

S E C O N D E D I T I O N

ENVIRONMENTAL SCIENCE

A Framework for Decision Making



DANIEL D. CHIRAS

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A Framework for Decision Making

SECOND EDITION

DANIEL D. CHIRAS

University of Colorado, Denver



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Preface

The first edition of *Environmental Science: A Framework for Decision Making* reached a large audience across the United States. Feedback from users and reviewers helped me prepare this second edition. My goal for the new edition was to create a slightly shorter book that fits the one-term course, without omitting any of the coverage and features that were so well received in the first edition.

As in the first edition, I set out to write a book that is user friendly, not laden with irrelevant statistics. I wanted to continue to present important facts and concepts in a clear and exciting way and to minimize bias by presenting the pros and cons of new technologies, population control policies, pollution control measures, and so on. My objective was to write a book that helps students learn the facts behind environmental issues and solutions so that they can make up their own minds about what should be done.

This book provides a broad overview of the many environmental problems facing humanity and the solutions to these quandaries. The chapters contain important information on ecology, anthropology, evolution, earth science, biology, ethics, economics, and other areas to enable students to understand more fully the sometimes overwhelming assortment of environmental problems facing the world. The melding of these disciplines results in new ways of looking at our environmental problems and opens up many avenues for solving them.

Themes

The central theme of this book is that time for action is running short; overpopulation, resource depletion, pollution, and indifference are rapidly catching up with us.

The second major theme is that the long-term well being of this planet and its inhabitants requires the development of a sustainable society—one that conserves nat-

ural resources, recycles, relies on renewable resources whenever possible, reduces pollution, and controls population growth. Such a society, based on the lessons from ecology, may seem foreign or even unattainable, but it remains our only realistic hope for prosperity for the long term. Careful planning and implementation will usher in a sustainable future.

The third theme is that complex environmental problems require complex solutions, not simple ameliorative steps that cure only the symptoms. Political, technological, economic, indeed even ethical changes must all be brought into play to solve the world's environmental dilemmas.

Finally, this book stresses that we are all part of the problem and must therefore be part of the solution. Air pollution is not just a problem of inadequate laws or corporate neglect, but also the result of our own wasteful practices. Solving these problems need not mean reverting to old-fashioned ways or even making tremendous sacrifices. It does mean using energy and other resources much more wisely, conserving all resources, recycling all that we can, using renewable resources, and limiting our family size. Numerous suggestions are given in each chapter for such personal solutions.

Organization

This book is divided in five parts and organized around three central issues—population, resources, and pollution. Part 1 provides a base of knowledge in ecology, earth science, chemistry, biology, evolution, and human social development. Part 2 covers population growth, the impacts of population, and population control. Part 3 deals with a variety of resource issues and outlines a plan for developing a sustainable society. Part 4 discusses pollution and the legal, technical, and personal solutions for

it. Part 5, the capstone of the book, places the population, resource, and pollution crisis against a social backdrop by looking at ethics, economics, and politics. It suggests ways to make the transition to a sustainable society.

Special Features

The following special features from the first edition have been retained to keep this text informative and useful and to increase student interest and involvement:

Models

One of the key features of this book is the use of conceptual models, which in this edition have been integrated in appropriate chapters. These models are easy to understand and are designed to encourage holistic thinking, emphasizing the systems approach to environmental problems. Below is a brief description of each model:

- *Population, Resource, and Pollution Model*: presents a fuller view of the human niche, and helps students see the way we affect our environment and vice versa.
- *Multiple Cause and Effect Model*: helps students analyze the causes of many of our current environmental dilemmas by exhibiting the web of cause and effect.
- *Impact Analysis Model*: shows the various impacts that we have on the environment and the ways in which we are affected by our own actions.
- *Risk Analysis Model*: examines the risks and benefits associated with today's new and existing hazards.

Chapter Supplements

Chapter supplements, found at the end of some chapters, provide more detailed coverage of important topics and provide an added degree of flexibility. Such topics of current interest include acid rain, indoor air pollution, stratospheric ozone depletion, radiation pollution, nuclear war, and environmental law.

