WORLD AGRICULTURE and the ENVIRONMENT



A Commodity-by-Commodity Guide to Impacts and Practices



JASON CLAY

World Agriculture and the Environment

D5-219

A COMMODITY-BY-COMMODITY

GUIDE TO IMPACTS AND PRACTICES

Jason Clay

Island Press / Washington • Covelo • London



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Library of Congress Cataloging-in-Publication data.

Clay, Jason W.

World agriculture and the environment: a commodity-by-commodity guide to impacts and practices / Jason Clay.

p. cm.

Includes bibliographical references (p.).

ISBN 1-55963-367-0 (cloth: alk. paper) — ISBN 1-55963-370-0 (pbk.:

alk. paper)

1. Agriculture—Environmental aspects. I. Title.

S589.75 .C53 2003

363.7 - dc22

2003016786

British Cataloguing-in-Publication data available.

Design by Kathleen Szawiola

Printed on recycled, acid-free paper



Manufactured in the United States of America 10 9 8 7 6 5 4 3 2 1

Live like you'll die tomorrow; farm like you'll live forever.

There are two basic truths that will shape the future of farming—there is a steady increase in the consumption of food and fiber produced by agriculture, while at the same time there is a steady decline in the quality and productivity of soil around the world. The two trends are on a collision course. This collision will not be avoided by a single solution.

It is this trajectory that explains why a former farmer, anthropologist, and human rights activist now works in an environmental organization focusing on agriculture. It is a question of survival. Most biodiversity lives in the soil rather than on top of it, and most is found in areas of human use rather than parks or protected areas. However, as a result of the increased demand for agricultural products and the use of unsustainable agricultural practices, farmers convert natural habitat into new agricultural lands after they exhaust and abandon the lands that they previously farmed. As a consequence, farming is the single largest threat to biodiversity and ecosystem functions of any single human activity on the planet.

This book shows how this pattern can be broken and identifies activities that producers, policy makers, researchers, market-chain players, and environmentalists can play in the creation of more sustainable agricultural practices within the evolving context of global trade.

The people who know the most about making farming more sustainable are farmers themselves. The most innovative among them are often simply trying to survive economically in an increasingly competitive world. They use resources more efficiently, and they are constantly experimenting with new crops, combinations of crops and practices, and technology. Innovation comes from experimentation. Many producers are actually farming with nature rather than against it. This does not mean that they are returning to the practices of their ancestors, but rather they are experimenting with a mix of old and new approaches that give them better returns with fewer inputs and fewer impacts. Many producers have learned a very important truth—that to save money is to make money. For example, some have found that they make more money increasing soil vitality and fertility and reducing inputs than they do by focusing on increased yields alone.

Many producers have also come to realize, some the hard way, that in a global economy with increased transparency and information what some producers do can

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affect the reputation of all. As a consequence, producers are organizing themselves to protect their interests and reputations. The most progressive are beginning to organize their industries to share experiences and lessons learned as well as to negotiate as larger blocks with regulators, buyers, investors, and nongovernmental organizations (NGOs).

Most environmental NGOs have no interest in becoming agricultural development agencies. But most have also come to realize that they cannot achieve their missions without ensuring that farming practices become more sustainable. Such groups are now beginning to develop agricultural programs through which they intend to engage producers, but most have not yet developed (much less implemented) detailed approaches through which they will engage agriculturalists. Furthermore, most NGOs are far more comfortable working with governments to develop regulatory approaches to address the negative impacts of agriculture—in short, to tell farmers what they cannot do. Such "stick" approaches are not likely to work by themselves. Furthermore, they provide no incentive for producers to do better than what is required by law.

This book identifies a number of approaches and market-based incentives that would encourage producers to achieve entirely new levels of performance, and as a result raise the expectations of government, and others, about what is even possible. The goal of NGOs should not be to put farmers out of business, but rather to make sure that they or their descendents can still farm the same piece of land in twenty or fifty years without the use of unsustainable inputs. This book identifies areas where agriculture can be made more sustainable globally while at the same time reducing pressure on natural habitats and increasing biodiversity and ecosystem services within areas that are farmed.

Government officials around the world have fewer resources with which to reduce the impacts of agriculture on the one hand or to make it more sustainable on the other. Increasingly, they are asked to do more with less. This book demonstrates how government land use and zoning programs can be based on the productive potential (or the unproductive potential) of areas as well as the value of natural resources and habitat for other purposes. It shows officials how to think about the medium- to long-term costs of allowing, much less giving incentives to, the establishment or continuation of unsustainable agricultural production systems.

