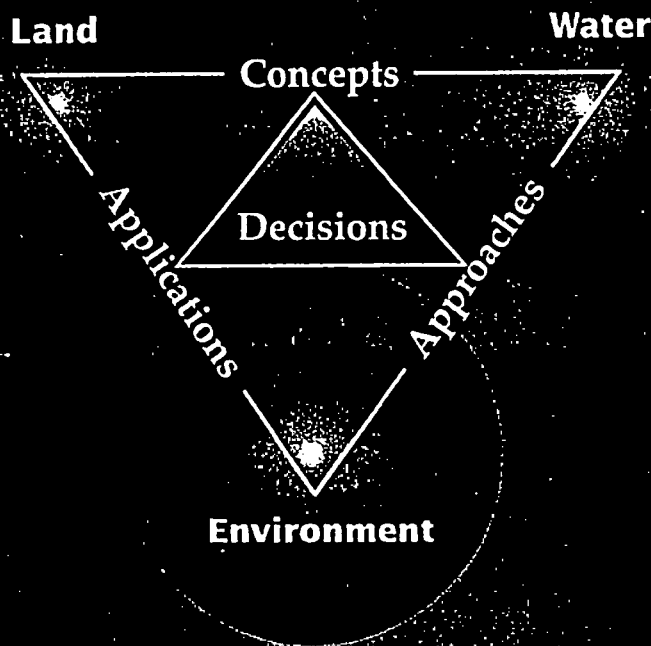


Multiple Objective Decision Making for Land, Water, and Environmental Management

Proceedings of the First International Conference on
Multiple Objective Decision Support Systems (MODSS)
for Land, Water, and Environmental Management:
Concepts, Approaches, and Applications



Edited by

S. A. El-Swaify and D. S. Yakowitz

Chapter 1

Introduction to Multiple Objective Decision Making for Land, Water, and Environmental Management

S.A. EL-SWAIFY AND DIANA S. YAKOWITZ

This book is the postconference Proceedings of MALAMA 'AINA (Preserve the Land) 1995, the "First International Conference on Multiple Objective Decision Support Systems (MODSS) for Land, Water, and Environmental Management: Concepts, Approaches, and Applications." The conference was convened in Honolulu, Hawaii, in July 1995 in recognition of the fact that considering multiple objectives and the development of computer-based decision aids are requisite to rational environmental decision making.

The selection of this rather specific conference topic is in direct contrast to MALAMA 'AINA 83, the first (truly) open global conference on soil erosion and conservation also held in Honolulu in January 1983, and indeed most recent international forums on managing natural resources. MALAMA 'AINA 95 was, in a way, a sequel but dealt with a new, specific, timely, and cutting-edge topic which reflects the emerging innovations for addressing natural resource management and environmental problems. This provided a higher dimension of multidisciplinary participation than at any of the previous natural resource conservation conferences.

Why Multiple Objective Decision Making and Decision Support Systems?

Over the past half century or so, agricultural research and technological innovations that depend on intensive external inputs have succeeded in assuring impressive increases in global agricultural productivity. The increases averaged about 3%/year and have kept up with the needs of increased populations on every continent except Africa (El-Swaify, 1994). However, this success story is nearing its limits for many reasons, primarily: (a) the decreasing availability of new productive lands and usable water resources (Buringh, 1982; El-Swaify, 1991), (b) the alarming rates of ongoing human-induced land, soil, and water resource degradation (ISRIC/UNEP, 1990), (c) the increasing encroachment on and over-stressing marginal, fragile, and degradation-vulnerable lands (see Chapter 3), (d) the inability to enhance the adoption of conservation-effective land use systems at rates sufficient to overtake ongoing degradation (Napier et al., 1994), and last but not least (e) the continuing expansion of earth populations at alarming rates.

Natural resource degradation, therefore, represents an important element of total "global change". In the broad sense, such a change encompasses not only changes in climate or atmospheric/stratospheric composition, but also other changes in the global life-support systems of human societies. Much of the international debate and research funding, however, focuses on global climate change, although other dynamic changes may be equally important, if not more so. Natural resource degradation is also a major force that drives global climate change. It is no surprise, therefore, that "Natural Resource Management" (NRM) has emerged globally as a key issue of the highest priority for assuring sustainable agricultural development, and has attracted renewed commitment from such mission-oriented institutions as the International Agricultural Research Institutes (IARIs). The conference's central topic and selected themes were propelled, to a large extent, by the recent paradigm shifts to sustainable development and environmental quality issues.

In view of the emerging paradigm shifts, managing natural resources, mitigating degradation threats, and conforming to proliferating environmental regulations is a complex task that must address the various expectations of many community segments and society sectors. Those expectations, when translated into specific planning objectives, are often in conflict with one another. A prominent example is the likelihood of conflict between "conventional, production-driven" and "environmentally-driven" objectives of natural resource use and management. One approach to reconciling these conflicts lies in "holistic, ecosystem-based" land use planning and development.

This approach requires the selection of an "ecosystem unit" that is most appropriate for planning (e.g., a well-defined hydrologic catchment or watershed), and applying quantitative criteria to plan land use and judge the many impacts of alternative management practices, preferably prior to project implementation. Land use consequences and impacts are often not in harmony and tradeoffs or "optimization" in decision making may be necessary. A specific example of conflict is the urgency in enhancing crop productivity, through intensified management and applied external inputs, while also controlling nonpoint source pollution and protecting both surface and groundwater qualities.