Point/Counterpoints and Viewpoints

As might be expected, complex environmental issues often result in hotly contested debates:

- Is outer space the answer to our population and resource problems?
- Are we responsible to future generations?
- Is population growth good or bad for us?
- Does environmental protection cost us jobs?

- Are we losing the war against cancer?
- Are we playing God with nature?

These and many other important and timely issues are debated in Point/Counterpoint or discussed in Viewpoint by such luminaries as Norman Myers, Ben Bova, Garret Hardin, Julian Simon, Amory and Hunter Lovins, Frederic Krupp, and others. These editorials can stimulate individual thinking as well as classroom discussion on many complex problems.

Color Galleries

Four color galleries are included in this book to emphasize some of the key concepts and issues. They are: the earth, the biomes, endangered species, and resource misuse.

Essays

Numerous Essays present interesting findings in environmental science to pique student interest. Newsworthy stories and unique ecological solutions to a number of problems are the topics of these brief articles.

Chapter Summaries

Each chapter is followed by a succinct summary of the important concepts and terms, designed to reinforce the key points. These summaries may also be valuable study tools.

New in the Second Edition

The second edition introduces a number of new features.

The Environmental Quotient

A simple test found in the Prologue to the book offers students a way to determine their attitudes regarding environmental issues as well as their current level of action—that is, how much they are doing to reduce pollution, resource waste, and so on. This section is designed to encourage individuals to take more active roles in solving environmental problems.

Case Studies

Another new feature in the second edition is the Case Study—in-depth studies of important issues in environmental science, such as genetic engineering, protecting Antarctica, problems facing the cleanup of the Great Lakes, and the links between air pollution and Parkinson's disease.

Increased Coverage of the Basic Sciences

I've added more information from the basic sciences to help students better understand environmental issues. The formation of the earth, the evolution of life, geological processes, chemistry, and other fundamental topics are covered in Chapter 2 and integrated in other chapters.

Updated Coverage

The second edition has been thoroughly updated with new discoveries, new environmental laws, the most recent statistics on resources, population, and pollution, and new suggested readings. New essays, viewpoints, photographs, tables, and line drawings have been added as well.

Acknowledgments

This book is the offspring of a great many people, for whom a mere thanks seems terribly inadequate. First and foremost are the thousands of scholars in anthropology, biology, chemistry, demography, natural resources, political science, economics, ecology, and dozens of other disciplines. Their ideas, their research, indeed their lives, form the foundation on which this book rests. To them a world of thanks and an enormous debt of gratitude.

A warm and very special thanks to my friend and colleague, Teresa Audesirk, who reviewed the second edition and helped make it more accurate and more readable and who helped supply me with mounds of reference material needed in the update.

A genuine thanks to the staff at Benjamin/Cummings who labored over this book as if it were their own. A special thanks to Andrew Crowley, my editor, who coordinated much of the long process, who read and commented on the manuscript throughout, who infused the project with enthusiasm and creativity, and whose high standards are evident everywhere; to Martine Westermann, who took over for Andy at the beginning of the production phase, reading and commenting on the text, helping me refine the basic science material and carefully updating facts and figures; to friend, compatriot, and developmental editor, Bonnie Garmus, whose work on the first edition still shows through; to Karen Gulliver, who guided this book through the tedious production stages; to Darcy Lanham who located the new photographs for this text; to eagle-eyed copyeditor Bill Waller who smoothed out the rough spots and carefully checked over the manuscript; to first edition research assistants Dave Shugarts, Cynthia Stuart, Diane Short, and Ann Beckenhauer and second edition research assistants Rae Nelson, Carmen Bal, and Elizabeth Yerkes, who helped update the book.

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Prologue

In an outlying village in Ethiopia, two children are lowered into a communal grave that houses the bodies of others who have died in recent days. Villagers stare vacantly at the men who cover the bodies with dirt; to the friends and relatives of these children who watch, death has lost much of its significance. Against the constant hunger and death, few mourn another child's passing.