Some governments, too, are experimenting with very innovative approaches to support or encourage sustainable agriculture. For instance, they are exploring how to link regulatory structures, licenses, and permits to performance and to better management practices (BMPs) in order to encourage the adoption and use of more sustainable practices as well as the standards by which performance is measured. While not exhaustive, this book offers a number of examples from different types of countries as well as from different types of crops and producers that provide government officials with considerable information about how to think about adapting or incorporating similar approaches in their own countries.

The manufacture and sale of agricultural products throughout the market chain from the producer to the consumer are increasingly centralized and vertically orga-

nized. Most of the players are monitoring the increased public concern regarding product quality in general and chemical residues in particular. Where there are consumer concerns there are potential liabilities. This book suggests how food manufacturers and retailers can begin to think about greening their supply chains through the adoption of BMP-based screens that reduce not only their overall liability, but also the environmental impact of their producers, and increase their profitability at the same time.

Finally, there are dozens of research topics and areas that are suggested for each of the crops discussed in this book as well as for hundreds of crops not discussed in this book. Such research could be pivotal in helping to put agriculture on a more sustainable footing. To best accomplish this, however, researchers may need to distance themselves from the money and interests of input suppliers as well as the latest theories of the day that preoccupy academia. There is a tremendous amount of research whose results and findings could be applied immediately and could help producers reduce their environmental impacts as well as increase their profitability. Most would consider such research timely and in the public interest.

While my editor would probably kill me for saying this, this book is not intended to be comprehensive. Libraries have been filled with books written about each of these crops. Rather, the goal of this book is to identify and analyze several concrete examples of ways that a wide range of commodities are being produced around the world that reduce their environmental impacts. The goal is to show that there are new ways of thinking and acting that reduce agricultural impacts. These ways of thinking are relevant to most crops produced on the planet, but they cannot be adopted whole cloth—they will have to be adapted to different crops and circumstances. The most important thing to take away from the book, then, is not what to think in any specific circumstance but rather how to think. And of course, while most of these actions make sense for farmers in their own right, there are also important roles for governments, buyers, environmentalists, investors, researchers, and consumers.

This book will stimulate dialogue and discussion among producers and between producers and others genuinely interested in these issues. Such discussion, based on new facts, will amplify, redirect, and focus the debate on sustainable agriculture. As such, the book should encourage the identification of BMPs from around the world and stimulate their analysis so that the lessons can be more widely disseminated to reduce the impacts of global agriculture and increase its sustainability and profitability at the same time. Our future, and the future of every other living thing on the planet, will depend on it.

Jason W. Clay 24 February 2003

ACKNOWLEDGMENTS

Most of the things I have done since a very early age in my life have influenced this book. By the age of two I was creating farms in my sandbox (which was made of an old tractor tire) complete with ponds, drainage systems, and fields with terraces and contour plowing. I first "drove" a tractor, a Farmal H, that same year. Like most children around the world, I learned about farming from my parents, relatives, and neighbors. The most important of these include W. E. and Doris Clay, my parents, Gordon Howitt, my uncle, and Rex Jameson, a neighbor. As with my six siblings, my first lessons were in the garden, then the barnyards and chicken houses, and finally the fields. In the spring of 1966 the same tractor that I had driven when not yet three turned over and killed my father, and I learned first hand about the darker side of farming and, equally important, the responsibility of making a living.

It seems that the more I tried to escape from farming, the more I was drawn back to it both as an observer and a student. I learned about shotgun houses, cotton, and tenants in southern Arkansas while working on an archeological dig amidst soybeans; corn, beans, and coffee from Tzotzil-speaking farmers in Chiapas, Mexico; coffee, cassava, beef, and horticulture from farmers in the breadbasket of the northeast of Brazil; bananas, sorghum, tea, and cattle from Ugandan refugees; and teff, honey, sorghum, and millet from Ethiopian refugees.

