

Environmental and Economic Sustainability



Paul E. Hardisty

 CRC Press
Taylor & Francis Group

Environmental and Economic Sustainability

Environmental and Ecological Risk Assessment

Series Editor

Michael C. Newman

College of William and Mary
Virginia Institute of Marine Science
Gloucester Point, Virginia

Published Titles

Coastal and Estuarine Risk Assessment

Edited by

Michael C. Newman, Morris H. Roberts, Jr., and Robert C. Hale

Risk Assessment with Time to Event Models

Edited by

Mark Crane, Michael C. Newman, Peter F. Chapman, and John Fenlon

Species Sensitivity Distributions in Ecotoxicology

Edited by

Leo Posthuma, Glenn W. Suter II, and Theo P. Traas

Regional Scale Ecological Risk Assessment: Using the Relative Risk Method

Edited by

Wayne G. Landis

Economics and Ecological Risk Assessment: Applications to Watershed Management

Edited by

Randall J.F. Bruins

Environmental Assessment of Estuarine Ecosystems: A Case Study

Edited by

Claude Amiard-Triquet and Philip S. Rainbow

Environmental and Economic Sustainability

Edited by

Paul E. Hardisty

Environmental and Economic Sustainability

Paul E. Hardisty



CRC Press is an imprint of the
Taylor & Francis Group, an **informa** business

CRC Press
Taylor & Francis Group
6000 Broken Sound Parkway NW, Suite 300
Boca Raton, FL 33487-2742

© 2010 by Taylor and Francis Group, LLC
CRC Press is an imprint of Taylor & Francis Group, an Informa business

No claim to original U.S. Government works

Printed in the United States of America on acid-free paper
10 9 8 7 6 5 4 3 2 1

International Standard Book Number: 978-1-4200-5948-9 (Hardback)

This book contains information obtained from authentic and highly regarded sources. Reasonable efforts have been made to publish reliable data and information, but the author and publisher cannot assume responsibility for the validity of all materials or the consequences of their use. The authors and publishers have attempted to trace the copyright holders of all material reproduced in this publication and apologize to copyright holders if permission to publish in this form has not been obtained. If any copyright material has not been acknowledged please write and let us know so we may rectify in any future reprint.

Except as permitted under U.S. Copyright Law, no part of this book may be reprinted, reproduced, transmitted, or utilized in any form by any electronic, mechanical, or other means, now known or hereafter invented, including photocopying, microfilming, and recording, or in any information storage or retrieval system, without written permission from the publishers.

For permission to photocopy or use material electronically from this work, please access www.copyright.com ([http://www.copyright.com/](http://www.copyright.com)) or contact the Copyright Clearance Center, Inc. (CCC), 222 Rosewood Drive, Danvers, MA 01923, 978-750-8400. CCC is a not-for-profit organization that provides licenses and registration for a variety of users. For organizations that have been granted a photocopy license by the CCC, a separate system of payment has been arranged.

Trademark Notice: Product or corporate names may be trademarks or registered trademarks, and are used only for identification and explanation without intent to infringe.

Library of Congress Cataloging-in-Publication Data

Hardisty, Paul E.
Environmental and economic sustainability / Paul E. Hardisty.
p. cm. -- (Environmental and ecological risk assessment)
Includes bibliographical references and index.
ISBN 978-1-4200-5948-9
1. Sustainable development. 2. Environmental protection. I. Title.

HC79.E5H3537 2010
338.9'27--dc22

2009052896

Visit the Taylor & Francis Web site at
<http://www.taylorandfrancis.com>

and the CRC Press Web site at
<http://www.crcpress.com>

Dedication

*To the mentors in my life: Dad, Fred, Tad, and Peter. Thanks
for your wisdom, guidance, criticism, and support.*