Worldwide, 700 people will die from starvation, extreme malnutrition, or infectious disease stemming from food shortages in the half hour it takes you to watch the evening news. This year alone, the death toll from hunger and associated diseases is estimated to be 40 million people. This is the equivalent of 300 jumbojets, each carrying 400 passengers, crashing with no survivors every day of the year. Almost half of the victims are children. Despite an outpouring of aid from the rich nations, hundreds of millions more will die in years to come.

A False Sense of Security?

For Africans of the southern Sahara, the future looks bleak. Long-term drought, overpopulation, continued misuse of the land, and political struggles all create spreading deserts that swallow farmland at an alarming rate. In this dilemma, nature dictates an extreme solution: people must die to reestablish the balance.

But what about those of us in the wealthy nations of the world? Need we worry? To many people, the answer is no. Resource shortages are a thing of the past. Newspaper headlines assure us of an "oil glut" that has forced OPEC nations to slash prices, bringing inflation under control. And there is renewed talk among politicians and business leaders of continued economic growth. Some critics believe that our sense of security is illusory. But why not feel secure; with an ally as powerful as technology, how could we not prosper?

Part of the answer may lie in the way we mistreat our soil, perhaps our greatest resource of all. In the United States, for example, farmers currently cultivate 170 million hectares (421 million acres) of land. According to recent estimates by the Department of Agriculture, nearly one-half of the United States' farmland is eroding faster than it can be replaced by natural processes. Perhaps more importantly, three of every four farmers are unaware that erosion on their property exceeds the replacement level. Making matters worse, there is very little land in reserve to replace the prime land now washing into U.S. waterways. Some experts believe that crop production could fall by 10% to 30% in the United States in the next 50 years if soil erosion continues unchecked. Costs of food will rise as good farmland is destroyed. The United States may lose its position as a leading food exporter. Grain shipments to hungry nations may be reduced as well, unless something is done . . . quickly.

Consider also one of our most valuable resources, oil, thought by many to be the lifeblood of industrial societies. Oil's economic importance to developed nations became clear in the 1970s when per-barrel prices jumped from \$3.00 to over \$35. A whirlwind of inflation began, perilously gripping the industrial world, nearly halting industrial production. The American economy, among others, was driven to its knees. Millions of workers were laid off as inflation brought industrial production to a near standstill.

Despite current, short-term gluts and falling prices, the long-range future of oil is dim. Estimated worldwide oil supplies will last only 70 more years at current consumption. Should consumption rise, as expected, even fewer oil years await us. Clearly, time is running out for oil.

Long before our wells run dry, however, the rich, oil-dependent nations will begin to flounder. By some estimates, somewhere around 2000 or 2010 global oil production will fall short of demand, sending prices sharply

upward. The inflation of the 1970s will seem like warm spring breezes compared to the hurricane winds of global inflation.

You and I, and millions of people like us, will very likely see the end of oil within our lifetimes. The time is ripe for charting new paths, but this nation and others are sitting back, swayed by reports of an apparent oil glut, waiting.

Declining resources are only part of the threat to modern society. Industrial economies jeopardize their future by destroying croplands, forests, streams, lakes, and buildings. Pollution and development threaten to rip apart the delicate web of life. Foremost on the list of pollutants is acid rain and snow.

Today, over 230 ponds and lakes in the Adirondacks have lost their aquatic life because of acids from industry and transportation. Deposited by rain and snow, these acids kill fish, algae, and aquatic plants. In southern Sweden 20,000 lakes are without or soon to be without fish because of widespread acid deposition. In Canada, 100 lakes have met a similar fate. But the effect of acid rain is felt much wider. For instance, much of the once-rich Black Forest in Germany has been poisoned by this toxic rain. And in the United States, acid precipitation causes an estimated \$5 billion worth of damage to buildings and statues. Much of the \$320 million damage to the Statue of Liberty was the result of acid rain.

