The Institute of Southeast Asian Studies was established as an autonomous organization in 1968. It is a regional research center for scholars and other specialists concerned with modern Southeast Asia, particularly the multi-faceted problems of stability and security, economic development, and political and social change.

The Institute is governed by a twenty-two member Board of Trustees comprising nominees from the Singapore Government, the National University of Singapore, the various Chambers of Commerce and professional and civic organizations. A ten-man Executive Committee oversees day-to-day operations; it is chaired by the Director, the Institute's chief academic and administrative officer.

The ASEAN Economic Research Unit is an integral part of the Institute, coming under the overall supervision of the Director who is also the Chairman of its Management Committee. The Unit was formed in 1979 in response to the need to deepen understanding of economic change and political developments in ASEAN. The day-to-day operations of the Unit are the responsibility of the Co-ordinator. A Regional Advisory Committee, consisting of a senior economist from each of the ASEAN countries, guides the work of the Unit.

The East-West Center is a public, nonprofit educational institution established in Hawaii in 1960 by the United States Congress. The Center's mandate is "to promote better relations and understanding among the nations of Asia, the Pacific, and the United States through cooperative study, training, and research."

Some 2,000 research fellows, graduate students, and professionals in business and government each year work with the Center's international staff on major Asia-Pacific issues relating to population, economic and trade policies, resources and development, the environment, culture and communication, and international relations. Since 1960, more than 25,000 men and women from the region have participated in the Center's cooperative programs.

Principal funding for the Center comes from the U.S. Congress. Support also comes from more than 20 Asian and Pacific governments, as well as private agencies and corporations. The Center has an international board of governors.

The East-West Environment and Policy Institute was established in October 1977 to increase understanding of the interrelationships among policies designed to meet a broad range of societal needs over time and the natural resources on which these policies depend or which they affect. Through interdisciplinary and multinational programs of research and training, the Institute seeks to develop and apply concepts useful in identifying alternatives available to decision-makers and assessing their implications. Progress and results of Institute programs are disseminated in the East-West Center region through books, occasional papers, working papers, newsletters, and other educational and informational materials.
Watershed Resources Management

Studies from Asia and the Pacific

edited by
K. William Easter
John A. Dixon
Maynard M. Hufschmidt
The responsibility for facts and opinions expressed in this publication rests exclusively with the authors and their interpretations do not necessarily reflect the views or the policy of the Institute and the Center or their supporters.
Contents

List of Figures and Tables ix
Foreword, Charles W. Howe xiii
Preface xv
List of Contributors xvii


   Watersheds as a Social and Physical Unit 4
   An Integrated Watershed Management Approach to Resource Management 6
   The Approach of the Book 12
   References 15

2 A Conceptual Framework for Watershed Management, Maynard M. Hufschmidt 17
   Major Elements of the Framework 17
   Application of the Analytical Framework 25
   Role of the Analytical Framework 30
   References 30

3 Biophysical Aspects in Watershed Management, Lawrence S. Hamilton and Andrew J. Pearce 33
   Biophysical Effects of Land Uses 33
   Biophysical Information Needed 48
Contents

4 Economic Analysis at the Watershed Level, *John A. Dixon and K. William Easter* 53
   An Integrated Economic Analysis 54
   Types of Economic Analysis 58
   Conceptual Issues within a BCA Framework 61
   Implications and Conclusions 68
   References 69

5 Economic Policies and Watershed Management, *Alfredo Sfeir-Younis* 71
   Accounting Unit 71
   Economic Policy Environment 73
   Intertemporal Questions in Economic Policy 75
   Policy Agenda 78
   Conclusion 79
   References 79

6 Behavioral and Social Dimensions, *George W. Lovelace and A. Terry Rambo* 81
   The Human Ecology Perspective 81
   Structural Parallels between Social Systems and Natural Systems 83
   Social and Behavioral Obstacles to Integrated Watershed Management 86
   Conclusion 88
   References 90

7 Institutional and Organizational Concerns in Upper Watershed Management, *Christopher J.N. Gibbs* 91
   Watersheds as Secondary Regions 91
   Institutions and Organizations 93
   Conclusions and Implications for Watershed Management 100
   References 101