Contents

Foreword	xvii
Preface.....	xix
About the Author	xxi

Chapter 1	Introduction.....	1
	The Exponential Era.....	1
	Crisis—Which Crisis?.....	1
	All Feeding Off Each Other.....	3
	Cheap Energy, Climate Change, and Poverty	3
	A Crisis of Sustainability	4
	Do We Want A Sustainable World?.....	5
	Industry Can and Must Be Part of the Answer	6
	True Sustainability for This Century	6
	Sustainability: Different Perspectives, Different Meanings.....	6
	Words, Thoughts, and Action	7
	What Do I Give Up? What Do I Get?.....	8
	Comparing Apples, Refrigerators, and Giraffes	8
	In the End, Money Rules	8
	The Dilemma for Industry.....	9
	Sustainable Decisions for the Twenty-First Century.....	10
	Making Sustainability Relevant to Business and Industry.....	11
	Environmental and Social Economics for Industry	12
	The Response of Business	14
	Objectives and Structure of the Book	15
	Notes.....	16
Chapter 2	Sustainability in the Twenty-First Century	17
	A Short History of Sustainability.....	17
	A 40-Year Journey	17
	Silent Spring	17
	Regulations with Power.....	17
	Earth Day.....	18
	Industry Awakens	18
	The Emergence of an Idea.....	19
	Environmental Economics	20
	Bhopal.....	20
	<i>Exxon Valdez</i>	20
	The Fight to Save the Ozone	21
	Sustainable Development Is Born	21
	Strong versus Weak Sustainability	22

The Triple Bottom Line	22
The Nobel Peace Prize	23
From Concept to Core Principle	23
The Challenges of the Twenty-First Century	24
An Overview of Global Trends	24
Our Changing Relationship with the Planet	25
More People, Less to Go Around	25
Providing a Decent Standard of Living for 10 Billion People	26
The Fossil Fuel Industry: An Example	26
The Metrics of Sustainability	27
Food and Poverty	28
The Hidden Costs of Food	28
Feeding a Growing Population	28
Poverty: Progress and Setbacks	29
Water	30
An Unevenly Distributed Renewable Resource	30
Moving Water	31
Increasing Water Stress	32
Water Is Life	33
Water Pollution	33
Water and Industry in the Middle East	34
Global Trends	35
Biodiversity	36
Ecosystem Services	36
The Living Planet Is Ill	37
Using More of Everything than the Earth Produces	38
The Plight of the Oceans	39
No Pain, No Change	40
Climate Change	41
The Effects of Climate Change	42
Public Opinion versus Science	42
A New Sense of Urgency	43
A Climate Change Risk Assessment	43
An Unsustainable Course	44
Despite Local Successes, Accelerating in the Wrong Direction	45
Time to Change Direction	46
Why Sustainability Has Not Worked	46
Overview	46
A Time of Plenty	47
The Industrial Revolution Changes the Rules	47
The Twentieth-Century Prosperity Explosion	47
The Energy–Climate Problem	48
Tangible Impact of Sustainability	49
Eighteenth-Century Economics	49
Economics for a Different Time	49

The Tragedy of the Commons	50
Without Price Signals Nothing Will Change.....	50
Twentieth-Century Engineering	50
Twenty-First Century Economics.....	51
Better Decision Making Will Make Us More Sustainable	51
It Is Not Only about Cost.....	51
It Is Also about Benefits.....	52
We Can Do This Now.....	52
Conclusion	53
Notes.....	54

Chapter 3 Quantifying Sustainability for Improved Decision Making	59
Balancing Environment, Society, and Economy	59
Introduction	59
The Problem with GDP	59
Promoting Unsustainable Behavior	60
A More Sustainable Alternative: Net National Welfare	61
From Macro to Micro	61
How Industry Makes Decisions.....	62
Economic Quantification of Sustainability	62
An Economic Definition of Sustainability	63
A Double-Edged Sword.....	64
The Externalities Can Be Worth a Lot.....	64
An Illustration: The NPV-Internal Rate of Return Trap	64
Example: Heat Recovery in the Petroleum Industry	65
The Environmental and Economic Sustainability Assessment:	
Embedding Sustainability in Decision Making	66
Approach Overview.....	66
Framing Workshop.....	67
Determine the Objective and the Level of Assessment.....	68
Identify Options for Achieving the Objective	70
Identify Assets to Be Included in the Assessment.....	71
Identify Risks and Constraints	73
Agree on Planning Horizon for the Assessment	73
Set the Life-Cycle Boundaries of the Assessment.....	74
Identify Range of Discount Rates to Use	75
Framing Session Output	76
Physical Quantification of Options.....	76
Socioenvironmental Economic Analysis	76
Full Social Cost–Benefit Analysis.....	76
Net Benefits.....	78
Valuation of Benefits	80
Private Benefits	80
External Benefits.....	80

