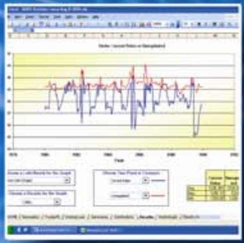
Shared Vision Planning

February 2007

Literature Review of Computer-Aided Collaborative Decision Making

2007-R-01



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Shared Vision Planning

The Shared Vision Planning program at the Institute for Water Resources (IWR) uses an innovative, collaborative approach to solve water resources management issues. It integrates traditional water resources planning methods, structured public participation, and collaborative computer modeling into a multifaceted planning process. This program is unique because it emphasizes public involvement in water resources management and the use of collectively developed computer models along with tried-and-true Corps planning principles.

Shared Vision Planning aims to improve the economic, environmental and social outcomes of water management decisions. By involving stakeholders throughout the planning process, the Shared Vision Planning process can facilitate a common understanding of a natural resource system and help stakeholders reach a management consensus that satisfies multiple interests. Shared Vision Planning allows IWR scientists to work directly with stakeholders to find acceptable solutions to issues surrounding the management of water resources.

Collaborating for Improved Water Resources Management

Through its Shared Vision Planning Program, IWR is applying the principles of public involvement and collaborative computer modeling to a series of water resources management case studies across the United States. Analyses, documents, and an enhanced web presence are being developed to impart the method and lessons of Shared Vision Planning to the wider planning community. All of these initiatives are designed to help planners and stakeholders use a collaborative approach to natural resources management.

By recognizing the importance of multiple stakeholder interests and the value of innovative technological support, Shared Vision Planning can make a positive impact on the current and future management of our nation's water resources. The Shared Vision Planning Program at IWR is developing partnerships with other organizations to more effectively implement this approach. The Program has already helped numerous stakeholders in previous projects to find acceptable water management solutions, and IWR looks forward to the continued spread and success of this planning approach.

For further information on the Shared Vision Planning program, please contact Hal Cardwell, 703-428-9071, Hal.E.Cardwell@usace.army.mil.

To learn more, please visit the Shared Vision Planning web site: www.svp.iwr.usace.army.mil

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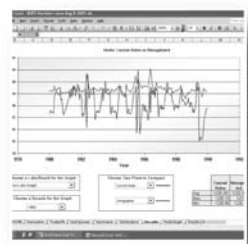

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Section 1
Introduction

Computer-aided collaborative decision making has become more important in water-resources management as the scope of studies has broadened both in terms of planning objectives and the number of interested stakeholders. Policy judgments and the choice of appropriate public investments in water resources involve numerous quantitative and qualitative considerations reflecting the values of multiple parties, which often make the decision-making process complex and contentious. Involvement of a range of stakeholders that represent the broad public interest—and not just collaboration across a few interest groups—is not only an expectation, but is a reality of contemporary water-resources planning. Therefore, there has been an increasing and deliberate emphasis to involve stakeholders in water-resource planning and management decision making, including participation in the analytical modeling process. Such stakeholder involvement is believed to lead to a more efficient decision-making process with more transparent treatment of underlying preferences and mapping of decision processes of multiple people.

There are a variety of ways in which computerized models can be blended to support collaborative planning and policy-making. Shared Vision Planning (SVP) is one technique capable of integrating computerized models within a collaborative framework for public decision making. Palmer et al. (2007)[1] describe SVP as a fusion of water-resources planning, structured public participation and collaborative modeling designed to improve water management outcomes. SVP relies on deliberative, inclusive decision-making processes, where analytical computer models are constructed with the participation of stakeholders.[2] There are likely other processes, perhaps not as formally named, with similar objectives as SVP, but which differ in how they integrate physical data and stakeholder interaction.

1.1 Purpose and Objectives

This report presents the results of a study undertaken to review and analyze literature on stakeholder participation and computer-aided decision-making approaches. The purpose of this report is to guide future developments in computer-aided collaborative decision-making approaches and to support their effectiveness. The primary objective of this report is to characterize and synthesize key features of collected studies and to identify successes and shortcomings associated with applications of processes that are similar to SVP.

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[1] Palmer, R., Cardwell, H., Lorie, M. and Werick, W. 2007. Disciplined Planning, Structured Participation and Collaborative Modeling – Applying Shared Vision Planning to Water Resources Decision Making.