8 Program Implementation, *K. William Easter* 103
   Program Implementation 104
   Evaluation of Implementation 109
   Implementation Issues 112
   Conclusion 116
   References 117
<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>The Potential Role of Agroforestry in Watershed Management, <em>Napoleon T. Vergara</em></td>
<td>119</td>
</tr>
<tr>
<td></td>
<td>Agroforestry: A Potential for Upland Watersheds</td>
<td>120</td>
</tr>
<tr>
<td></td>
<td>Agroforestry in Upland Watersheds: Constraints and Opportunities</td>
<td>126</td>
</tr>
<tr>
<td></td>
<td>References</td>
<td>129</td>
</tr>
<tr>
<td><strong>Part II: Applications</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Watersheds in Hawaii: An Historical Example of Integrated Management, <em>Joseph R. Morgan</em></td>
<td>133</td>
</tr>
<tr>
<td></td>
<td>Ancient Hawaiian Society and Land Use</td>
<td>134</td>
</tr>
<tr>
<td></td>
<td>Lessons from the Past</td>
<td>142</td>
</tr>
<tr>
<td></td>
<td>References</td>
<td>143</td>
</tr>
<tr>
<td>11</td>
<td>Annexation, Alienation, and Underdevelopment of the Watershed Community, <em>Anis A. Dani</em></td>
<td>145</td>
</tr>
<tr>
<td></td>
<td>The Ecology of the Hindu Kush-Himalaya</td>
<td>147</td>
</tr>
<tr>
<td></td>
<td>The Process of Incorporation</td>
<td>148</td>
</tr>
<tr>
<td></td>
<td>Incorporation of the Watershed Community</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>Restoring the Balance</td>
<td>154</td>
</tr>
<tr>
<td></td>
<td>Conclusion</td>
<td>156</td>
</tr>
<tr>
<td></td>
<td>References</td>
<td>156</td>
</tr>
<tr>
<td>12</td>
<td>The Role of Extension: A Northern Thailand Watershed Case Study, <em>Peter W.C. Hoare</em></td>
<td>159</td>
</tr>
<tr>
<td></td>
<td>Northern Thailand Setting</td>
<td>159</td>
</tr>
<tr>
<td></td>
<td>The Role of Extension</td>
<td>166</td>
</tr>
<tr>
<td></td>
<td>Conclusion</td>
<td>172</td>
</tr>
<tr>
<td></td>
<td>References</td>
<td>173</td>
</tr>
<tr>
<td>13</td>
<td>Watershed Management in Indonesia: The Case of Java's Densely Populated Upper Watersheds, <em>David S. McCauley</em></td>
<td>177</td>
</tr>
<tr>
<td></td>
<td>Evolution of Upland Land Use</td>
<td>179</td>
</tr>
<tr>
<td></td>
<td>Renewed Attention for Upland Areas</td>
<td>182</td>
</tr>
<tr>
<td></td>
<td>Present Trends in Addressing the Problems</td>
<td>184</td>
</tr>
<tr>
<td></td>
<td>Conclusion</td>
<td>187</td>
</tr>
<tr>
<td></td>
<td>References</td>
<td>188</td>
</tr>
<tr>
<td>Chapter</td>
<td>Title</td>
<td>Page</td>
</tr>
<tr>
<td>---------</td>
<td>----------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td></td>
<td>The Lower Agno River Watershed</td>
<td>191</td>
</tr>
<tr>
<td></td>
<td>The San Roque Multipurpose Project</td>
<td>194</td>
</tr>
<tr>
<td></td>
<td>Analysis of the Project</td>
<td>195</td>
</tr>
<tr>
<td></td>
<td>Conclusion</td>
<td>203</td>
</tr>
<tr>
<td></td>
<td>References</td>
<td>204</td>
</tr>
<tr>
<td></td>
<td>A Conceptual Model</td>
<td>206</td>
</tr>
<tr>
<td></td>
<td>A Research Agenda</td>
<td>208</td>
</tr>
<tr>
<td></td>
<td>Lessons Learned</td>
<td>210</td>
</tr>
<tr>
<td></td>
<td>Reference</td>
<td>213</td>
</tr>
<tr>
<td></td>
<td>Index</td>
<td>215</td>
</tr>
</tbody>
</table>
FIGURES

1.1 A natural and social system schematic of a watershed 8
2.1 The five stages of integrated watershed management 18
2.2 Watershed management as a planned system 20
2.3 Generalized watershed management system in physical output terms 22
2.4 A three-dimensional analytical framework for watershed management 26
3.1 The hydrologic cycle 36
3.2 Erosion and sedimentation processes in a watershed 39
3.3 Average monthly streamflow and the increase in flow during seven years of annual recutting of deciduous forest on Watershed 17, Coweeta, USA 44
3.4 Stylized stream hydrograph response to a storm event 45
4.1 The private and social perspective of a watershed 57
4.2 Typical stream of project benefits and costs 58
6.1 A simplified model of human-environmental relations in the watershed context 84
8.1 Problems of implementation in watershed management and the role of implementation research 110
Figures and Tables

