Introduction

1. THE CURRENT WORLD FOOD CRISIS

The current world food crisis that began in 2007–2008 is in many ways similar to the hundreds or thousands of local and regional crises that have transpired since the beginning of agriculture. As we have seen, there are sharply contrasting perspectives on the causes and solutions of food crises past and present—and on how to prevent them in the future. The "mainstream" and "alternative" perspectives can sound superficially similar, yet they differ fundamentally in terms of their theories and assumptions, problem definitions and solutions.

The mainstream emphasizes the direction that brought us the most dramatic and significant successes in terms of increased food production—supporting the modern, large-scale, industrially based system that is most developed in the United States, Canada, Australia, and western Europe. The alternative emphasizes that the successes of the mainstream have also created many environmental and social problems, and that the conditions that allowed the mainstream approach to flourish no longer exist—the population is much larger, and new resources for production are more limited by scarcity and degradation. Therefore, many taking an alternative approach argue that we need to build on more traditional, less resource-intensive small-scale agriculture, while incorporating the best elements of modern science and technology, seeking solutions that nurture people and communities psychologically and socially as well as physically.[1]

The dichotomy between mainstream and alternative as I've just described it is a simple model, a sort of caricature, that nonetheless can be useful for understanding. It is important to remember that all our knowledge about the world is comprised of models and that all

models are simplifications—the useful models are the ones that help us advance toward the goals we have chosen. I believe that this model can help us toward a deeper understanding of our agrifood system, which is the starting point for moving it in the direction of our goals. In chapters 3 and 4 I will elaborate on this model, and in part 2 I will explore its complexities and contradictions as I apply it to making sense of agrifood systems past, present, and future.

2. FEEDING THE FUTURE

Part of what makes finding solutions for agrifood system problems so controversial are the predictions of large increases in future demand for food, driven by increasing population—now past seven billion and expected to add at least two billion more before it stops growing—and increasing per capita consumption, driven by changing diets that include more processed and animal foods. For example, an analysis by the United Nations Food and Agriculture Organization (FAO) for the interval from 2005–2007 to 2050 projects an increase in per capita demand for meat and oil crops by 28 percent and 39 percent, respectively. Based on an estimated increase in population of 39 percent, this means an increase in production of 76 percent and 86 percent, respectively (table 0.1), and an overall increase in food production of approximately 60 percent (Alexandratos and Bruinsma 2012:21, 99). Even for cereals, which have a projected per capita increase in demand of only 5 percent, required production would have to increase by 30 percent because of population growth; this means that yields would have to increase by 30 percent, because arable land will likely increase very minimally (4 percent).

So how will this expected demand be met? The *mainstream* industrial agrifood system has been remarkably successful over the long run in increasing food production at a rate faster than population growth, with the promise of continuing to do so in the immediate future. Supporters of this system believe that a globally integrated agrifood system and technological breakthroughs, for example in genetic engineering of crop plants or precision agriculture, are key to providing enough food for the future (Evans 1998, Fedoroff et al. 2010). Advocates of *alternative* agrifood systems have a different perspective—they argue that the demand can be lowered via better diets (Eshel 2010) and reduction of waste, and that supply can be increased in more sustainable ways, with ecological agriculture based on traditional methods and more local control (IAASTD 2009). But the issue is far from settled, and it hinges on disagreements over values as well as facts. A major problem from an alternative perspective is that the mainstream agrifood system monopolizes the bulk of research and development resources, leaving little opportunity for developing the kinds of solutions needed to save the planet, nurture communities, and increase human happiness.