[2] Stephenson, K. 2002. "The What and Why of Shared Vision Planning for Water Supply" Speech prepared for the panel session "Collaborative Water Supply Planning: A Shared Vision Approach for the Rappahannock River Basin." Water Security in the 21st Century Conference, Washington, DC. July 30, 2002.

This report addresses several objectives:

- Identify bibliographic resources that use or discuss the application of computer-aided decision-making approaches

- Characterize particular experiences in the form of annotations that cover the broad elements of modeling, stakeholder involvement and collaboration—the principal components of SVP

- Summarize the characteristics of computer-aided decision-making research by means of limited meta-analysis of the annotated studies

Furthermore, this report serves as an initial means to connect researchers and related organizations to form a more prominent community of practice for computer-aided decision making. The study bibliography and annotations are intended to provide an early resource for interested researchers and practitioners of water-resources management, which will be expanded over time as new people, information and ideas emerge.

1.2 Organization of Report

Following this introductory section, Section 2 provides an overview of the approach used to identify and review pertinent literature on computer-aided decision making. Section 3 provides a synthesis of the literature reviewed in the form of a meta-analysis that characterizes the application of modeling, stakeholder involvement and collaboration processes. Section 4 provides principal conclusions and recommendations for additional research activities.

The results of the literature review process are represented in a set of appendices. Appendix A contains a set of annotations that summarize particular reports and case examples that were selected in consultation with IWR. Appendix B provides a comprehensive list of bibliographic entries for literature sources on computer-aided decision making.

Section 2
Research Methodology

2.1 Identification of Literature Sources

In preparation for the literature review, the study team met to discuss ways to identify literature sources related to the implementation of computer-aided decision-making processes. Literature search parameters were broadly defined to include peer reviewed papers, conference proceedings and government and non-government reports, as well as relevant presentations and other documents pertaining to computer-aided decision making.

The traditional means of key word searches of library and internet sources was considered inefficient due to the sheer number of possible search criteria and the subsequent need to screen a potentially vast set of extraneous information. Many different phrases have been used to describe the same processes that are encompassed by the computer-aided decision-making literature, such as "collaborative planning," "group model building" and "decision support modeling" (Figure 1). While a search of such related phrases revealed a wealth of potential sources, it also confirmed that such broad search would be difficult to manage.[3]

Key words and phrases often associated with computer-aided decision-making

- Collaborative modeling/analysis
- Collaborative planning
- Group model building
- Mediated modeling
- Decision support modeling
- Group decision support
- Cooperative modeling
- Negotiated rule-making
- Participatory modeling/analysis
- Participatory science
- Joint fact finding
- Collaborative learning
- Computer-aided negotiation
- Shared vision planning/modeling

FIGURE 1
KEY WORDS AND PHRASES ASSOCIATED WITH COMPUTER-AIDED DECISION-MAKING

A survey of people known to be involved in the field of computer-aided decision making was considered to be more efficient for identifying pertinent literature. Reaching out directly to people was also deemed more valuable for identifying and exploring the network of individuals that represent leading authorities in the relevant subject matter. An e-mail survey was constructed to introduce the purpose of the study and to request information (Figure 2).[4] An initial raw list of approximately 40 potential contacts was developed by the study team. E-mail contact was ultimately made with 31 potential leads and 16 contacts replied to the e-mail survey. The individuals who responded generally provided useful recommendations and guidance, including copies of their own work, working reference lists and links to appropriate websites and other potential sources.

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3 Initial internet searches (in July 2006) found relatively more direct (or exact phrase) "hits" for collaborative learning (~1.1 million links), collaborative planning (~810,000 links) and group decision support (~260,000 links). The fewest number of direct search hits were associated with computer-aided negotiation (105). A search on SVP resulted in 405 hits.

4 The authors recognize that many pertinent studies can be missed using this data collection approach. However, given the constraints of the project, this was considered a suitable course of action, since it is designed to expand an initial network of contacts into a larger network that can help identify additional literature resources over time.

Dear ______,

I am working with the U.S. Army Corps of Engineers' Institute for Water Resources (IWR) to assemble an annotated bibliography of case studies and papers in computer-aided water-conflict resolution and I have been given your name as someone whose work may be relevant. IWR is performing this work as part of its shared vision planning program www.iwr.usace.army.mil/iwr/svp/home.htm and as a step in developing an interagency center for Computer-Aided Dispute Resolution (CADRe) that promotes the application of computer-aided collaborative decision-making methods to avoid or manage water conflicts. The hope is that CADRe will make more people aware of these new techniques and create a named community that will help people doing this work to find each other and share what they have learned.