Davydd Greenwood, Milt Barnett, Bill DeWalt, Norm Uphoff, Walt Coward, John Whiting, Sir Peter Bauer, and Ford Runge helped me understand farming and farmers within wider cultural, political, and economic contexts. Amory Lovins, Jim LaFleur, Jose Zaglul, Konrad von Moltke, John Forgash, Allan Nations, Greg Simmonds, Peter Kenmore, Gordon and Anita Roddick, Ben Cohen, Dave Cole, Florence Sender, Josh Mailman, Jeff Dlott, Sue Hall, Diane Osgood, Robins McIntosh, Werner Jost, Joaquin Orrantia, Jose Vicente Mogollon, Rachel Stringfellow, and literally thousands of farmers from six continents, each in their own way, helped me to understand not what farming is or was, but what farming as a business is becoming and might yet be.

However, I would never have tried to pull all this information together in one place without the support of Diane Wood, former Vice President of the Center for Conservation Innovation of World Wildlife Fund (WWF), who provided the greatest part of the funding for writing this book. Others within WWF (presently or in the

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past) who provided support, information, or encouragement include Barbara Hoskinson, Amy Salzman, David Schorr, Polly Hoppin, Sarah Lynch, Sheila O'Connor, Andrea Ries, Richard Perkins, Elizabeth Guttenstein, Jean Paul Paddack, Garo Batmanian, Bella Rocher, Andrew Ng, Lucy Aquino, Judy Oglethorpe, Sara Christiansen, Doreen Robinson, and Anthony Anderson.

A number of individuals have helped with the research for this book and have my heartfelt thanks. Katherine Bostick certainly stands out for her willingness to see this project through to the end and for catching many inconsistencies. Other researchers from WWF include, in the order of their involvement, Gautham Rao, Miranda Mockrin, Tim Green, Govindarajan Dhanasekaran, and Taryn Fransen. In addition, Martha Alt, Andrea and Jeff Vallina, Jim and Andre LaFleur, and Alexa Clay also assisted with the research, fact finding, and preparation of the book. Panfilo Tabora and students Cleomar Bizonhin, Juan Francisco Chiriboga, Frankys Maikel de la Osa, Guido Durán Maridueña, Karina Garcés Herrera, Diego Garcia Velasco, Xiomara Gonzalez Hernandez, Jose Rafaél Gonzalez, Rebecca Gutierrez Bermudez, Jered Hayes, Edmar Hodgson Sobalvarro, Tania Johanning Villegas, Maria Enith Melendez, Yerling Miranda Jimenez, Kelly Rohlfing, Anna Sommer, Jose Maria Tijerino Picado, Luis Antonio Velex, and Paul Whitsell from EARTH University in Costa Rica assisted with research for tropical crops.

In addition to the support from WWF to write this book, work undertaken for or supported by the Ford, MacArthur, AVINA, and Packard Foundations; the Pew Charitable Trusts; the Interchurch Organization for Development Cooperation (ICCO); the World Bank; the Food and Agriculture Organization of the United Nations; and the Multilateral Investment Fund of the Inter-American Development Bank all contributed to the analysis presented here.

Todd Baldwin of Island Press had the courage to edit and sharpen the text as well as to fight for pages to make the book more comprehensive. Thanks for both. And thanks to Cecilia González and Chace Caven for seeing the editing process through to the end.

Thanks also go to my children, Alexa, Zale, and Hawkins, for their patience and understanding during the research and writing of this work, which required my time and attention during formative periods of their lives. Finally, my deepest thanks for insights and encouragement goes to my wife, Mary Ann Mills. Without her support, the travel, research, and writing for this book would not have been possible.

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INTRODUCTION

In 1837 John Deere patented the steel plow that cut through native prairie grasses and converted them to farms, first in the United States and then in distant lands. This plow, more than any other invention, symbolized the human ability literally to turn nature on its head. The steel plow became the foundation for modern agriculture. As the plows and the machines that pulled them got bigger, more and more land could be farmed by fewer people. Every increase in scale and intensity, however, increased environmental impacts as well. Over time it has become apparent that agricultural practices, more than any other single factor, have determined the state of the global environment.

But that picture may be changing. Though the John Deere name is synonymous with mechanized agriculture, the company has started venturing into the realm of sustainable agriculture. John Deere recently entered into a joint venture with a Brazilian agricultural company. This company held land that was producing primarily through cultivation techniques that eliminate tillage. The strategy of this partner is to buy degraded pasture and rebuild the soil to fully productive land for the cultivation of such crops as soybeans. Seeds are planted without turning the soil and organic matter is left on the surface. Such practices reduce soil degradation, erosion, and the use of fertilizers and pesticides, while increasing the soil's retention of water and other agricultural inputs added during production. The system is based on crop sequencing (growing two or three crops in the same year) as well as three-year crop rotations. The ground is planted with grass to build organic matter. Other improvements include keeping marginal lands out of production; areas that are not appropriate for farming are terraced and planted to trees. Perhaps even more interesting, the workers on the farm have an equity position in the company based on their length of employment and productivity. This is the new face of agriculture, and a few corporations like John Deere and its partners are beginning to invest in it. But it will take a long time to become the global norm.

