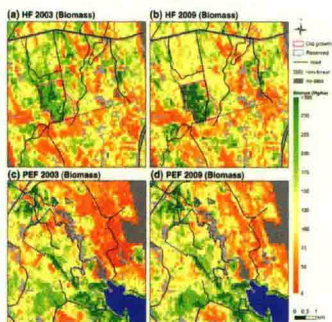
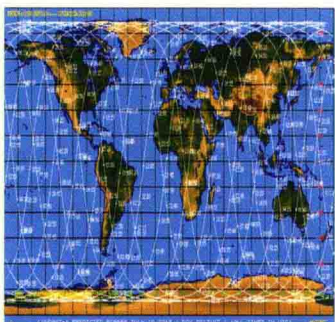




AN INTEGRATED APPROACH TO ENVIRONMENTAL MANAGEMENT

EDITED BY

DIBYENDU SARKAR • RUPALI DATTA
AVINANDAN MUKHERJEE • ROBYN HANNIGAN



WILEY

AN INTEGRATED APPROACH TO ENVIRONMENTAL MANAGEMENT

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ABOUT THE EDITORS

Dr. Dibyendu Sarkar is a professor of environmental geochemistry and the founding director of the environmental management PhD program (2009–2015) at Montclair State University, New Jersey. Prior to joining Montclair State, Dibs served as an assistant and associate professor and associate dean of Graduate Studies and Research at the University of Texas at San Antonio (2000–2008), after graduating with a PhD in geochemistry from the University of Tennessee (December 1997) and working as a postdoctoral researcher in Soil and Water Science at the University of Florida (1998–2000). Between 2000 and 2015, he advised 10 PhD students and 15 MS students and trained 14 postdoctoral research associates. Dibs has so far published over 300 journal articles, book chapters, conference proceedings, and technical abstracts. He has authored a research monograph, edited two books, and has generated more than \$5 million in grant funding to support his research activities and those of his students/postdocs. His research has appeared in a wide range of environmental journals, such as *Environmental Science and Technology*, *Journal of Hazardous Materials*, *Journal of Environmental Quality*, *Soil Science Society of America Journal*, *Chemosphere*, *Environmental Pollution*, *Journal of Colloid and Interface Science*, etc. Dibs is a member of several scientific and professional organizations, including Geological Society of America, American Society of Agronomy, American Geophysical Union, and American Association of Petroleum Geologists, and has received many research and teaching awards from them. He has served on numerous committees and organized many symposia and theme sessions for these organizations. Dibs is a Fellow of the Geological Society of America and a principal of SIROM

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Dr. Rupali Datta is an associate professor and the graduate program director of the Department of Biological Sciences at Michigan Technological University. Rupali's primary research interest lies in the application of plant biochemistry, genetics, molecular biology, and microbiology in solving environmental problems, using phytoremediation, plant-microbe interactions, and bioremediation. Her research involves the study of interactions between plant, soil, microbial, and water systems to understand the mechanisms of uptake and detoxification of specific environmental contaminants in biota from two broad angles—biochemistry and genetics. She has close to 100 research publications and more than 150 technical abstracts and conference proceedings and has generated more than two million dollars in research funding. Her research is strongly related to student experiential learning. So far, she has graduated four PhD students and eight MS students and supervised four postdoctoral fellows. Prior to joining Michigan Tech, Rupali was

an assistant professor in the Department of Earth and Environmental Sciences at the University of Texas at San Antonio. Rupali is an associate editor of two Springer journals—namely, *Current Pollution Reports* and *International Journal of Environmental Science and Technology*—and serves as a reviewer for more than 50 journals and several grant funding agencies. She is also a principal of SIROM Scientific Solutions, LLC.

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editorial board member of *Hospital Topics* and *Asia-Pacific Journal of Marketing and Logistics*, and ad hoc reviewer for a variety of journals. Avi has so far advised 5 PhD students and a host of master's degree students and postdoctoral scholars over his academic career.

Dr. Robyn Hannigan is professor and founding dean of School for the Environment at the University of Massachusetts at Boston. A graduate of the University of Rochester, Robyn's research centers on coastal ecosystem and resource management and evaluation of past climate to inform adaptation in coastal systems. Specifically, her work focuses on the impact of ocean acidification on fish and shellfish and the reconstruction of ocean acidification events in Earth's deep past. Robyn has published over 100 peer-reviewed articles across fields of geochemistry and environmental science. She is a fellow of the American Association for the Advancement of Science and Geological Society of America and an Aldo Leopold Leadership fellow. She served as the chair of the Consortium of Universities for the Advancement of Hydrologic Sciences, Inc. In addition to Robyn's academic achievements, she and her students hold several patents in areas of sample introduction technologies for mass spectrometric identification of important metals in biological samples. Robyn started a company with former students, GeoMed Analytical, which uses geochemical methods to study human health and seafood resource issues such as food sourcing and metals in disease treatment and diagnosis.