Yet, regardless of one's perspective, there is also shockingly bad news about every element of our agrifood systems—from the contamination of drinking water with agricultural chemicals to the deteriorating nutritional quality of the food supply and of child nutritional status, from the loss of crop genetic resources to loss of prime farmland. It seems that our

TABLE 0.1. FAO Projections of Future Food Demand

	2005/2007	2050	Percent change, 2005/2007–2050
Population (million), UN 2008 revision	6,592	9,150	38.8
Cereals, food (kg/capita)	158	160	1.3
Cereals, all uses (kg/capita)	314	330	5.1
Meat, food (kg/capita)	38.7	49.4	27.6
Oilcrops (oil. equiv.), food (kg/cap)	12.1	16.2	33.9
Oilcrops (oil. equiv.), all uses (kg/cap)	21.9	30.5	39.3
Cereals, production (million tonnes)	2,068	3,009	45.5
Meat, production (million tonnes)	258	455	76.4
Oilcrops (oil. equiv.), Food (million tonnes)	80	148	85.8
Cereal yields (tonnes/ha; rice paddy)	3.3	4.3	29.5
Arable land area (million ha)	1,592	1,661	4.3

Source: Data from (Alexandratos and Bruinsma 2012:21), and calculations based on those data.

agrifood system has been going in a direction that is producing at least as many problems as solutions. While those in power have demanded more food and higher yields to maintain and expand their power for millennia, pushing farmers into practices that were environmentally and socially destructive (Diamond 2005), their effects were mostly localized. Today, however, we have a global system, highly degraded environments, and more than seven billion humans to feed, with one billion of those chronically hungry.

In order to move toward a more desirable future, we need to understand the successes and failures of our past and current agrifood systems and how they are linked in time and space. We also need to agree on how to define that future and on how we need to change our current system to get there. The goals of this book are meant to contribute to this process.

3. GOALS OF THIS BOOK

I have two main goals for this book. The *first* is to encourage critical thinking by explaining the concepts that I think are key to understanding the problems and potential solutions for the challenges facing our agrifood systems. This includes demonstrating how these concepts can be applied to specific situations so that readers can use them to analyze new situations and discuss their findings with others. I hope this results in better understanding of the challenges we face, where they come from, and the options for responding to them—empowering readers to participate in a critical and constructive way in the discussions and decisions that will determine the future of food and agriculture. My *second* main goal is to demonstrate how I have applied these concepts in my own thinking about agrifood systems; I share what I have concluded about the problems and solutions based on my own research and values. These two goals are synergistic in that if I achieve the first, it means that readers will be able to independently critique my application of the concepts and my conclusions.

In other words, this book is a guide to the concepts I have found useful in analyzing the agrifood system *and* to the conclusions that using these concepts has led me to. This means that *Balancing on a Planet* (hereafter, *BOP*) is different from many other books about agriculture and food in that it does *not* attempt a review of what we know about the history of food and agriculture or its current state around the world, nor is it simply a polemic in favor of a particular agenda for change. It provides a framework for analysis of empirical data and for explicit discussion of subjective goals, illustrated by case studies from around the world.

3.1. Critical Thinking

The key to achieving the first goal of understanding problems and potential solutions is critical thinking. This includes the ability to distinguish between how the world is and how we would like it to be. As I described in the preface, when I was living in Zorse I would often lie awake at night thinking about why people in the village were hungry—and I could name a number of proximal causes, such as drought, eroded soils, and loss of labor to migration, as well as intermediate causes, such as the undermining and brutalization of indigenous communities by European colonialists, corrupt and ineffective foreign and national development workers, and changing climate patterns. But no matter what causal path I traced in my mind, all paths ended at lack of agreement among individuals and groups about how the world *does* work based on empirical data (empirically based assumptions) and lack of agreement about how the world *should* work based on values about what is good (value-based assumptions).[2] The disagreements are difficult to overcome in part because the analytical part of our brains tends to be lazy, so we often don't bother to make the effort to disentangle these two very different ways of thinking.[3]

The result is that we are usually unaware of how our value assumptions about how the world should work influence our empirical assumptions about how the world actually does work. For example, if we assume that the knowledge and culture of small-scale family farmers *should* be valued, and that they *should* have access to production resources, we may be more likely to assume that these farmers' loss of knowledge and resources *is* the cause of the food crisis (LVC 2010). Our empirical assumptions also influence our assumptions about the way the world should be. For example, if we assume that the food crisis *is* primarily due to a lack of food production and that yields on small-scale family farms *are* much lower than those on corporate, industrial farms, we may be more likely to assume that to solve the food crisis the former *should* be replaced by the latter (e.g., Collier 2008). While this kind of interaction between empirical and value-based assumptions exists among farmers, consumers, scientists, and all of us, to a greater or lesser extent, it is more serious in people and organizations operating at higher structural and geographical levels—both the amount of information they have to process and the consequences of their decisions are much greater.