Societies and communities are, therefore, undergoing increased interest in the subject of conflict resolution. Conflict resolution always involves multiple stakeholders and the multiple decision criteria of the interested parties (Hipel et al., 1993). This reality and the complexity of most decision-making situations require that many researchers and decision makers apply multiple-objective tools of decision making rather than those that are merely driven by single objectives.

The considerations discussed above, the complexity of many of the models and large databases required for predicting various scenarios, and the need to examine many contingency plans or points of view with the goal of arriving at optimal choices, underpin the need for MODSS. We envisage an increased adoption of this and other operations research (OR) techniques by developers for aiding decision making in environmental management toward the same goals.

Why a Conference?

Much has been accomplished in the MODSS arena in recent years. Current scientific literature is enriched with considerable knowledge, experience, and a variety of approaches that lend themselves to developing quantitative multiobjective decision support tools to allow making recommendations on "simultaneously" productive, sustainable, and environmentally sound land use. This first international conference was so timed as to take advantage of current progress and to share these accomplishments among the global scientific community. As will be noted in the final chapter of this book, our expectations were by and large realized. A global scope was justified because the impacts of many natural resource decisions indeed extend beyond what previously may have been considered to be of only national or local concern.

Ideal decision tools for valid recommendations on land, water, and environmental management must include quantitative and analytical components; must span and integrate the physical, biological, socioeconomic, and policy elements of decision making; and must be user-friendly and directly relevant to client needs. Fortunately, participants included scientists representing both the "hard" and "soft" scientific disciplines and interdisciplines relevant to land resource utilization and management and who are actively contributing the knowledge required for the development of decision aids. Over 30 countries were represented at the conference by speakers and authors from all continents with the exception of Antarctica. Real world applications from all these regions were presented at the meeting.

One goal of the conference was to provide a forum for the demonstration of DSS currently in use or under development for natural resource planning. Many of the papers presented were exploratory in nature and involve research plans and/or the investigation of appropriate decision factors and techniques to be considered. The topics covered by the authors of such papers underscore the need for continued activity and should spur interaction between researchers and the development of many alternative systems which provide clientele with a set of choices to meet their respective needs. Presented case studies demonstrate how the application of MODSS has addressed, or can address, critical needs in land use planning and management in various countries or regions. As shown in the coming chapters, and in the summation chapter, applications included a

spectrum ranging from compliance with environmental regulations to identifying opportunities for contributing to the planning of sustainable land use in developing, especially tropical, countries.

An Overview of Emerging Emphases

Despite the wide diversity among conference contributions, it was possible to logically fit individual presentations and sessions, and indeed the contributions to this book, into one of the following four major "themes":

1. Relevance for addressing user needs, various society sectors, and different levels of clientele
2. MODSS methodologies, tools, components, and integration
3. Economic, social, cultural, and policy issues and applications, including risk assessment, conflict resolution, and sustainable development
4. Applicability to global and regional issues, especially in Asia and the Pacific, including degradation processes in small island ecosystems and major river basins, and competitive uses of water for agriculture and aquaculture

These themes are presented following the introductory Part I, as Parts II, III, IV, and V of this book, respectively. Many of the papers in these sections could have logically been included in other sections as well. Therefore, it should not be assumed that papers in the last section, for example, do not cover topics in the other three.

Several topics were given special emphasis with multiple follow-up workgroup sessions. These included two panels on the role of MODSS in integrated assessment, relevance for and applications of MODSS to sustainability issues, explanations and demonstrations of available MODSS software, and incorporating socioeconomic considerations in multiple objective decision making. A mid-week field excursion was designed to demonstrate the relevance of conference topics to the dynamics of rapidly changing natural resource use in the "highly compressed" whole-island ecosystems of the state of Hawaii, and to also highlight the wisdom of certain indigenous historic concepts of land allocation and use as symbolized by the "holistic watershed-plus" of Ahupua`a addressed briefly in the next chapter. The final day was dedicated to presentations of session synthesis by assigned theme spokespersons and open discussions among all participants of the week's contributions. A synthesis of those is presented in the closing chapter of the book.

As planned, environmental issues received considerable emphasis at the conference and are addressed by several authors in this volume. These have been addressed in the context of:

- Water management, with a focus on water supply and quality
- Environmentally compatible agricultural land use and management, including crop selection, irrigation management, tillage systems, pesticide and nutrient management, erosion control, combating soil degradation, assessing market demand, and enhancing farm profitability

- Land use planning, conservation planning, and reclamation (restoration), with emphasis on economic, social, and environmental implications
- Waste management and remediation of contaminated sites, with concern for human, wildlife, water, and vegetation health
- Natural areas and steep land management, with concern for deforestation, wildlife, erosion control, recreation, and other economic issues
- Aquaculture, with concern for food supply, competition, and water quality
- Livestock management, with concern for economics, food supply, and fertilizer

Further details are presented in the respective chapters and a follow-up synthesis is provided in Part VI.

The conference and material included in this volume illustrate the diversity of perspectives and points of view held by those involved in environmental management in our global community. We believe that awareness of and sensitivity to such diverse issues are healthy steps in reconciling conflicts that may arise in striving for technically sound, economically viable, socially acceptable, and environmentally compatible natural resource management systems.

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