common, as is the misuse of irrigation water. In other locales and regions environmental pollution reduces yields of some sensitive crops. How long can these impacts continue before they start undermining the global capacity to feed ourselves?

But I cannot subscribe to the final catastrophist diagnosis of our civilization being caught in an unstoppable slide toward a global demise. Neither runaway population growth nor irretrievable degradation of agroecosystems is a preordained matter: we know how to take care of most of the problems we face today, be it through often surprisingly simple technical fixes or through better socioeconomic arrangements. Our ingenuity is far from exhausted, and we can do so much more with so much less.

Cornucopians—with their robust faith in admirable adaptive capacities of our species and with their recitals of impressive examples of human inventiveness overcoming seemingly impossible challenges—see existing problems and looming threats merely as matters awaiting effective solutions. Again, there is much I find persuasive and appealing in their diagnosis—but I also have serious doubts about the inevitability of forthcoming solutions.

In spite of our rich repertoire of technical fixes and social adaptations, we have a tendency to wait too long before we commit these resources in a decisive, and effective, manner. Nor can we be certain that we will always judge correctly the acuteness of a problem demanding a timely solution. For example, what would have happened to our crops and to our health if the emissions of chlorofluorocarbons will have continued for another generation, thinning the protective layer of stratospheric ozone by 20 or 40 percent?

Acting as an advocate, I have no difficulty in arraying selected arguments in support of either of the two antipodal camps of catastrophist and cornucopian futures. Acting as a scientist for whom the ancient Roman *sine ira et studio* is not an empty phrase, I have to distance myself from both of these extremes. But a more realistic appraisal cannot be found by a mechanistic conversion to the middle ground. The only intellectually honest account must be pieced together by discarding a variety of myths found across the whole spectrum of our understanding of food, nutrition, agriculture, and the environment, by retaining and amplifying every solid, nondoctrinaire position of extreme explications, and by carefully acknowledging intricate interdependencies as well as clear primacies of various factors.

Consequently, it is not the middle ground I seek but rather the truth, be it uncomfortable or encouraging. When writing on these matters long before the two labels came into common usage, Alfred Sauvy noted crisply that "lack of precision in data and in method of analysis allows shortcuts toward reaching an objective predetermined by prejudice, shaped largely either by faith in progress or by conservative scepticism" (Sauvy 1949).

Shared Concerns

The first guiding principle of this book is to steer clear of either of these two rocks and to show that we have quite a few incremental, unglamorous, but ultimately highly effective means to deal with the challenge. In chapter I will present the catastrophists's argument, laying out basic concerns about our capacity to feed the world population. As I progress to discuss environmental constraints and opportunities, it will become clear that I share an acute concern about a number of unfolding changes that narrow or undermine our path of effective action. At the same time, I will show why I disagree with the catastrophists: the main reason is what I call the slack in the system, an enormous range of opportunities of doing things better.

Obviously, few of these improvements could be accomplished without widespread and effective economic, political, and social transformations. I would never underestimate the roles played by these diverse human factors in food production: it is self-evident that these influences—from government subsidies to the effects of rising incomes and health concerns on food choices—have had a profound impact on agricultural output. But this book will offer no normative solutions, no policy advice in these regards. I have several reasons for limiting my inquiry to the assessment of biophysical constraints and opportunities.

In the first place, we already have two recent assessments of global agricultural potential—FAO's very broadly conceived *World Agriculture: Towards 2010* (Alexandratos 1995), and the World Bank's more narrowly structured study *The World Food Outlook* (Mitchell et al. 1997)—which were edited by economists, and which deal primarily with economic factors and policy issues, as well as Dyson's analysis of global population and food trends which has strong social and economic components (Dyson 1996). In the second place, by focusing on critical biophysical determinants of crop yields and animal productivities, the book probes the lasting fundamentals that can be changed and modified only on time scales very different from those required to discard or to adopt yet another set of ephemeral policies.

For example, a large part of a policy-oriented book written just ten years ago would have to be devoted to the pervasive effect of truly monstrous governmental subsidies setting the rich world's agriculture onto often counterproductive and environmentally damaging courses. Some of the worst excesses of these subsidies are now gone, and many more may be removed in the near future—but concerns about soil erosion, water supply, and biodiversity cannot be disposed of by legislative fiat.