Therefore, an important way of achieving the first goal of *BOP* is to analyze the assumptions underlying different perspectives about how the world is and should be, including our own assumptions. Throughout *BOP* I try to present as openly as possible my own conclu-

sions and assumptions while also standing back and viewing them critically—that is, not becoming too attached to them and remaining open to new data, to alternative interpretations of data, and to appreciating different values. For example, my values include the assumptions that equity of resource access and use for all people is good and that interacting with the biophysical world in ways that maintain high biological and cultural diversity and ecosystem functioning is good, and my analysis of the data leads me to empirical assumptions that anthropogenic climate change is a real and immense threat and that small-scale, resource-poor farmers' behaviors are often based on insightful and efficacious understandings of their environments and crops.

3.2. The Results of My Critical Thinking

So, what have I concluded about the problems with our agrifood system and the best way to solve these problems? Explaining my conclusions and the process by which I reached them is the second goal of *BOP*. It was my fascination with the many different ways that humans grow and eat food that first led me to farm communities around the world. I have worked with farmers, gardeners, and scientists on research and development projects in northeast Ghana; in the Swabi valley in Pakistan; in the Central Valleys of Oaxaca, Mexico; and in the United States, on the Zuni and Hopi reservations and in Santa Barbara County, California. In addition, I have spent shorter periods of time researching agrifood systems in other places, including Burkina Faso, Egypt, India, Syria, Mali, and China. I have interviewed people and collected observational data, in addition to studying the research of others. Since climbing in those old apple trees as a boy, I have also become avid about food gardening and cooking, experiences that give me a personal connection to the process and experience of growing and preparing food. Finally, I have thought a great deal about the successes and problems of different ways of growing and eating food.

One of my central conclusions is that small-scale, traditional, locally oriented, low-external-input agrifood systems are an important resource for the future. Much of the Earth's remaining cultural and biological diversity is in the care of small-scale farmers. Many of the farmers I have worked with use knowledge and methods passed on through generations to grow locally adapted crop varieties, evaluating and incorporating new ideas from other farming traditions, from extension agents, and from scientists. I have celebrated with them their successful harvests and eaten special foods made from those harvests, rich with history, meaning, and flavor.

These farmers are often proud of what they do and know, and while they seek improvements in their farming and their lives in general, most do not want to abandon those things they value about their way of life. For example, in Oaxaca, Mexico, when farmers were asked as part of our research on crop diversity if they wanted their children to be maize and bean farmers like themselves, 91 percent said "yes" (Soleri, Cleveland, Castro García et al. n.d.). However, these same farmers see the world changing rapidly from the traditions of the many generations that preceded them—only 47 percent thought their children would actually grow up to be maize and bean farmers.

I have also seen farmers struggle to feed themselves and to understand the forces seemingly beyond their control that make the survival of their agrifood system almost impossible—population growth; environmental degradation; climate change; market fluctuations; privatization of water, land, and other resources; inappropriate development projects; and corrupt and incompetent governments and development organizations at home and abroad. I have also seen many young women and men, including many of my students, choose to work as small-scale farmers, food processors, chefs, and distributors instead of in careers that are less risky and more remunerative. In the midst of the most productive industrial agrifood system in the world, and with college degrees in hand, most of these students who choose to work in the agrifood system are moving away from the vision of mainstream agronomists and economists, choosing to create and participate in alternative ways of doing things.

While I see much potential in small-scale agriculture for solving the world food crises, I am also aware that small-scale farming is often physically and mentally grueling, and that most farmers are not well rewarded for their work. According to one estimate, the more than two billion people living on almost five hundred million small-scale (less than 2-ha) farms in the Third World include half of the world's undernourished people and the majority living in absolute poverty (IFAD 2011:1).[4] In short, I am not a nostalgic romantic. There is no going back to the small-scale agriculture of the past—doing so would be neither possible nor desirable. It was often a very hard life, and the world is a different place now, with more than seven billion humans to support. But simply continuing to promote the mainstream agrifood system is not the answer either.