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PREFACE

The last few decades have seen a tremendous increase in the anthropogenic pressures on the environment. The result has been widespread environmental degradation, along with increasing negative social and economic impacts, especially on the vulnerable sections of the population, not only in the United States but all around the globe. Although environmental management concepts have been around since the 1970s, it is mostly in recent years that they have become ubiquitous. Thus far, the efforts to combat environmental problems have been predominantly piecemeal and top-down; consequently, both the reception of environmental policies and their effectiveness have been less than satisfactory in most cases. Today, increasing concerns about the environment are leading legislators, regulators, communities, corporations, and consumers to make new choices in terms of scientific research priorities, engineering investments, infrastructure and regulations, purchasing patterns, product usage, and disposal behavior, to name a few of many. The emerging field of environmental management takes a holistic view of environmental problems, recognizing the interconnectedness of social, economic, political, and environmental processes. The emphasis on primary benefits of environmental awareness and sensitivity to sustainability paradigms is critical to winning over the mainstream population in this global race to manage the most important issues where environment plays a critical role, such as climate change and human and ecological health. Accordingly, the field adopts an eclectic and integrative approach to environmental problem solving, combining theories, research methods, and analytical techniques drawn from a gamut of disciplines, as far apart as geochemistry and political

science. The heterogeneity inherent in the subject of environmental management makes the field an exciting arena of discovery while also producing challenges in terms of coherence and consistency.

Our main goal in writing the book was to provide a single one-stop treatise on the rapidly evolving multidisciplinary subject of environmental management. The idea came to us back in fall 2008 when the senior editor (DS) joined Montclair State University to build its PhD program in environmental management and soon realized the challenges in putting together a comprehensive tertiary-level program in this highly interdisciplinary field. The definition of environmental management varied from person to person, depending on their individual areas of specialization. It was almost like John Godfrey Saxe's classic poem "The Blind Men and the Elephant." People's concept of environmental management depends upon which part of the elephant they are handling. To complicate things further, there wasn't any comprehensive textbook on environmental management that approaches the subject from various disciplinary viewpoints with an objective to bring them all together in the end. Thus, came the idea of this book and an interdisciplinary team of editors and a contributor from the broad areas of science, engineering, social science, and business, who approached highly qualified authors to discuss the roles of their individual disciplines in environmental management.

The book is intended to be the first and only scholarly book that will be positioned as a leading textbook, as well as a specialist reference resource of academic information and analysis on environmental management from multiple perspectives, highlighting cutting-edge research, new concepts

and theories, and fresh practical ideas and initiatives that can be readily applied in societies and organizations. The book will mitigate a major deficiency in the field of environmental management, as currently envisioned: namely, it's fracturing along the disciplinary boundaries, with the result that presents a fragmented picture, with its different components seemingly at odds with each other. The book—by simultaneously adopting multiple perspectives and by striving to unify them, through a rigorous examination of the underlying interconnections—will provide a much-needed integrative thrust that will clarify and crystallize the subject of environmental management. This will be particularly useful for practitioners and students of policy who need to be keenly aware of and sensitive to the distinctive aspects of environmental management that can both be overlapping and even competing at times.

The 21 chapters in the book are divided into three perspective sections, namely, (I) Natural Science and Engineering, (II) Business and Social Science, and (III) Methods and Tools. In Section I, we discuss how the principles of geology, biology, soil science, chemistry, and engineering are applied in environmental management research and practices. We also deal with green energy, climate change, and green architecture. The first half of Section II is devoted to the elements of sustainable business, such as green marketing, corporate social responsibility, socially responsible investing, environmental economics, and the role of public relations and organization communications in environmental management. Social science aspects are discussed in the second half of Section II, specifically focusing on participatory approaches, environmental ethics, and environmental law and policy. Section III focuses on the common methods and tools that we use in environmental management research and practice, including statistics, geographic information systems, remote sensing, as well as life cycle analysis, environmental auditing, and environmental risk assessment. Each chapter is accompanied by a detailed list of supplementary readings to guide the interested reader to relevant literature on the topic (Appendix A). The chapters in the book are meant to be primers, which can be extended to develop individual courses. Appendix B contains model syllabi for the benefit of both instructors who may want to offer the courses and students who would get

some idea on what a full course in those individual topics might look like. Finally, in Appendix C, we present three model curricula for environmental management degrees in all three levels, bachelors, masters, and doctoral.