Internal Costs.....	81
External Costs.....	82
Valuing the Environment and Society.....	82
Overview	83
Valuation Techniques	83
Actual Market Techniques.....	83
Surrogate Market Techniques.....	84
Hypothetical Market Techniques.....	84
Greenhouse Gas Emissions	84
The Carbon Markets.....	85
The Social Cost of Carbon	85
Air Pollution	87
Water.....	89
The Total Economic Value of Water	90
Water Value Estimates.....	91
Biodiversity.....	91
Overview.....	91
Social Externalities.....	94
Using Valuation Data.....	94
Applying the Environmental and Economic Sustainability	
Assessment	97
Application of Social Cost–Benefit Analysis in Decision	
Making	97
Apportionment of Costs and Benefits.....	97
Externalities Change Perception of Optimality.....	98
Private Sector Organizations and External Costs	100
An Environmental, Social, and Economic Optimum.....	101
Full Environmental, Social, and Economic Life-Cycle	
Modeling.....	102
Calculation Software	102
Optimizing Decision Making.....	103
Sensitivity Analysis	103
Gauging the Implications.....	104
Communicating Decisions.....	107
Examples	107
Notes.....	108
Chapter 4 Water	113
Introduction	113
Water Management in Industry: Overview	114
Water Use and Protection in Oilfield Development in North	
Africa.....	115
Background.....	115
Water Resources in North Africa	119
An Ancient Groundwater Resource.....	119

Water Use and Availability in Libya.....	120
Water Use in the Petroleum Sector and Regulatory Context.....	121
Environmental and Economic Sustainability Assessment	
Objective and Options	122
Option Development and Costing	122
Option 1: Base Case—Unrestricted Freshwater Use.....	123
Option 2: Lower Groundwater Use Option	124
Option 3: No Groundwater Use Option	124
Option 4: No Freshwater Use with PFW Rejected into the Producing Formation	125
Option 5: Alternative Source of Injection Water	125
Option 6: Community-Based Bottled Water Operation	125
Option 7: Solar Desalination Mitigation Replacement.....	126
Benefits Assessment	127
Approach.....	127
Benefits Valuation.....	127
Costs and Benefits: Base Case.....	129
Sensitivity Analysis	131
Case of High Water Value	131
Case of High Oil Value and High Water Value	133
Variation of Discount Rate	133
Implications	134
Produced Water Management in Oilfield Operations	135
Background: Produced Water.....	135
Example: Produced Water Disposal and Groundwater Protection.....	135
Example: Produced Formation Water Reuse Assessment.....	137
Background.....	137
Options Development and Costing	137
Benefits Identification and Valuation.....	138
Base Case Economic Sustainability Analysis	142
Sensitivity Analysis	144
Implications	144
Limitations.....	144
The Value of More Data	145
Water Management in Mine Development.....	145
Background.....	145
Options Description.....	146
Option Costs	148
Benefits Assessment and Valuation	150
Greenhouse Gas Emissions	151
Total Economic Value of Water.....	151
Proliferation of Weeds	152
Indigenous and Heritage Value.....	153
Ecological Footprint	154
Loss of Creek Valley Biodiversity	154

Ecosystem Support Value of Streams.....	155
Community Amenity Value of Streams	155
Benefits Summary	155
Proportion of Benefits Realized by Each Option	156
Economic Sustainability Assessment Results	157
Scope and Basis of the Assessment	157
Base Case Analysis.....	157
Base Case without Heritage.....	157
Solar Thermal Power Plant Option.....	161
Sensitivity Analysis	163
Sensitivity to the TEV of Water.....	163
Sensitivity to Energy Price Escalation.....	164
Conclusions and Implications.....	165
Limitations.....	166
Example: Determining a Sustainable Wastewater Treatment and Discharge Strategy	167
Overview: Treatment and Discharge of Wastewater	167
Basis of Analysis	168
Treatment and Discharge Options	168
Benefits	169
Proportion of Benefits Realized by Each Option	171
Apportionment Due to Treatment Quality	171
Apportionment Due to Location.....	172
Options Costs.....	172
Assessment Results: Base Case	172
Sensitivity Analysis	176
Conclusions.....	178
Summary	178
Notes.....	178
 Chapter 5 Greenhouse Gases and Climate Change	181
Introduction	181
Carbon Mitigation Risk.....	182
Pricing Carbon in Business Decisions	183
Example: GHG Management in the Gas Industry.....	186
Adaptation Risks	187
Overview	187
Example.....	187
A Caution to Designers, Engineers, and Managers.....	189
Example: GHG Management in Heavy Oil Production	189
Background.....	189
Options	190
Cost Estimate Basis and Assumptions	191
Benefits Assessment and Valuation	193
Benefits Summary	193