Compounding our problems is the growing threat of nuclear war. Besides killing millions of people, nuclear war could drastically change global climate, perhaps ushering in a nuclear winter by sweeping millions of tons of dust into the atmosphere that block sunlight and cause surface temperatures to fall. Avoiding a nuclear war ranks high on our list of priorities.

The long-term future of the world is in jeopardy. It is not just the poor of Ethiopia or Chad or Sudan who stand to lose, but also the wealthy residents who make up one-fourth of the world's population but consume 80% of its resources. The rich and the poor are locked in a crisis created by overpopulation, vanishing resources, and excessive pollution.

Tragedy of Our Times

Paul Valery once noted that the tragedy of our times is that the future is not what it used to be. In reality, though, the future is rarely what we think it will be. The tragedy of our times is that few people realize that the future has changed. We are, as a whole, going about our daily lives as if nothing has happened, lulled into complacency by old and fairly unrealistic dreams. Oil gluts, falling gasoline prices, and economic stability have given us a false sense of security at a time when we need, more than anything, three key ingredients: foresight, planning, and action—both individually and collectively.

This book examines the crisis of population, resources, and pollution that engulfs humankind. You will find it a hopeful book, filled with solutions. It views our dilemma in much the same way that the Chinese view crises. Their word for crisis is *wei-chi*. The first part means "beware of danger." The second part means "opportunity for change."

In this spirit, I invite you to look at the critical paths we are now on. You will see that the human race can survive the human race and prosper. But changes must be made—big changes in the way we think and the ways we act.

The Secrets of Nature

What alterations in our course are necessary? Experts disagree, but many believe that the key to our long-term survival lies in the widely ignored lessons of nature. Consider these facts: undisturbed ecosystems persist for decades, centuries, even millions of years. The rate of extinction in such ecosystems is low. Human society, on the other hand, now wipes out a vertebrate (backboned) species every nine months and itself faces global extinction after only a relatively short stay on earth. Why is it that nature persists while we deplete and destroy? The secret of nature is that survival hinges on a sustainable system—a system that perpetuates itself without destroying the very things that permit life to continue.

Nature capitalizes on four major strategies to meet this end. The first is recycling. The global ecosystem is a consummate recycler. Water, carbon, oxygen, nitrogen, and all other substances are used over and over. As a result, new generations are built from the old. The long-term future of humankind depends on following a similar direction.

Nature's second secret is the use of renewable resources—resources that renew themselves through natural biological or physical and chemical processes. Wood, water, and wind are examples. For millennia, humankind heated its homes with wood, reaped the riches of the biological world for food, and fashioned its goods from flax and other plant products. Only in the past 200 years has our allegiance to renewable resources wavered. Today, we depend heavily on a variety of non-renewable substances: fuel, plastics, and synthetic fabrics made from oil; metals; and so on. Our new dependency, many think, is a dangerous trap. It cannot be sustained indefinitely. Our long-term future requires a greater dependency on resources that can renew themselves. Protecting these resources is a form of self care.

Nature's third secret is conservation. A fat wildebeest or an obese ostrich do not exist in nature. For the most part, organisms use what they need—no more, no less. Modern industrial societies, on the other hand, are often

gluttonous, overeating, wastefully consuming, and recklessly depleting. Ecologists warn us that we cannot do so forever with impunity.

The fourth secret of nature is population control. Through a variety of ways, populations of living things are kept from living beyond their means. Predators trim the prey populations. Diseases eliminate the weak and aged. Environmental conditions keep populations from exploding. For humans, technological advances, medicine, and sanitation have removed many of the natural barriers to human population explosion. The upshot of the rapid human population expansion is often foul-smelling skies, filthy water, and landscapes devoid of vegetation and animal life. The ecosystem is sacrificed to continue population growth. Most ecologists agree that we must learn to control our numbers to preserve the global ecosystem.