One of the great contradictions of our time is that we know more about and are better able to save spaces and species than ever before. But we are losing both species and their habitats faster than ever, and more often than not the cause is agriculture.

Parks and protected areas, comprising about 5 percent of the land on the planet, have long been recognized as cornerstones of effective efforts to save biodiversity and

ecosystems. Yet most species on the planet today live where people are trying to make a living. In general, most parks and protected areas were created to protect geologic formations and areas of striking beauty or cultural value, not biodiversity.

In any event, it is difficult to imagine how the size of parks and protected areas can be effectively maintained—much less increased in area—in the current and foreseeable political climate. Many protected areas are systematically attacked from all sides. Around the world, legal and illegal invasions of such areas are undertaken by oil and gas companies, miners, loggers, and others looking for resources that can be exploited. In addition, about half of the world's current protected areas are surrounded by agriculturalists, many of whom see protected areas as their next fields. The net effect of such actions is to reduce the value of such areas for biodiversity conservation. Even if the areas currently under protection can be maintained, recent research suggests that some 30 to 50 percent of species within them will disappear because their populations are too small to survive over the long run on the protected land available.

By contrast to the land under formal protection, about half of the habitable land on Earth is used for agriculture and livestock production. Because of this enormous scale, agriculture represents both a significant threat and an opportunity to protect biodiversity. One strategy for saving biodiversity is to help producers become more sustainable and productive so they can stay where they are, instead of expanding into pristine areas, while at the same time accommodating more biodiversity on their lands. Agriculturalists are the managers of global lands. They shape the face of the Earth (Tilman et al. 2002).

The environmental costs of agricultural practices (referred to as environmental externalities, ecological footprints, subsidies from nature, or passing environmental costs on to future generations) are usually not measured. When producers are not required to cover the true costs, they pass them on to society. For example, most current agricultural practices reduce the ability of ecosystems to provide goods and services. Clearing natural habitat and soil erosion both reduce carbon sequestered in the environment. This loss of organic matter in the soil reduces the ability of soil to absorb and retain water. Such practices not only increase overall environmental degradation downstream, they also increase the amount of external inputs (especially fertilizer) required to maintain productivity. Not only can more sustainable agricultural practices reduce these impacts, they can also make agriculture a central part of the environmental restoration process.

The goal for sustainable agriculture must be to insure that society benefits not only from the production of food and fiber but also from the maintenance or restoration of ecosystem services such as watershed protection, healthy soil and the biodiversity that depends on both. Globally, land cleared for agriculture is rarely allowed to return to a "natural" state. There are some exceptions in the eastern United States and Europe, but in general, once converted, land is used in one form or another by humans often until virtually nothing will grow there. At that point it may be abandoned, but it will never regain the biological diversity that it once had. The extent of

environmental degradation caused by agriculture can still be seen near archeological sites in Central America and Southeast Asia that are a thousand years old. To restore such degraded land to productivity and reestablish other ecosystem services might be possible, but only at great expense.

Sustainable agriculture requires that ranchers and farmers alike be rewarded for producing food, fiber, and ecosystem services (Tilman et al. 2002). Globally, the main obstacle to this approach is that current subsidies support unsustainable production systems in one part of the world and make them necessary for survival in the rest. However, if a portion of these subsidies were used to pay for the production or maintenance of ecosystem services, they could increase overall agricultural production, profitability, and viability in the short, medium, and long term.

CURRENT AGRICULTURAL PRODUCTION

Agricultural production has modified the natural landscape more than any other human activity. The land dedicated to agricultural production continues to grow (see Table I.1). Globally, agricultural land use has increased at a rate of approximately 13 million hectares per year for the past thirty years. Much of this expansion has come at the expense of forests (except in North America and Europe). Producers are whittling away at natural habitat on the margins of agricultural areas. Because roads, infrastructure, and urban expansion often come at the expense of agricultural land, agricultural expansion into new areas is even more rapid than suggested by these figures, which reflect only net growth.