Proportion of Benefits Realized by Each Protection Measure	194
Economic Sustainability Assessment Results	194
Scope and Basis of the Analysis	194
Base Case	194
Sensitivity Analysis	197
Sensitivity to Energy Price Escalation	197
Sensitivity to CO ₂ Value	199
Sensitivity to NO _x and SO _x Emissions	200
Sensitivity to Water TEV	200
Sensitivity to Discount Rate	200
Option Selection	201
Implications	202
Summary	203
Notes	203
Chapter 6 Energy	205
Introduction	205
Creating a Sustainable Future	205
Sustainability and Energy	205
An Energy Mix for the Future	206
Example: The External Costs of Power Production	207
Example: Commercial-Scale Solar Thermal Power in Australia	210
Introduction	210
CSP Technology Overview	211
Facility Description and Costing	211
Financial Analysis	213
Environmental and Economic Sustainability Assessment	215
Energy Security	217
Carbon Cost Reduction	217
Carbon Emission Reductions	217
Early Mover Advantages	218
Public Relations and Corporate Responsibility Benefits	218
Example: Comparing Renewable Energy Options	218
Introduction	218
Options Description and Costing	218
Benefits Assessment	219
Valuing Salinity Amelioration Benefits	221
Cost–Benefit Analysis	221
Base Case Results	222
Sensitivity Analysis	224
Sensitivity to GHG Value	225
Sensitivity to Salinity Amelioration Benefits	225
Sensitivity to Revenue from Activated Carbon	226
Sensitivity to Energy Price	226

Sensitivity to Social Discount Rate	226
Cumulative Probability	226
Decision-Making Implications	227
Summary	228
Notes.....	229
Chapter 7 Contaminated Sites and Waste	231
Introduction	231
Conceptual Framework	232
Space and Time	232
Remedial Objective	233
Remedial Strategy	234
Remedial Technology	235
The Economics of Remediation	235
Financial Costs of Remediation	236
External Costs of Remediation.....	236
Benefits of Remediation	238
Private Benefits.....	239
External Benefits	239
Remediation of Brownfield Sites: Unlocking Private Benefit	240
Blight Reduction: External Benefit.....	242
Economic Sustainability Analysis for Contaminated Land.....	243
Overview	243
Application	244
The Social Cost of Waste Management Using Landfill	244
Overview	244
An Overview of Waste Trends	245
Social Costs	246
Social Costs and Landfill Taxes	247
Summary	248
Case History: Brownfield Redevelopment in Canada	248
Background and Setting	248
Site Description and Contaminant Distribution	249
Remedial Approach.....	249
Cost–Benefit Analysis	250
Implementation and Outcomes.....	251
A Wider Perspective.....	251
Case History: Groundwater Remediation at a Refinery in Europe.....	252
Overview	252
Site Conditions.....	252
Risk Assessment	252
Constraints to Remediation	253
Level of Analysis	255

Remedial Costs.....	257
N1: Monitored Natural Attenuation.....	257
S1: Readily Mobile NAPL Removal Plus MNA.....	257
S2: Full NAPL Removal Plus MNA.....	257
S3: Full NAPL Removal and Site Remediation as Part of Site Decommissioning Plus MNA.....	257
P1: Hydraulic Containment at Chemical Manufacture Area Boundary	258
R1: Divert Groundwater Pumping to Other Abstraction Wells	258
R2: Treat BHA Groundwater Abstraction.....	258
R3: Replace Extracted Groundwater with Main Water.....	258
External Costs.....	258
Benefits	258
Property Value	259
Water Abstracted from BHA	260
Benefits to Neighbors.....	260
Aquifer Value.....	261
Estuary.....	261
Benefit Apportionment	262
Base Case Assessment Results	262
Sensitivity Analysis	262
Discussion.....	264
Implications	266
Remediating NAPLs in Fractured Aquifers.....	266
Introduction	266
Technical Considerations.....	267
Example: DNAPL in a Fractured Carbonate Aquifer, United States	268
Background.....	268
Benefits of Remediation	269
Remedial Approach Options	270
Simple High-Level Environmental and Economic Sustainability Analysis	270
Implications	270
Example: NAPL in a Fractured Carbonate Aquifer, United Kingdom.....	271
Background.....	271
Remedial Objective	272
Benefits of Remediation	273
Remedial Approach Options	274
Indicative Remedial Costs	274
Base Case Analysis.....	276
Sensitivity Analysis and Decision Making	279
Discussion.....	282
Notes.....	283