9.1 Natural terraces formed over time by contour hedges or strips in an agroforestry system 121
9.2 Nutrient losses from, and transfers within, an agroforestry system 123
9.3 Natural and man-induced nutrient inputs into an agroforestry system 124
10.1 The radial draining pattern of streams in Kauai and the location of Halelea District with its nine historical ahupuāa 139
11.1 Highland-lowland relationships in watershed management 149
12.1 Location of Highland Agricultural and Social Development (HASD) Project sites in the Far North of Thailand 160
12.2 The Royal Thai Government organizations for hilltribe development with emphasis on the Highland Agricultural and Social Development (HASD) Project, 1980 165
13.1 Map of Java and Madura indicating the major river systems and areas over 200 m in elevation 178
14.1 Map of Agno River, Upper and Lower Agno River watersheds in Luzon, Philippines 192

Tables

1.1 Definitions of watershed-related terms 5
1.2 Summary of rationale for a watershed approach to rural development 6
2.1 The three major activities of watershed management 24
2.2 Examples of watershed management tasks required at the planning stage, classified by management activities and management system elements 27
2.3 Examples of tasks involving implementation tools, classified by stages of the management process and management activities 28
3.1 Examples of a few resource utilization and management practices to meet two specific watershed management goals 34
3.2 Some vegetative cover factors for West Africa 37
4.1 A comparison of financial and economic analysis 56
4.2 Present value of a future net return of $100 at four
discount rates 63
4.3 Relationship between the goods and services
associated with watershed management projects and
location 65
8.1 The watershed management process and the
watershed management elements for program
implementation 104
9.1 Nitrogen yields of selected tree legumes 124
12.1 Records from three problem-solving meetings in
Northern Thailand 168
13.1 Reported land use of Java and Madura by province
in 1980 180
14.1 Total volume of sediment deposits trapped in the
proposed SRMPP Reservoir over a 50-year period, without watershed management 196
14.2 Total volume of sediment deposited by storage
zones through year 50 for proposed SRMPP
Reservoir, without watershed management 197
14.3 Economic loss due to sedimentation of the planned
SRMPP Reservoir, without watershed management 198
14.4 Volume of sediment in the proposed SRMPP
Reservoir, with watershed management 199
14.5 Volume of sediment and value of loss by active
storage pools, with and without watershed manage-
ment conditions 200
14.6 Present values and benefit-cost ratios of watershed
management program under assumed sedimentation
rates 201
14.7 Sensitivity analysis, SRMPP Watershed Manage-
ment Project 202
14.8 Comparative economic analysis of mine tailings
disposal methods, Lower Agno River Watershed 203
Foreword

The impacts of upper watershed land-use practices on resource systems lower in the watershed or river basin have long been recognized as a major problem area: siltation of the river bed, reservoirs, and irrigation systems; impacts on estuarine mangroves and coastal fisheries; increased severity of flooding and drought; and deposition of chemical residues. The watershed is thus comprised of a sequence of linked resource systems, but the linkage is one way. This complicates the integrated management of watershed resources, for not only do different agencies typically have responsibility in different parts of the watershed and for the management of different resources, but the private parties in the upper watershed are not motivated to take into account the costs they impose on the lower watershed.

In addition to the traditional problems, the "Green Revolution" is now spreading to the upper watershed: the search is on for ways of increasing the productivity and population carrying capacity of the higher elevation lands. This requires consideration of nontraditional patterns of land use and even greater integration of upstream and downstream considerations. This will require institutional innovation to overcome traditional barriers to interagency cooperation and to manage watershed activities from a basin-wide viewpoint. It will require open reviews of interagency rivalries and not just the passing of another law.

This volume discusses all of these complexities within a unified conceptual framework, which is followed by interesting case studies. The book should be of great utility to watershed and river basin managers, consultants, and scholars doing further work on the biophysical, economic, social, and institutional aspects of watershed and river basin management.

Charles W. Howe
General Editor

Charles W. Howe is professor of economics at the University of Colorado, specializing in water resource development and related topics.
Preface

This book is the outgrowth of independent and collaborative work on water resources and watershed management in developing countries at both the East-West Center and the University of Minnesota. Researchers at these institutions have worked extensively on irrigation problems, techniques for planning and evaluating projects, and the biophysical aspects of tropical watersheds. After studying the broad questions of water resource management, it became clear that some important aspects of watershed management research had been neglected. These gaps included the socioeconomic aspects of watershed use and methods for integration of these aspects with the biophysical elements.