Although economic and social fixes cannot transcend the biophysical limits, they must provide the means for tapping many opportunities for increasing efficiencies and optimizing performances within those constraints. Some of these constraints—such as the total volume of water in ancient aquifers tapped for irrigation—are fixed. Others—such as the maximum water use efficiencies by plants—can change as a result of the changing environment or plant breeding. Too few of these opportunities will be realized unless modern societies pay much greater attention to their food production, which must begin with sustained commitment to both basic and applied research.

When judged by the allocation of labor force, ours are predominantly service economies. They depend, however, no less than millennia ago, on adequate food production. I find it astonishing that this truism is so widely, and so easily, discounted. Saying, as so many economists do, that agriculture does not matter as much as it used to because it now accounts for just a few percentage points of the GDP betrays a touchingly naive trust in arbitrary accounting procedures and the most profound ignorance of the real world. Our "postmodern" civilization would do quite well without Microsoft and Oracle, without ATMs and the WWW—but it would disintegrate in a matter of years without synthetic nitrogen fertilizers, and it would collapse in a matter of months without thriving bacteria. Our first duty is to take care of these true essentials.

Foundations of Agroecosystems

Growing crops is nothing else but a more or less astute management of peculiarly simplified ecosystems. Soils, waters, and biota, above all microorganisms, provide irreplaceable biophysical foundations of these agroecosystems. Chapter 2 is devoted to their critical assessments. The chapter evaluates the claims concerning the potential availabilities of cultivable land, water and nutrients, looks at the gap between typical field performances and maximum photosynthetic efficiencies, and assesses the risks of declining biodiversity.

I conclude, as did de Vries, that none of these basic biophysical factors—availability of farmland, supply of water and plant nutrients, limits on photosynthetic efficiency of crops, and biodiversity required for permanent food production—will pose early and unmanageable restrictions to further growth of food production (Penning de Vries et al., 1995, 1996). Naturally, this conclusion does not imply that there will be no regional shortfalls of some of these fundamental resources. Local and regional scarcities of land, water, and diverse biota are already common, and they may become increasingly severe without appropriate management.

And although the availabilities of cropland, water, and plant nutrients, as well as the provision of essential environmental services by bacteria, fungi, and invertebrates, may more than suffice in global terms, local scarcities will be made much worse due to unusually high rates of anthropogenic change affecting soils, waters, and biota in agroecosystems. Chapter 3 offers a critical look at these changes affecting the biophysical underpinnings of properly functioning food production. It will consider the complex, and far from satisfactory, evidence regarding the rates of soil erosion and its impact on crop yields: selective arguments support either very worrisome conclusions or a relatively relaxed outlook, but it is very difficult to offer any confident long-term prognoses. Similar lack of clarity is evident in appraising qualitative soil decline, above all losses of soil organic matter and salinization.

Whatever the verdicts concerning the current situation and likely prospects might be, I will show that we know how to prevent these kinds of ecosystemic degradation and how to maintain productive soils. We also know what to do in order to reduce one of the most common, and still rising, kinds of environmental pollution generated by agriculture, the introduction of excessive amounts of reactive nitrogen lost from inorganic fertilizers and animal manures. Banning chlorofluorocarbons removed a potentially major threat to agricultural productivity arising from the thinning of the Earth's protective stratospheric ozone layer, but controls of tropospheric ozone, an aggressive oxidant reducing crop yields in all areas affected by photochemical smog, are much more difficult. With rising urbanization and spreading car ownership these effects will be especially worrisome in Asia's populous nations.

Possibility of a relative rapid global warming induced by higher concentrations of anthropogenic greenhouse gases poses by far the greatest potential threat to future agricultural production. The closing part of chapter 3 reviews the best available evidence of possible environmental consequences and their likely effects on crop yields and livestock. These impacts may range from barely noticeable departures from long-term means to gradual changes to which we may rather easily adapt (by introducing new cultivars or by adjusting agronomic practices) to shifts occurring at rates unprecedented in human history and resulting in serious degradation of local or regional production capacity.

Unfortunately, our limited prognostic abilities do not allow us to pinpoint with confidence where such drastic changes are most likely to occur. We are on much safer ground concluding that unless global warming proceeds much faster than expected global food production should be able to adjust to most of its consequences, and our adaptations should be able to keep its negative impacts within tolerable limits.