Such are the secrets of nature: recycling, renewable resources, conservation, and population control. It is ironic that today we must go back to nature to relearn these forgotten lessons. If we are to survive for thousands of years to come, we must build a sustainable society, a society that lives in harmony with nature, not a society that seeks complete domination over all living things or destroys its renewable resource base. Building a sustainable society does not mean reverting to a primitive existence, it means using resources in a pattern laid down by nature.

Frontiers

A great frontier lies ahead of us. It is not the great expanse of space or the oceanic depths that we must conquer, but rather it is ourselves. Ahead of us lies the greatest and sometimes most inaccessible frontier—that of self-understanding and self-control. Before we race further into space to satisfy our needs, we must learn to look deeper within ourselves and find ways to build a sustainable society.

We can achieve such a society within our lifetimes, but each of us must help. Individuals must do more than pay lip service to recycling, conservation, renewable resources, and population control, and they must take action now. This book looks at the problems and suggests ways to build a sustainable society. It concerns itself more with the long-term future of humankind, recognizing fully that we must make changes now to transition smoothly into sustainability. Some of you may wonder why we should worry about future generations. Shouldn't we let them fend for themselves? And why should we change our ways now? Part of the answer is that we hold the future in our hands. At no time in history has the present generation had such potential to shape the future. The decisions we make on nuclear energy, acid rain, and tropical rainforests will affect our sons and daughters and

theirs more profoundly than they will affect us. It is for this reason alone that we must rethink the past and redefine the future.

A sustainable society will not be a radical departure from our current way. In fact, many examples of sustainability are now commonplace, like bottle bills, battery recycling, water conservation, and wilderness preservation. It takes only a small effort and a little wisdom to get back on track. Abraham Lincoln said it best, "As the times are new, so we must think and act anew." Let this be our challenge: to see that the future is no longer what it used to be and to build a future that will last.

What is Your EQ?

All organisms draw from the environment the things they need to survive. Of all living things, however, we humans place the largest demands on the environment. Our advanced technologies and burgeoning numbers are cause for an enormous strain on earth's life-giving support systems. By driving our cars, watering our lawns, feeding our families, recreating, and thousands of other activities we pollute and deplete resources.

Many futurists believe that to build a lasting society humanity must be more environmentally conscious and learn to reduce its impact and resource demand. The test presented here can help achieve this goal in two ways: First, it can help each of us assess our attitudes toward the environment. Second, it can help us assess the environmental impacts of our lifestyles.

Please take a few minutes to answer the following questions. When you have finished add up your scores and compare them with the scales provided at the end. You might want to analyze areas in the second test (on actions and impacts) to see where you need work and draw up a plan to improve your score, but be careful to select a realistic goal. Retake the test at the end of the semester and compare your scores to see the progress you have made.

Environmental Quotient

Area 1: Environmental Attitudes

This section queries your attitudes toward the environment. Please answer them as honestly as possible, indicating what you really think and not what you think your professor might want to hear.

Please note that words mean different things to different people. Thus, it is difficult to find a wording that suits each person.

Circle the correct responses and total them for your attitude score.