I believe that an important aspect of creating alternatives for the future will be to combine small-scale, traditional agriculture with select aspects of modern, scientific agriculture in ways that provide solutions to the current food crisis—long-term solutions to balancing our biological need for food with our environmental impact in ways that also fulfill our cultural, social, and psychological needs. This means searching for basic principles that underlie both modern and traditional agriculture, both modern and traditional demographic behavior, and both modern and traditional values and social organizations. This is not a quick fix, but it may be one of the best ways to solve the present food crisis and to avoid future ones. As I will discuss in more detail in chapters 3 and 4, there are usually trade-offs between what is possible and our goals for the future, and also between the different goals we have for the future. We need to minimize these trade-offs, to look for ways to make the system work better for everyone. We need to think critically, holistically, systemically, and compassionately. And we need to get to work right away.

4. THE LAYOUT OF THIS BOOK

To address my goals, I have organized *BOP* into two parts. In part 1, *Agrifood Systems History and Future,* I focus on the food demand-supply problem, the underlying factors that drive our past and current agrifood crises and successes, and how basic concepts such as sustainability can be useful tools for understanding those factors and moving toward a better

future. In part 2, Moving toward Sustainable Agrifood Systems: *A Balancing Act,* I give more detailed examples of how these concepts can be applied and how I have applied them in my own thinking.

Chapter 1 is about the relationship between the demand and supply sides of the agrifood system: the demand for food created by an increasing number of people and increasing per capita food consumption, and the supply of food based on the ability of technology and the environment to produce it. The fundamental concept was laid out by Malthus: population tends to increase geometrically and food supply arithmetically. Like other organisms, humans are selected for their success in reproducing, leading to growth in numbers, but the ability of the environment to feed the growing numbers is limited. There are four basic ways humans can respond to avoid the collision between demand and supply. Humans have been very good at avoiding this collision by increasing the production of food, but ultimately it can be avoided only by conscious personal and social planning. An example of calculating the Earth's human carrying capacity (HCC), based on demand—total human energy requirements—and supply of water for growing rice to meet that demand, illustrates the critical roles of efficiencies and assumptions in determining supply and demand.

In chapter 2 I explore in more depth the supply side of the equation: What determines how much food we can produce? How has agriculture evolved in ways that increase HCC? I begin with the first agricultural revolution, the Neolithic, and the way in which it dramatically changed the relationship of humans with other species, with the environment, and with other humans. We will see how changes in these three fundamental relationships have continued through time with the spread of agriculture from its centers of origin, the scientific-industrial revolution, the Green Revolution, and the biotech revolution. Because the focus of these revolutions has been overwhelmingly on increasing short-term production, the social and environmental costs have often been ignored, yet they have undermined HCC over the longer term in many places. Ensuring a future for our species will require balancing short-term strategies with long-term or sustainable strategies, the subject of chapters 3 and 4.

Chapter 3 describes how the sustainability revolution is a response to the problems caused by the supply-side approach and a discussion of how sustainability can shift the emphasis to dealing with the demand side—how to reduce growth in population, consumption, and inefficient technologies. I show that sustainability is a subjective concept about what we want the future to be and therefore requires discussion of values to reach agreement. It also requires objective analysis of the current situation and the effectiveness of different solutions. Important concepts for this analysis are how knowledge is generated, and how we can understand the similarities and differences in knowledge among farmers, among scientists, and between farmers and scientists.

Chapter 4 concludes part 1 by describing how the three main emphases in agrifood system sustainability—economic, environmental, and social—can have very different goals, theories, and solutions. These emphases also often have very different assumptions about the key concepts of the agrifood system, including markets, natural resources, human nature, discount rates, internalization of externalities, and risk management. In general, the

mainstream perspective has an economic emphasis, and alternative perspectives have environmental and social emphases. The simplified characterization of the three emphases provides a framework for more nuanced understanding and analysis, illustrated by further examination of the current world food crisis.