Efficiency Gains in Food Production

The second guiding principle of my systematic look at our capacity to feed the still-growing human population is to focus attention on the enormous slack in global food production and to review, carefully and conservatively, numerous opportunities for reducing these inefficiencies. All but a small share of increased food production during the twenty-first century will have to come from intensified cropping. In chapter 4 I argue that this inevitable intensification should not rely primarily on new inputs, but rather on more efficient use of existing resources. Tightening the production slack should be particularly rewarding as far as the two key inputs to intensive cropping are concerned: both fertilizer and water use efficiencies are well below the realistically achievable rates. Chapter 4 reviews the best available evidence of this performance slack and details major opportunities for increasing efficiencies. Although no single measure can produce major savings, combinations of appropriate actions can yield impressive gains.

Prevailing fertilizer applications are accompanied by large nutrient losses; nitrogen leakage is particularly large due to leaching, erosion, volatilization, and denitrification. As a result, as little as 20–30 percent of nitrogen used in rice paddies, and often no more than 40 percent of the nutrient applied to rainfed fields, are taken up by crops. Direct measures reducing these losses include regular soil testing, choice of suitable fertilizing compounds, proper ratios of applied plant macronutrients (N, P, and K), adequate supply of micronutrients, correct timing of fertilizer applications, and proper placement of fertilizers. Better agronomic practices, ranging from the cultivation of green manures and organic recycling to reduced tillage and good weed control, would further improve the efficiency of fertilizer use. Combination of these measures has the potential to increase nitrogen fertilizer use efficiency in affluent nations by another 20–25 percent during the next twenty to thirty years, and gains of up to 50 percent are possible in those modernizing countries where the current use is most wasteful.

Similar efficiency improvements are possible for the use of water, both in irrigated and in rainfed fields. Capital-intensive substitution of traditional irrigation methods (flooding and furrow distribution) by pressurized systems (sprinklers, center pivots, lateral lines, and drip irrigation) can more than double average irrigation efficiencies, but simple management measures can be surprisingly effective. They include the planting of inherently more water-efficient C_4 crops, optimized timing of irrigation (taking into account a host of measured environmental conditions), and widespread use of agronomic practices promoting water conservation (ranging from reduced tillage to residue recycling).

Indeed, the delivery of production inputs on time and without excess and the optimization of essential agroecosystemic services that sustain high yields will be the key ingredients of a more precise farming of the coming generations. Although field farming can never become as precise as manufacturing, we must strive for an appreciable increase in the overall performance of cropping. I see the emerging GPS-guided (Global Positioning System) precision farming as only a very small part of this effort: more precise farming must rely on a much broader spectrum of information-rich management approaches ranging from recurrent soil testing to optimal timing of production inputs.

Omnivory is an important part of our evolutionary heritage, and the general affinity for consumption of animal foods has meant that with rising standards of living larger shares of crop harvests have been fed to large animals, poultry, and fish; for cereal grains the global share used for feed is now close to 50 percent and rising. In chapter 5 I present detailed calculations of feeding efficiencies for all important animal foods: milk, eggs, poultry, pork, and beef, as well as for representative herbivorous and carnivorous fishes (carp and salmon). I express the efficiencies per unit of edible product, a more revealing measure than the common comparisons per unit of live weight.

All comparisons—per unit of feed, or in terms of overall feed energy and feed protein conversion—favor milk followed by herbivorous fish, eggs, and chicken. Efficiency of pork production is much closer to that of chicken rather then cattle feeding, and the pig's omnivory is an added advantage in societies with a limited supply of feed grain. Chicken is the most efficient producer of protein per unit of space (including the area needed to grow the feed), and eggs require the least amount of water per unit of edible energy as well as per unit of dietary protein. All these considerations have played a limited role in affluent countries enjoying high intakes of animal foods—but they should become increasingly important as the populous countries of Asia and Africa strive to improve the quality of their diets.