1. Generally speaking, how strongly do you favor the environmental movement?
Not at all 0 1 2 3 4 5 Strongly support
2. Generally speaking, would you favor environmental protection if it meant slower economic growth?
Not at all 0 1 2 3 4 5 Very much so
3. Generally speaking, would you support a candidate for public office if he or she favored spending more to reduce pollution?
Not at all 0 1 2 3 4 5 Very much so
4. Would you be willing to change your lifestyle (say, reduce home energy consumption or use mass transit more often) to help reduce air pollution?
Not at all 0 1 2 3 4 5 Very much so
5. Would you favor a reduction in population growth in the United States?
Not at all 0 1 2 3 4 5 Very much so
6. Would you support a reduction in U.S. population size?
Not at all 0 1 2 3 4 5 Very much so
7. Would you support a reduction in population growth in Third World nations?
Not at all 0 1 2 3 4 5 Very much so
8. Would you support a nationwide recycling bill, requiring all bottles and cans to be returned for recycling?
Not at all 0 1 2 3 4 5 Very much so
9. Do you support the nationwide law to increase the speed limit on the nation's highways?
Very much so 0 1 2 3 4 5 Not at all
10. Generally speaking, would you prefer to live in a nation that emphasizes conservation of energy over development of new energy supplies?
Not at all 0 1 2 3 4 5 Very much so
11. Generally speaking, do you support wilderness protection, even if important minerals could no longer be extracted from the land?
Not at all 0 1 2 3 4 5 Very much so
12. Do you think that humans are apart from nature and immune to its laws or a part of it and, therefore, subject to its rules?
Apart from 0 1 2 3 4 5 A part of nature
13. Given the choice between a vehicle that gets 40 miles per gallon and one that gets 25 miles per gallon but costs \$1,000 less, would you buy the low-polluting gas miser (supposing that the cars are identical in all other respects)?
Probably not 0 1 2 3 4 5 Absolutely
14. Would you oppose a 10% increase in food prices to cut back on soil erosion to protect America's farms for future generations?
Absolutely 0 1 2 3 4 5 Absolutely not
15. Would you support a 10% increase in the cost of all paper, books, wood and wood products if that money were to be spent on protecting tropical rainforests?
Probably not 0 1 2 3 4 5 Absolutely
16. Generally speaking, would you support your state if it refused to sponsor the Winter Olympics, which would bring in millions of dollars of revenue, because the site would irreparably damage a popular cross-country skiing and hiking spot, as well as the habitat of an endangered species?
Probably not 0 1 2 3 4 5 Absolutely
17. Would you voluntarily water your lawn at night or reduce the length of your daily showers to help your city/town conserve water?
Probably not 0 1 2 3 4 5 Absolutely
18. Which should dictate the way resources are managed?
Economics 0 1 2 3 4 5 Environmental concerns
19. Humans are superior to all other forms of life and should dominate nature?
Absolutely 0 1 2 3 4 5 Absolutely not
20. Generally speaking, would you prefer to live in a society that conserves resources to benefit future generations if it means fewer material goods for you?
Absolutely not 0 1 2 3 4 5 Absolutely

Environmental Attitude Scale

Your environmental attitude is	if you scored
Very strong	90–100
Strong	80–89
Moderately strong	60–79
Moderately weak	40–59
Weak	20–39
Very weak	0–19

Area 2: Actions and Impacts

This section assesses your actions and impacts. Answer each question and add up the score when you are finished.

Give yourself

1. 10 points if you plan to have 0–2 children _____
2. 5 points if you generally recycle all of your aluminum cans _____
3. 5 points if you generally recycle your newspaper _____
4. 5 points if you generally recycle your glass containers _____
5. 20 points if you drive a car that gets over 45 miles per gallon on the highway _____
6. 10 points if you drive a car that gets over 35 miles per gallon on the highway _____
7. 5 points if you drive a car that gets over 25 miles per gallon on the highway _____
8. 20 points if you walk, take a bus, carpool, or ride your bike to work or school _____
9. 5 points if you use energy-conserving lightbulbs _____

10. 10 points if you keep your heat at 68° F in the winter _____
11. 10 points if you generally donate old clothes and other goods to charitable organizations _____
12. 10 points if you have your car tuned at least once a year _____
13. 5 points if you generally turn off your TV or stereo when you leave home _____
14. 5 points if you turn off lights when you're out of a room for more than a minute _____
15. 5 points if you turn the water off while you're brushing your teeth _____
16. 5 points if you take showers shorter than 5 minutes _____
17. 5 points if you regularly obey the speed limit _____
18. 5 points if you have written a congressional representative stating your view on an environmental issue within the past year _____
19. 5 points if you regularly read an environmental publication _____
20. 5 points if you are a member of an environmental organization _____
- Total score _____

Action and Impact Scale

Your rating is	if you scored
Excellent; keep up the good work	over 100
Good; but there's room for improvement	75–100
Fair; there's plenty of room for improvement	50–74
Poor; lots of room for improvement with a little effort on your part	less than 50

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