Chapter 8	Best Practice for the Twenty-First Century	287
	Summary	287
	Technology	288
	Management and Decision Making	289
	The Necessary Evolution of the Environmental Impact	
	Assessment	289
	Regulatory Capacity Development	290
	Revealing the Real Cost of Corruption	290
	Into the Future	291
	Now Is the Right Time	291
	From Remediation to Prevention	292
	Future Value Trends	293
	Toward a New Metric of Success	294
	Industry Can Lead the Way and Benefit in the Process	294
	Summary	295
	Notes	295
Index		297

Foreword

Until relatively recently, serious discussion of environmental issues at board level was the preserve of an enlightened few companies. For most, protection of the environment was considered to be only a legal compliance issue. However, recognition of the magnitude and severity of human impact on the global climate, coupled with society's demand for greater corporate social responsibility, has changed all that. Whilst climate change has dominated the environmental agenda in recent years, there is a growing awareness that preservation of the wider environment, dwindling resources and social well-being demand an integrated approach if future generations are to prosper.

Whilst this is a great philosophical conclusion to reach, we live in a world where the common global language is money. Hardisty's book shows us how to use the language of money to make decisions that are right for the environment, society, and, critically, the commercial world that we rely upon to increase our quality of life. This does not mean that we are being encouraged to somehow "sell out" the environment, but rather that by measuring and internalizing the value of the environment and resources to society, we will make decisions that are more sustainable for all.

Dr. Steve Wallace

*Head of Climate Change and Environment
National Grid*

Preface

At the United Nations Copenhagen Climate Conference in December 2009, I had the opportunity to meet with a senior scientist from the U.S. National Oceanographic and Atmospheric Administration (NOAA) in the U.S. pavilion. He was playing with a remote control device that was directing the data feed to four high-definition projectors aimed at a massive translucent sphere hanging from the ceiling. The sphere, of course, was Earth. He brought up satellite and radar imaging data on Arctic sea ice for every day going back several years and then let it run. We watched the sea ice go through its yearly cycle of winter expansion and summer contraction. He stopped the run at mid-September 2009 and described what we could see: an ice pack that was at its third smallest areal extent ever (2007 was the lowest; it dropped 35% below the long-term average in one year, with a slight recovery in 2008). Then, he explained the significance of the vast gray areas clearly visible against the white ice. “These are areas of thinning ice,” he said. He went on to explain that the overall volume of Arctic ice is now less than one-third of what it was in the 1970s, and that 2009 was the lowest ever on record (so far).

The data are coming in quickly now. The World Meteorological Organization reported that the decade ending in 2009 was the warmest ever on record, and that each successive decade has been warmer than the last. The year 2009 was the fifth warmest on record. Twelve of the warmest years on record have occurred in the last 12 years. The natural climate has always been variable, but now the human-induced overprinting is becoming more and more dominant. And yet, our emissions continue to accelerate.

Climate change is not the only issue facing us in the twenty-first century. Water scarcity, the urgent need to produce more food for the billions we will add to the world’s population over the next 40 years, the increasing disparity between rich and poor, the unraveling of many of the world’s ecosystems, species loss, and the plight of the oceans are all equally deserving of our attention. We need to find and implement solutions to all of these (and other) challenges, and do it quickly, or face a perilous future.

Many of the fixes, particularly to global issues like climate change, may at first appear to be global in scale, solved only by international treaties and national policy. But, the combined effect of the millions of smaller-scale project and policy decisions made every day by businesses, industry, and organizations of all kinds is what makes global trends. At this smaller scale, a move toward more environmentally, socially, and economically sustainable choices, options, and policies can have a powerful effect.