A combination of dairy products, aquacultured herbivorous fish, and eggs, chicken, and pork offers the most efficient way to produce animal protein, but appreciable opportunities to increase reproductive and feeding efficiencies are present for all domesticated species. Universally applicable measures include better use of organic wastes, better harvesting, better processing and storage of roughage and concentrate feeds, and better use of feed additives to improve quality and palatability and to boost nitrogen utilization. More attention should be also given to the breeding and management of animals best suited for the tropics and to sustainable ways of both fresh- and salt-water aquaculture. As in the case of crop production, a large part of the increased animal food output during the next generation should come from a more efficient use of existing feeds.

Food Consumption and Requirements

The quest for tightening up the slack in the food system must go beyond fields and barns. Appraising this potential requires us to investigate the entire food chain. I have long been puzzled at why food—human needs for it, its availability at the retail and household level, its actual consumption, and its consequences—is largely absent from most publications and meetings on the achievements and prospects of the world's agriculture. To dwell solely on factors, conditions, and opportunities for increasing crop harvests and for boosting the productivities of domesticated animals is to offer a badly truncated view of the world's food prospects.

This omission implies that the understanding of food flows beyond the farm gate, appreciation of nutritional needs, and the rational management of the demand for food are matters of little consequence for the global food supply. The very opposite is true, but the task of integrating these considerations into appraisals of possible futures of food supply is complicated by our surprisingly poor understanding of many critical realities: we cannot be confidently prescriptive about how much people should eat. Nor do we know with a great accuracy how much they actually do eat.

In chapter 6 I will show that our statistics on outputs of agricultural commodities and on average food intakes are not as accurate as commonly believed: whereas the uncertainties are marginal in affluent countries, they are substantial throughout Asia, Africa, and Latin America. Major reasons for this include general underreporting of cultivated areas, rough estimates of staple crop harvests, and omission of food produced in kitchen gardens and gathered from the wild. Considerable uncertainties also surround the inexplicably neglected matter of harvest and postharvest food losses: in poor countries they amount commonly to 10–15 percent of the initial yield, and their reduction deserves at least as much attention as the quest for higher yields.

Commonly used food balance sheets are thus often based on imperfect information, and as they summarize food supply available at retail level they do not tell us what we actually eat. Although availabilities and intakes correlate, large variations preclude the use of any reliable scaling to derive the latter rates from the former values, and only repeated dietary surveys can find the typical levels of food consumption. However, the paucity of such studies and inherent weaknesses of such commonly used survey methods as single-day recalls of food intake make it difficult to come up even with good averages. Both underestimates and overestimates of actual intakes are common.

Averages of per capita food energy consumption range mostly between 2,000 and 2,300 kcal/day. This means that in affluent countries, whose daily per capita food supply averages more than 3,500/kcal, the gap between availability and consumption amounts to as much as 40–45 percent of all produced food; reducing this enormous retail, household, and institutional waste should be yet another essential component of the quest for more efficient food systems.

In chapter 7 I demonstrate how our understanding of human nutritional needs, a quest begun during the last decades of the nineteenth century, is still evolving as every decade brings new emphases, new recommendations, and new puzzles. Micronutrient shortages, above all those of iodine, vitamin A, and iron, can be relatively easily remedied by inexpensive supplements. Quantifying and eliminating shortages of food energy and dietary proteins is a much greater challenge.

Most of our knowledge of human energy requirements has been derived from studies in the affluent nations of the northern hemisphere. Standard equations of basal metabolic requirements allow for excellent predictions of energy needs in children, are of limited use for adults (particularly men), and overpredict the needs of populations living in the tropics. Recent studies also demonstrate considerable variability of energy needs not only among individuals but also among groups and populations. Average needs are surprisingly low in some agricultural and pastoral populations adapted to low food availability, as well as in affluent societies dominated by sedentary life styles (particularly for females).

Although the recommendations of desirable protein intakes have undergone many changes during the twentieth century, we still do not have definite standards. Earlier recommendations resulted in exaggerated totals of malnourished people, while recent studies are concerned proper ratios of individual essential amino acids and with dietary protein digestibility. Both energy and protein studies have a number of important implications for assessing the global nutritional adequacy.

Calculations based on the best available evidence show that global food needs average only about 2,000–2,100 kcal/day, substantially below the conservatively estimated supply of 2,800 kcal/day. Even a complete elimination of stunting and higher food needs for more active lives would raise the mean consumption totals by no more than 10 percent. And because of admirable human adaptability, including very