There are several factors that determine the overall damage from agricultural production as well as the strategies to address it. Most agricultural commodity production is for basic foodstuffs, and most products are consumed within the country that produced them. Some 90 percent of all arable land is planted to annual crops, which cause more damage than perennials. Because annual crop production methods tend to exhaust the soil in which the crops are grown, producers must continually convert natural habitat to agricultural uses. As soil loses its fertility, land is used for a succession of different crops with fewer and fewer nutritional requirements. This can be visualized as farming down the nutrient chain.

TABLE 1.1. Clobal Land Area by Use (in billions of hectares)

	1961	1970	1980	1990	2000
Total agricultural area	4.41	4.50	4.72	4.91	4.97
Total arable land	1.27	1.30	1.33	1.38	1.36
Total permanent pasture	3.14	3.21	3.29	3.41	3.48
Total forest and woodlands ¹	4.37	4.33	4.30	4.32	4.17
Non-arable and non-permanent crops	11.70	11.65	11.60	11.54	11.56

Source: FAO 2002.

Data for 1996.

Many think of capital-intensive, high-input production systems when they think of industrial agricultural commodities, and they think that these systems are somehow a distinct category of farm from those that put food on our table. In truth most high-input, intensive production systems are used to produce food crops that are destined primarily for the food industry and that feed most people on the planet.

Of course, agricultural crops are also used to manufacture nonfood products. These include fiber crops such as cotton, hemp, sisal, jute, flax, and wood pulp. To-bacco is also a major nonfood crop. In addition, plantation-grown natural rubber is indispensable in the manufacture of a number of key industrial products. The area of production devoted to these agricultural crops, however, is only a small fraction of that devoted to food crops.

IN SEARCH OF THE "IDEAL" AGRICULTURE

Many environmentalists do not believe that conventional farming can be improved sufficiently to reduce its damaging effects to acceptable levels. They would rather see agricultural producers revert to less intensive forms of low- or no-input agriculture that were common a century ago. These systems of production relied on a mix of crops, trees, livestock, and ground cover and on crop rotations rather than more intensive monocrop production. Through their diversity, such systems offered more protection against pests and the weather. Nutrients were recycled within the system and through livestock. Production was more labor-intensive. Such systems of production, it is said, produced less environmental degradation and were more sustainable than today's intensive, highly specialized agricultural production systems.

Such agricultural production systems have ancient roots. China's Yellow River (Huang He) Valley and Iraq's Tigris-Euphrates floodplains have been farmed more or less continuously for more than 7,000 years. Similar farming systems have been deployed or developed independently in Asia, Europe, and the Americas for 2,000 to 3,000 years. It is clear that some agricultural production systems can be operated over centuries or longer.

Nonetheless, there are several flaws in this "idealization" of less intensive farming, at least as it is often portrayed. Historically (and even in many areas where such farming is still being practiced today), the evidence is not conclusive that it was or is less hard on the land than many current practices. Some of these less intensive farming systems have failed, and often population densities have pushed cultivation levels beyond what is sustainable. There is ample evidence that parts of the Andes, Mesoamerica, North Africa, the Middle East, Europe, South and Southeast Asia, New England and even the Great Plains (to name but a few) were overfarmed to the point of degradation or collapse using "traditional" forms of agricultural production. Even today some of the most "traditional" production systems are found in rural areas with the most severe malnutrition and famine, as well as some of the most severe environmental degradation.

Most importantly, the Earth is currently home to over 6 billion people. Supporting them all by low-intensity cropping—depending solely on recycling organic mat-

ter and using crop rotation with legumes—would require doubling or tripling the area currently cultivated. This land would have to come from somewhere—and would most likely mean the elimination of most if not all tropical rainforests and the conversion of a large part of tropical and subtropical grasslands too. Lower-intensity agricultural practices are very labor-intensive, so such reversion would also require the return of a substantial share of the labor force to farming (Smil 2000). These are hardly acceptable alternatives.

During the last forty years global population nearly doubled. Contrary to many predictions, as the population has increased, global food production increased to feed most people. In fact, global per capita agricultural production increased 25 percent, while the amount of land needed to produce this additional food increased by only 10 percent. Table I.2 shows that, with the exception of wheat, the increases in consumption of major food crops are significantly larger than the increase in lands devoted to producing these crops. Where there have been famines, they have been caused by politics and human policies. Moreover, they need never have happened. While that may give little consolation to those who starve, it should give guidance to those who want to prevent famine in the future. Life expectancy has risen dramatically; China, for example, now has a mean life expectancy of sixty-nine years, up from thirty-five years in the 1950s (Chen and Ge 1995). The world prices of nearly every staple foodstuff are, in inflation-adjusted terms, lower than a generation ago. Most are at their lowest level for any time for which there are records.