We sincerely hope that the book justifies our aim to provide a convenient one-stop compendium consisting of theories, analytical techniques, and applications drawn from natural sciences and engineering, social sciences and policy, and business and economics, which are constitutive of the contemporary environmental management. We hope that it is deemed useful by both students and practitioners in the field, particularly the students finding the broad coverage of the field a useful starting point for pursuing their specific interests. The bird's-eye view afforded by the book hopefully enables students, especially at the postgraduate level (both master's and doctoral) to better locate their own interests and research in the evolving trajectory of the field. Hopefully, the practitioners and policy makers will also be able to appreciate the tremendous possibilities in the field of environmental management that are often obscured by the academic treatments focused on a "nuts-and-bolts" approach alone. Here, the multiple perspectives will be particularly useful in encouraging lateral thinking and in promoting cross-fertilization across disciplinary boundaries.

This book would not have been possible without the contributions of the many authors who worked diligently with us as we tried to assemble this complex volume of interrelated topics, which complement one another in the process of developing a holistic platform to encompass the intricacies of this highly interdisciplinary, continuously evolving field of study. Michael Leventhal of Wiley provided apt guidance on publication requirements and kept us on time. The family members of the four editors (DS, RD, AM, RH) made sacrifices to make the project successful.

January 2015

DIBYENDU SARKAR
RUPALI DATTA
AVINANDAN MUKHERJEE
ROBYN HANNIGAN
(with contributions from Neeraj Vedwan)

ENDORSEMENTS

An Integrated Approach to Environmental Management—edited by Drs. Dibyendu Sarkar, Rupali Datta, Avinandan Mukherjee, and Robyn Hannigan—makes a strong case for the necessity of and the complexity of environmental management. The book identifies the interplay of technical elements and business and societal elements. An important part of environmental management is defining the context of the problem being managed—geological, biological, chemical, and structural (soil). The book discusses how the technical context defines engineering parameters needed to attain sustainable solutions. The second main aspect of integrated management is defining and managing the societal context including economics, legal, ethics, and policy. The goal is to define participatory management approaches. Finally, the book provides a cogent overview of new methods and tools for integrated management. An Integrated Approach to Environmental Management provides the framework and details needed to fulfill its promise of an integrated approach to environmental management. It is a tremendous resource for environmental professionals.

DR. RICHARD A. BROWN
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Environmental Resources Management, Inc.

This is a long-awaited textbook in environmental management. The authors masterfully combine the latest scientific discoveries, technological advances, and social and economic aspects to present an in-depth analysis and state-of-the-art methodologies for the implementation of innovative solutions and management practices toward a sustainable world. The sustainment of mankind and advancement of our civilization depend on our ability to properly utilize the planet's resources and promulgate policies and practices that address the social and economic impacts of anthropogenic activities. This book is written with particular focus on these

pressing issues, and it discusses them with lucidity and erudition. It constitutes an invaluable reference for the student, teacher, and practitioner of environmental management and sustainability.

DR. CHRISTOS CHRISTODOULATOS
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Stevens Institute of Technology

Environmental management degrees are now being offered at various levels in universities and are increasingly in demand. However, most textbooks on this topic concentrate on the scientific and engineering aspects, ignoring the economic, business, and social aspects of environmental management. This book is a very laudable attempt on the part of the editors to provide an integrated perspective on environmental management, for the first time. All readers, whatever their field of expertise or intended expertise in environmental management, will find much to spark their interest in this book. Its breadth and scope, the variety of subject matter explored, and detailed nature of the chapters will provoke creative thoughts in both students and educators alike. The book is brilliantly conceived and organized; the chapters are well thought out and written by experts; the editors are all highly qualified and experienced and have all done a great job in identifying and assembling the perfect contents under the leadership of the senior editor, Dr. Sarkar, who directs one of the very few PhD programs in environmental management in the United States. As an educator, I particularly appreciate the teaching tools the book provides, in terms of model syllabi and further reading suggestions.

DR. NURDAN S DUZGOREN-AYDIN
Professor and Chairperson, Department of
Geoscience and Geography
New Jersey City University

With An Integrated Approach to Environmental Management, Professor Sarkar and his coeditors have developed a timely and much needed treatment of the highly multidisciplinary and rapidly changing environmental management field. As an environmental engineer with more than 25 years of experience from the diverse perspectives of industry, consulting, and academia, I applaud the editor's efforts to bridge the disparate but interrelated aspects of environmental management from the scientific bases (e.g., geology, biology, and chemistry) to the business elements (e.g., sustainability, laws and policy, and public relations) and applications. This book provides an effective framework by which environmental professionals can rationalize and engage with complex anthropogenic environmental challenges in our increasingly interconnected global society. Moreover, it helps to reinforce the fact that solutions to such vexing environmental challenges as climate change, the proliferation of surface water and groundwater contamination in fast-growing industrial economies, and Brownfields redevelopment will invariably require multidisciplinary perspectives, experience, and paradigms. I believe that *An Integrated Approach to Environmental Management* will prove to be a "go-to" asset on every environmental professional's bookshelf.