Part 2 moves from the general discussion of problems and solutions to specific aspects of the long-term food crisis, and it provides examples of how to apply the concepts introduced in part 1. Chapters 5, 6, and 7 take up the three fundamental changes of the Neolithic—increased management of other species, ecosystems, and people—in more detail, showing how supply-side solutions worked through subsequent revolutions and how they can be combined with demand-side solutions to create a more sustainable alternative agrifood system, one that contrasts with the mainstream vision. In chapters 8 and 9 I address two of the biggest challenges to creating a more sustainable agrifood system—global climate disruption and economic globalization—and discuss the potential for diet change, food waste reduction, and localization to meet these challenges.

Chapter 5 is about the management of other species, focusing on the basics of plant breeding in a broad perspective that includes environmental and social as well as biological variables. Building on the introduction to farmer and scientist knowledge in chapter 3, I show how fundamental biological variables are understood and used in different ways with different results by small-scale farmer and professional scientist plant breeders, in many ways reflecting the contrasting alternative and mainstream perspectives. I illustrate this for three topics important for crop improvement: yield and yield stability and narrow versus wide adaptation, collaboration between farmers and scientists, and genetically engineered crop varieties. Similarities and differences among farmers, among plant breeders, and between farmers and breeders can often be accounted for by similarities and differences in their experiences of biophysical reality—that is, the germplasm and the growing environments they have worked with; their experiences of social reality, including social and institutional settings; and the way they create new knowledge as influenced by preexisting knowledge, technology, and practice.

Chapter 6 describes the development of ecosystems management, and how this is different in traditional and industrial agrifood systems. The move to sustainability can be thought of as a search for those unique "places" where the stability and diversity of traditional systems can be combined with the high yields of industrial systems. I describe how polyculture can produce greater yields than monoculture, illustrated with a case study from Yunnan, China, where growing traditional and modern rice varieties together eliminated the need for fungicides and increased yields and farmer income.

The ways in which humans manage themselves in order to manage agrifood system resources is the focus of chapter 7. It describes how resources can be categorized as private, public, or common pool, and how common-pool resources can be managed by private individuals or corporations, governments, or communities—or not managed at all. Common property management has the potential to internalize negative externalities in ways that optimize the equal distribution of benefits, including to future generations, yet it has been

largely ignored or dismissed by the mainstream agrifood system. I show how game theory can help us understand success and failure of different management types, and I provide examples of the potential of common property management for irrigation water and crop genetic resources.

In chapter 8 I discuss anthropogenic climate change, to which the agrifood system is one of the largest—perhaps *the* largest—single contributor and which in turn has profound effects on the agrifood system. I look at the relationship of climate change to the evolution of biogeochemical cycles in the history of the Earth and to recent changes in the agrifood system. I give examples of two key cycles, carbon and nitrogen, and show how our agrifood system has affected these cycles in ways that make big contributions to climate change and therefore offers opportunities for mitigating that change. Solutions that receive the bulk of attention typically require a lot of additional research, technology development, and resources and entail a lot of uncertainty and risk, with benefits slow to materialize. Some of these approaches will need to be part of the longer-term solution—for example, increasing soil carbon sequestration, increasing the efficiency of nitrogen fertilizer use, and reducing food packaging and transport. My focus, however, is on strategies available to us right now: reducing the high level of waste from field to fork and adding more healthy plant foods to our diets while reducing processed and animal foods. These behavioral changes receive relatively little attention, yet they require few resources and can have dramatic and rapid benefits. Their biggest challenges are cultural, social, and economic.

In chapter 9 I examine what has become the most popular alternative to the problems caused by the mainstream globalized and industrial agrifood system—grassroots localization. In the industrial world, the push for localization seeks to reshape the economic, social, and physical infrastructure of agrifood systems; in the Third World, it seeks to conserve and improve what remains of local agrifood systems. Localization is a critical case study of how different values and goals for the future can lead to very different interpretations and actions. The battle over localization is a microcosm of the battle over who gets to set the goals of our agrifood system and select the paths to reach them, and it is embedded in the larger economic, environmental, and cultural struggle for the future of the planet. This is why we must all keep asking the key questions, carefully examining our empirical and value assumptions, and use indicators for sustainability that most accurately reflect our goals for the agrifood system.