This apparent bounty is due in large part to the "green revolution" in agriculture. Since 1900 the world's cultivated area increased by about one-third, but because of a more than fourfold increase in productivity, total production has increased almost sixfold. A major portion of this gain can be attributed to selective breeding programs and to an eightyfold increase in external energy inputs, mostly in the form of fossil fuels (Smil 2000). This energy is used for machinery, fuel, and fertilizer and pesticide production. Energy, machinery, and agricultural chemicals have been

TABLE 1.2. Feeding a Hungry World

Сгор	Contribution to Total Food Demand (%)	Change in Demand 1974–1994 (%)	Change in Area of Production 1974–1994 (%)
Rice	30	71	52
Wheat	18	97	96
Corn (maize)	13	115	72
Cassava	12	40	17
Potatoes	5	115	25
Sorghum	4	54	18
Bananas	4	47	14
Sweet potatoes	4	37	20
Food legumes	3	32	13
Barley	3	79	22
Plantains	2	29	-13
Millet	2	28	12

Source: FAO and CGIAR as cited in The Washington Post, 1995.

substituted for labor. Other gains have come from reduced storage losses and increased food distribution to a wider range of consumers over more of the year.

On the other hand, it is clear that the Earth's current population cannot be supported in the American lifestyle, in which an estimated 40 percent of food is thrown away. The issue of feeding the world is not one of overpopulation, but rather a fundamentally different one of overconsumption. Such waste has an undeniable impact on the biosphere through the use of natural, material resources that are required to produce what is wasted.

The current answer to feeding the world is large-scale, high-input, monoculture (monocropping) agricultural production systems, which have existed for only 50 to 100 years. The environmental problems caused by such production systems perpetuate and intensify earlier agricultural impacts. The most damage is caused by habitat conversion (and the corresponding loss of biodiversity and ecosystem functions), soil erosion and degradation, and pollution (from fertilizer and pesticides). These impacts are not new. They result from the expansion of agriculture into natural habitats, shortened or eliminated fallow cycles, adoption of double and even triple cropping schemes, introduction of faster maturing and higher yielding varieties, and use of heavy machinery that causes soil compaction. In addition, the consolidation of smaller farms into huge operations, salinization of soil resulting from improper irrigation practices, use of agrochemicals, inefficient use of larger quantities of water, and consequent creation of more effluents from farming systems also contribute to increasing levels of environmental degradation.

These negative impacts raise serious questions about the long-term sustainability of high-input, intensive agriculture. The increasing dependence on globally limited supplies of fossil fuels is not sustainable. Continuous intensive monocropping may be productive and profitable in the short term, but as it is possible only through the application of increasing amounts of synthetic chemical fertilizers and pesticides, it is not sustainable over time. It is in no small part responsible for the modern form of "shifting cultivation" that results in the moving agricultural frontiers that are found around the world.

And of course this list of threats posed by intensive agriculture does not account for the growing tendency of farmers to turn to genetically modified organisms (GMOs) and the latest round of biotech inputs to increase productivity on ever less fertile land. These too may pose severe threats to biodiversity and to agriculture itself through the creation of noxious pests and weeds or, more importantly, the mutation or loss of beneficial soil microorganisms.

Around the world today, agriculture is practiced by a wide range of producers. Whether farmers sell 100 percent of their product to markets or are primarily subsistence-oriented (producing food for their families and selling surplus into local markets) they all have the potential to cause environmental damage. As producers become more dependent on markets to meet their own wants and needs, they produce what their circumstances will allow them to to obtain the highest returns with the fewest risks. Initially this means selling surplus subsistence production. Over time, however, it means planting cash crops within less intensive production systems.

Eventually even this focus can shift as producers move to intensive monocropping systems, with subsistence crops marginalized into gardens. In many areas of the world there is still considerable local market demand for subsistence crops, but even in these markets what is valued can shift over time. For example, in Africa, production is shifting from such traditional crops as sorghum, millet, and cassava to rice, corn (maize), and wheat.