Three workshops held at the East-West Center helped highlight the effects of watershed mismanagement on soil erosion, slope stability, and channel and reservoir sedimentation. The first of the workshops held in January 1983 focused on how technical information and knowledge can be used to help generate alternative policies for soil and water conservation research and monitoring activities. The workshop participants concluded that one of the greatest problems facing policymakers is the translation of soil and water conservation principles into effective policies. Such translation requires a thorough assessment of the nature, extent, and impact of soil erosion and an evaluation of its effects. The necessary information is often sparse or absent; therefore, the policymaker must rely on strategies that keep options open.

The second workshop held in early May 1984 was on the “Effects of Forest Land Use on Erosion and Slope Stability.” Workshop speakers emphasized forest removal and road construction as causes of the serious increase in landslides and accelerated erosion rates. Most of the research on these problems has been done in moist temperate steepland forests in western United States, Japan, and New Zealand; thus, a serious research gap exists regarding tropical forests in much of Asia.

At the third workshop held at the East-West Center during the third week of May 1984, the participants presented a wide range of papers on river and reservoir sedimentation and associated watershed management questions (many of which have been published in the December 1984 and March 1985 issues of Water International). Hufschmidt pointed out that there has been no rigorous analysis of the root causes of the failures in implementing watershed management projects. Such evaluations require carefully constructed case studies of the Asian watershed management experience based on an integrated framework of analysis.
In an effort to stimulate research to help fill some of the gaps identified in the earlier workshops, a fourth workshop was held, with support from USAID, at the East-West Center in January 1985 on "Research for Integrated Watershed Management in Developing Countries." As a key part of this workshop, six papers were prepared by the Environment and Policy Institute (EAPI) staff working closely together to develop an interdisciplinary approach to watershed management. These papers were revised to provide the framework of analysis presented in this book.

We hope that this book captures the exciting interaction that went on as the conceptual papers were being written. Even more important, we hope that this book will provoke discussion and further research into the complicated but fascinating and important area of watershed management.

Many people contributed to the creation of this book. Valuable comments on both the substance and organization of the book were received from Prof. Herbert H. Stoevener, Department of Agricultural Economics, Virginia Polytechnic Institute and State University; Prof. Charles W. Howe, Department of Economics, University of Colorado; and Prof. Samir A. El-Swaify, Department of Agronomy and Soil Science, University of Hawaii. We owe special thanks to many colleagues at the East-West Center: Helen Takeuchi, EAPI editor, and Joan Nakamura and Betty Schweithelm, typists, carefully handled the many revisions of the manuscript. Louise Fallon, research fellow, helped edit and rework several chapters. The authors of the various chapters responded quickly to the suggestions of the editors for revisions and requests for additional material.

This book was originally published in 1986 by Westview Press, Boulder, Colorado, as a volume in its "Studies in Water Policy and Management," Prof. Charles W. Howe, general editor. This edition contains all of the text of the original edition with the exception of one chapter from "Part II: Applications" section of the book.

K. William Easter
John A. Dixon
Maynard M. Hufschmidt
Contributors

Nicomedes D. Briones
East-West Center
Honolulu, Hawaii

Anis A. Dani
International Center for Integrated Mountain Development (ICIMOD)
Kathmandu, Nepal

John A. Dixon
East-West Center

K. William Easter
University of Minnesota
St. Paul, Minnesota

Christopher J.N. Gibbs
East-West Center

Lawrence S. Hamilton
East-West Center

Peter W.C. Hoare
Chiang Mai University
Chiang Mai, Thailand

Maynard M. Hufschmidt
East-West Center

George W. Lovelace
East-West Center

David S. McCauley
East-West Center

Joseph R. Morgan
University of Hawaii and East-West Center

Andrew J. Pearce
Forest Research Institute
Christchurch, New Zealand

A. Terry Rambo
East-West Center

xvii
| Alfredo Sfeir-Younis | World Bank  
| Washington, D.C. |
|---------------------|------------|
| Napoleon T. Vergara | East-West Center |

The Editors

K. William Easter is professor of agriculture and applied economics at the University of Minnesota. John A. Dixon is research associate at the Environment and Policy Institute at the East-West Center, Hawaii, where Maynard M. Hufschmidt is a senior fellow.