This book, the result of over 15 years of research and practice, introduces the environmental and economic sustainability assessment (EESA), a process that helps decision makers at all levels balance the needs of society, the environment, and business over the long term by quantifying sustainability in a way that is physically based and objective. Ultimately, this book is about communication: including stakeholders

in a transparent process that provides a robust view of how various options compare over a wide range of possible future conditions using a language that everyone understands—money.

In Copenhagen, the real climate change debate was mostly about money: who is going to pay and how much, how developing countries can access financing. Although everyone understands that we must act, they also realize that nothing can be done without funding—simply because money is how we measure *value* (whether we like it or not). Ultimately, the solutions to the problems of the twenty-first century will come from understanding and acknowledging the tremendous value that the environment provides, and reflecting that value within decision making at every level so that *society as a whole* is better off from each choice we make. Perhaps it will be the sum of all of those beneficial decisions, taken every day, at every level, that will help to change the world.

Paul E. Hardisty

About the Author

Paul E. Hardisty is executive director, Sustainability and EcoNomics™ for WorleyParsons, one of the world's largest engineering companies. For over twenty years, he has been advising industry and governments around the world on environmental strategy and sustainability. He is a visiting professor in environmental engineering at Imperial College, London, and adjunct professor at the University of Western Australia School of Business, where he teaches sustainability and climate change to MBA students. Paul is the author of numerous technical papers, books, and newspaper articles on environmental issues and a soon-to-be-released novel, which he describes as an eco-thriller. He is a contributor to President Gorbachev's Climate Change Task Force, a member of the Waste Management Authority of Western Australia, and a director of Green Cross Australia. Paul lives in Western Australia with his wife, Heidi, and two sons, Zachary and Declan, and for fun competes in Ironman triathlons.



1 Introduction

THE EXPONENTIAL ERA

In the twenty-first century, the world is a place of unrelenting and ever-accelerating change. Financial turmoil sends the global economy from the heights of boom to unprecedented depression in a few short months; the price of oil skyrockets to over five times its previous long-term average and then tumbles down again in a matter of weeks (Figure 1.1); after taking a hundred thousand years to reach just over 6 billion, the world's population will grow by almost 4 billion in the next 40 years¹ (Figure 1.2); the extent of arctic sea ice, in steady decline since the middle of the last century, falls off alarmingly in 2007 and 2008;² emissions of greenhouse gases (GHGs) to the atmosphere are rising faster than ever before.³

We live in the exponential era—a time unique in history, when a confluence of overlapping and mutually reinforcing factors is propelling the world into unknown economic, social, and environmental territory at an accelerating rate.⁴ Not only are there ever more people on the planet,⁵ but quickening development, particularly in India and China, means that each of these people is demanding more of the world's resources. Technology spurs development, and our exploding technological prowess allows us to wield greater power over our environment and surroundings than ever before. A single man with a D8 caterpillar can now clear as much land in a day as his grandfather could have in a decade of hard manual labor. Our ability to assimilate, use, and process data and information is exploding, just as predicted by Gordon Moore, the founder of Intel. In the 1960s, he predicted that the number of transistors on a silicon chip would double every 18 months—and it has, inexorably, since then.⁶ But, a rapidly rising global population, combined with accelerating development and resource use, surging energy demand, and an ever-expanding need for water and food, is also creating huge stress on the natural environment. This combination of forces, which some are now calling simply *global change*, is leading to chronic overfishing, large-scale clearing of native forest, an alarming and accelerating loss of global biodiversity, and increasingly stronger evidence of the impacts of climate change.⁷ Many are now calling this a time of unprecedented global environmental crisis.⁸

CRISIS—WHICH CRISIS?

But other issues, equally worthy of the dubious distinction “crisis,” abound. Poverty remains a blight on humanity. Today, according to the most recent statistics from the United Nations, approximately 45% of the world's population lives on less than US\$1 per day.⁹ In the United States or Europe, that much would not buy one decent meal. An astonishing 65% of the world lives on less than US\$2 per day. And, the