Despite all the problems with intensive industrial agriculture, it is equally clear that low-input cultivation systems, as they were practiced in the past, cannot meet the current food and industrial needs that people around the world have come to expect from agriculture. Somewhere between these two extremes are systems of production that are more sustainable and productive and that make better use of fewer resources than either the less input-intensive or more intensive systems that currently dominate global agricultural production.

Any use of natural resources has impacts. The problem at this time is that producers have no incentives to reduce their negative impacts. If anything, because there are no disincentives to reduce environmental impacts, producers have every reason to ignore them. The question for societies is which impacts are acceptable, and how to discourage the practices that lead to unacceptable impacts.

THE ORGANIZATION OF THIS BOOK

This book identifies and explores the main threats that key agricultural commodities pose to the environment as well as the overall global trends that shape those threats. It then identifies new practices as well as tried-and-true ones that can increase production while minimizing environmental costs. Many who analyze the environmental impacts of agriculture focus on trade policies that affect specific agricultural commodities traded internationally. There are two problems with this approach. First, most agricultural products are consumed in the producing country and not traded across borders, even in a processed form. Second, the main environmental impacts are on the ground; for example, they relate to production practices, not trade. Trade and trade policies are one way to approach the problem, but only if they can be focused in such a way as to reduce the production impacts of commodities that are not by and large traded internationally.

This book takes the position that working with farmers directly to identify or codevelop better management practices (BMPs) may be far more effective in the short term and may provide better information to inform subsequent trade and policy strategies. While some BMPs may be encouraged by government or even international trading partners, most probably will not. In the end, the protection of endangered species and habitats with high conservation value is often essentially a local or regional issue that involves subsistence farmers or producers connected to local markets rather than international ones.

Another issue that receives considerable attention among those interested in agriculture, poverty, and the environment is who causes the most environmental damage. A common assumption is that large-scale, capital-intensive, high-input

commercial farms have more negative impacts than small farmers who are trying to scrape together a living by producing food for their families and selling surplus locally. In fact, both are to blame. An increasing body of evidence suggests that smaller, more marginal producers may actually cause the bulk of environmental damage in both developing and developed countries. This damage can result from farming marginal land, not having efficient equipment (or the money to buy it), or not having good information about better practices.

This book does not attempt to answer the question of whether large-scale, high-input; low-input; or subsistence agriculture causes most environmental damage. Rather, the focus is to identify which practices are more environmentally destructive and whether better practices exist to reduce or avoid those impacts altogether for any of these systems of production. The focus is on primary production directly rather than on the processing of the primary products, except where processing occurs largely on the farm. Likewise, the focus is not on value-added processing through intensive feedlot systems such as those for cattle, chicken, or pigs. Such operations are more similar to factories than to farms and should be subject to the same pollution controls as other factories.

The twenty-one crops that are the focus of this volume include: bananas, beef, cashews, cassava, cocoa, coffee, corn (maize), cotton, oil palm, oranges, plantation-grown wood pulp, rice, rubber, salmon and shrimp from aquaculture, sorghum, soybeans, sugarcane, tea, tobacco, and wheat. These crops occupy most of the land used for agriculture in the world (see Table I.3). In addition, they represent a mix of temperate and tropical crops, annual and perennial crops, food and nonfood crops, meat and vegetable crops, and crops that are primarily traded internationally as well as those that are consumed primarily in the country of origin.

A number of significant crops are not discussed in this book. In many cases, the excluded crops are those whose area of production is in decline, or ones that are not deemed as globally significant as another crop that is included. Some of the more obvious tradeoffs were the inclusion of wheat instead of barley, rye, or oats; sorghum instead of millet; cassava instead of sweet potato; soybeans and oil palm instead of peanuts (groundnuts), sunflowers, canola (rapeseed), olives, or coconuts; and sugarcane instead of sugar beets.

Some of the omitted crops are very important locally. This is the case with such crops as potatoes, grapes, apples, horticulture crops, cut flowers, or sugar beets. The assumption, however, is that the issues and lessons that are raised through the discussion of the crops that are included are transferable to most of the others. And, while no blueprints for sustainability are included, the larger purpose of this work is to help the reader understand how to think about agricultural production and the environment.

The discussion for each crop chapter follows the same outline. Each chapter begins with "Fast Facts" that summarize important comparable information for each crop, including maps of production areas. These facts include: the total area in and volume of production, the average and total value of production, the main produc-