DR. DANIEL W. ELLIOTT
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This unique book provides readers with an approach to environmental management that synthesizes all the different areas under which current analyses and policies are conducted. Much of the literature that pertains to this subject is disjointed in its approach, largely ignoring the business aspects to environmental management. As Adam Smith observed, as long as the economic and financial incentives are not in line with the desired environmental objectives, no amount of regulation or exhortation can induce businesses as well as individuals to adopt the required goals.

This volume, however, remedies the challenge of disjointed analyses by presenting us with an amazing "one-stop shop." The finance/business/economics synthesis pertaining to environmental management presented in this book, coupled with its unique mix of theory and practice, makes it a veritable game changer in the field of environmental management.

DR. FARROKH LANGDANA
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Professor of Finance/Economics
Rutgers Business School

This book coauthored by faculty from physical sciences as well as business school brings about a unique integration of the many diverse topics that would normally be found in eight different books. The responsibility for developing a sustainable future lies on the shoulder of every citizen, professional, and

most importantly everyone contributing to the cause. This unique book brings us together and provides the platform to work as a group.

DR. SOMENATH MITRA
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Distinguished Professor, Chemistry and
Environmental Science
New Jersey Institute of Technology

Environmental management is a rapidly developing field of interdisciplinary pedagogy. Many universities now offer bachelor's and master's degrees in environmental management, and a few offer doctoral degrees. However, there is a serious lack in availability of comprehensive textbooks in environmental management. The book edited by Sarkar, Datta, Mukherjee, and Hannigan fills that void. It provides a clear panoramic view of the field, with expert authors providing their disciplinary viewpoints and commentaries, which have been nicely organized in 3 major perspectives: natural science and engineering, business and social science, and methods and tools. The highly qualified editors have done an extremely good job in pulling all these various perspectives together in a single volume, thus making the book a true one-stop shop for students interested in pursuing a career in environmental management. Faculty members will appreciate the model syllabi accompanying each chapter, along with the comprehensive further readings list.

DR. MAX SEEL
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*Many advanced academic text and reference books do a good job in providing a great deal of detailed information on the topic at hand, primarily drawing from the work in one discipline and perhaps a few closely related ones. The complexity of the topic in this book, environmental management, requires us to draw on many fields to understand the problems better and, more importantly, to formulate solutions to the multiple issues involved. I am particularly impressed with the philosophy of the book that breaks down our stereotypical academic silos and thus provides an enriched and enhanced perspective on this important topic. There is indeed a significant need for *An Integrated Approach to Environment Management*, which includes research in the natural sciences, engineering, the social sciences, and business and management, and I am glad to see that the authors have addressed this need in their book.*

DR. BEHERUZ N. SETHNA
President Emeritus and Regents' Professor
of Business
The University of West Georgia

This book provides a refreshingly integrated reference to environmental management encompassing natural science, engineering, economics, statistics, remote sensing, and a broad array of multidisciplinary facets. Varieties of conceptual bases presented in this book offer an opportunity to the readers to derive cumulative wisdom by connecting the lessons learned from different chapters. There is a well-proportionate combination of theoretical and practical aspects of environmental management. The comprehensive treatise of both fundamental and applied components of environmental studies under one cover makes the book unique. Inclusion of local as well as global issues across wide geographical diversity furthers the universal appeal of this book.

DR. SHANKAR SHARMA
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State of California

(Disclaimer: This is not an endorsement by the State of California and solely represents Dr. Sharma's academic observation.)

This book represents a fresh and balanced perspective on environmental management. There is growing urgency to understand and measure environmental outcomes at all levels of the global economy. The integration of a science and engineering with sustainability,

policy, and business will provide students and practitioners with a comprehensive range of tools and ideas for advancing environmental practices. The model curricula will support programs developing the environmental leaders of tomorrow. As a scientist having supported environmental services in the private sector for nearly 30 years, I appreciate the importance of balancing good science with economic reality.

DR. TAMARA L. SORELL
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Brown and Caldwell

Finally, there is a comprehensive textbook in the interdisciplinary field of environmental management! I am very impressed by the breadth of the book (covering topics in natural science and engineering as well as business and social science), thanks to the diverse expertise of the editors (environmental geochemistry/biology/science and business/marketing). This is not only a very useful textbook for students but also a valuable resource book for practitioners in the environmental management field.

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SECTION I

ENVIRONMENTAL MANAGEMENT: THE NATURAL SCIENCE AND ENGINEERING PERSPECTIVE