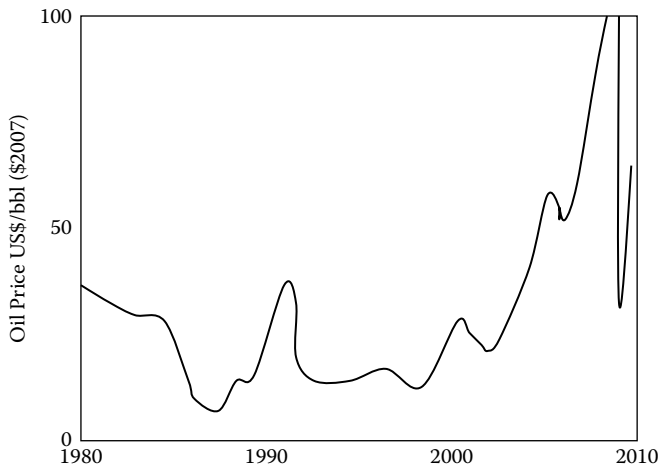


FIGURE 1.1 Actual oil price in U.S. dollars per barrel, 1975–2009, with 2% and 5% increase trend lines from 1988.

numbers of chronically poor are increasing despite the efforts of well-intentioned organizations and individuals around the world. But, the disparity in income is not the only measure of poverty. Never before in modern history has wealth been more concentrated in fewer hands: The richest 1% of the people on the planet control about half of the wealth. The poorest half of the population, over 3 billion people, owns less than 1% of the planet's wealth. This shocking inequality is also growing, accelerating in the wrong direction (20 years ago the top 1% controlled about a quarter of the wealth). Poverty can also be measured in other ways. Over 1 billion people on the planet lack access to safe, clean drinking water, and that number is rising. Lacking this most fundamental of goods, these people are *water poor*, and it affects every

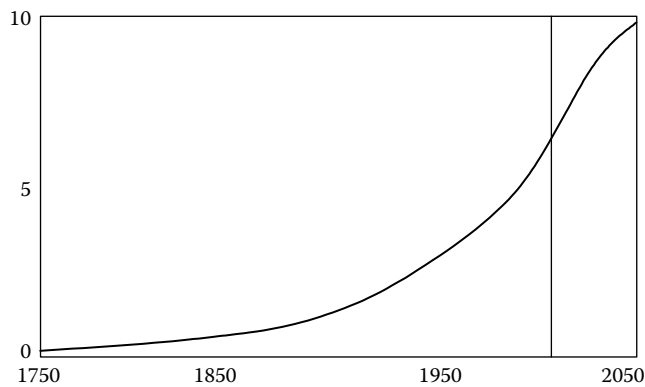


FIGURE 1.2 World population growth 1750–2050 based on data from U.N. Population Project and Cohen (1995).

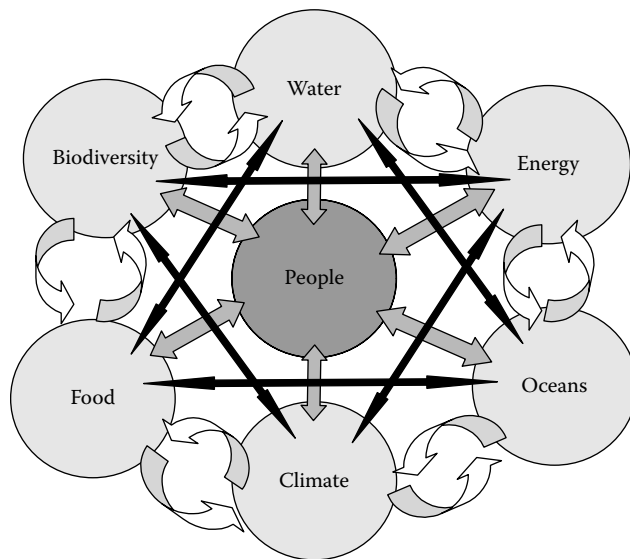


FIGURE 1.3 An interconnected world: humankind’s all-affecting role on the planet.

part of their lives. These are all examples of increasingly unsustainable trends—they cannot continue indefinitely, as history has shown, without causing major ruptures in society.

ALL FEEDING OFF EACH OTHER

Many, if not most, of these crises are actually interlinked, interdependent, and mutually reinforcing. Figure 1.3 provides a basic schematic overview of the causative and consequential links between people and the world we inhabit. The interdependence is startling. An economic paradigm that focuses on gross domestic product (GDP) and does not explicitly account for the value of external issues (environment, society, depletion of natural capital) accelerates the use of natural resources of all kinds and concentrates wealth; concentration of economic wealth and income disparity create poverty; poverty causes environmental degradation as people are forced to destroy natural capital just to survive; environmental degradation further reinforces the poverty cycle as the land is degraded; and pollution leads to health impacts, further loss of income-generating potential, damage to the means of livelihood, and eventually social strife. Civil unrest among the disaffected and displaced leads to the rise of extremism and terrorism. And as the population grows, and each of these issues develops more rapidly, the need for solutions becomes even more urgent.¹⁰

CHEAP ENERGY, CLIMATE CHANGE, AND POVERTY

The widespread availability of “cheap” fossil energy has driven global economic growth, creating prosperity for many (but not most), but as a consequence has laden the atmosphere with billion of tonnes of GHGs, which are accelerating the natural

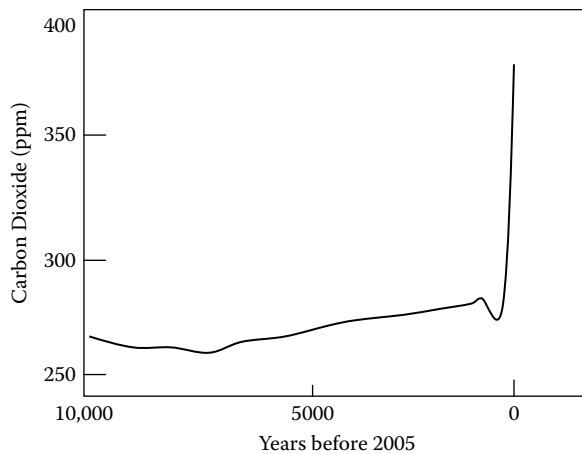


FIGURE 1.4 Atmospheric concentrations of CO₂ over the last 10,000 years (based on data from the Intergovernmental Panel on Climate Change, Fourth Assessment Report: The Physical Science Basics, 2007, Cambridge University Press, Cambridge, UK).

changes in the Earth's climate (Figure 1.4). Climate change is, among other things, essentially a story of the redistribution of water, increasingly through extreme weather events.¹¹ That means, in very general terms, more flooding in areas that are already wet and more drought in areas that are already arid.¹² Flood or drought—both lead to hardship, loss of economic activity, declining agricultural production, and damage to property. Climate change is predicted to have a disproportionate effect on the poorest people of the world and so will only reinforce poverty and the wealth and income disparities between haves and have-nots.¹³ Even our efforts to protect ourselves against climate change, if executed using current business-as-usual decision making and technology, will act to reinforce climate change. In Australia, for instance, chronic drought due to changing rainfall patterns triggered by climate change¹⁴ has led to the building of new desalination plants, with more planned. If powered by electricity from a predominantly coal-fired grid, these plants will add more GHGs to the atmosphere, exacerbating climate change. These anthropogenic feedback loops will simply reinforce the problem in a descending spiral. The harsher the impacts of climate change, the more energy we will need to protect ourselves and adapt, the worse climate change will get. One of the most pressing questions facing people and governments around the world today is: Which of these simultaneous crises do we deal with, and how?

A CRISIS OF SUSTAINABILITY

These, and other issues such as the threat of terrorism, nuclear proliferation, AIDS, pandemics, and basic food security, are all essentially *crises of sustainability*—they cannot go on indefinitely. Societies, ecosystems, countries, sectors, industries, people—all are locked together on the same planet, subject to the same laws of physics and biology. One way or another, unsustainable behavior will eventually lead to

sample content of Environmental and Economic Sustainability (Environmental and Ecological Risk Assessment)

- [The Knowledge: How to Rebuild Our World from Scratch pdf, azw \(kindle\), epub, doc, mobi](#)
- [read The Arabian Nights \(Barnes & Noble Classics\)](#)
- [Neutral Milk Hotel's In the Aeroplane Over the Sea \(33 1/3 Series\) pdf](#)
- [read online Dom's Guide To Submissive Training, Volume 1](#)

- <http://weddingcellist.com/lib/Weather-for-Dummies.pdf>
- <http://xn--d1aboelcb1f.xn--p1ai/lib/The-Arabian-Nights--Barnes---Noble-Classics-.pdf>
- <http://paulczajak.com/?library/Games-of-State--Tom-Clancy-s-Op-Center--Book-3-.pdf>
- <http://pittiger.com/lib/Lonely-Planet-Scotland-s-Highlands---Islands--3rd-Edition-.pdf>