Our major focus for this bibliography is real-world cases where experts have worked with stakeholders and decision makers to build transparent integrated models that people trust and **use** to solve water problems—be they basin-wide planning, reservoir operations, drought management, etc. If your work is relevant to this focus, we would like to include it in our bibliography (understanding that copyright protection may limit us). Could you provide us papers or links to your papers or other papers you'd recommend for that purpose? I would also like to keep you informed of the progress we make and would be happy to send you a copy of the report when we finish it this fall.

Best regards,

FIGURE 2
E-MAIL SURVEY USED TO REQUEST INFORMATION

2.2 Development of Bibliography

The development of the bibliography did not focus on rapidly reading through volumes of technical literature, but rather concentrated on strategically identifying studies and materials as provided by the e-mail contacts, which were considered likely to have applicability to computer-aided collaborative decision making. Although the e-mail survey produced the initial basis for collecting references, works cited in the initial references also identified sources that seemed applicable to the bibliography.

The goal at the outset of the study was to produce a bibliography of about 200 references. However, by the end of the data collection phase, a total of 248 bibliographic entries were compiled. Appendix B contains the bibliography, which is intended to serve as a rich and expandable information base on the topic of computer-aided decision making.[5]

2.3 Screening of Entries for Annotation

In general, the approach for screening the bibliographic entries involved scanning of executive summaries, study introductions and study conclusions for relevance. The goal of the screening process was to narrow the list of references to no more than 50 for which to develop annotated summaries. For this initial screening, indications of the following key elements/criteria were used to gauge the relevance of any particular study/report:

A. Existence or structured public participation process

[5] The bibliography of Appendix B actually contains 260 entries, which includes the addition of several more sources subsequent to the initial deliverable to IWR.

B. Use of stakeholder collaboration in analytical-modeling process

C. Context of integrated water-resources planning and environmental management

D. Context of a real, or applied, planning problem (as opposed to a paper concerned with theory or policy)

E. Involved resolution of disputes or presence of conflicting interests and stakeholder negotiation

When taken together, these criteria (or project elements) were assumed to adequately capture the spirit of SVP as applied to integrated water and environmental-resources issues and were used intentionally to cast a broad and inclusive net for screening.[6]

A spreadsheet was created to house the bibliographic entries and to provide a format to screen and select studies for narrative annotations. The screening spreadsheet was used to calculate a simple score for each bibliographic entry, where each entry was assessed by the consultant team and given 1 point for the existence of each criterion listed above. Thus, the initial ratings resulted in a range of scores from 0 to 5, where a score of 5 indicated that all of the rating criteria seemed to be covered and a score of 0 indicated that an individual reference was judged to contain none of the rating criteria or had not been physically acquired (yet, from the title and referrer, seemed applicable to the bibliography).

Table 1 presents a breakdown of the ratings according to the initial assessment criteria. Out of a total of 248 bibliographic entries, 167 studies and related materials were reviewed and characterized, most of which were collected from reports and guidance provided by the e-mail contacts. Seventy references were judged to contain all of the core elements of SVP (criteria A, B

TABLE 1
SCREENING CRITERIA AND GENERAL CHARACTERIZATION OF LITERATURE REVIEWED
(N=248 BIBLIOGRAPHIC ENTRIES)

Screening Criteria	Number of Studies	Percent of Sample
Bibliographic reference located and reviewed	167	67%
A. Structured public/stakeholder participation	103	42%
B. Collaborative modeling/decision support	127	51%
E. Integrated planning perspective	156	63%
C. Applied planning problem	98	40%
D. Dispute resolution/conflicting interests	95	38%
Elements A, B, C identified (score $\geq$ 3)	70	28%
Elements A, B, C, D, E identified (score = 5)	39	16%

6 Palmer et al. (2007) defines shared vision planning and establishes a rationale for why these elements were selected.

and C above), while 39 references were considered to contain all five of the review criteria.[7]

2.4 Selection of Studies for Annotation

A simple voting procedure was designed to screen the studies included in the bibliography into a smaller set for which narrative annotations would be developed. Three members of the study team who were not directly involved in the compilation of literature (2 persons from IWR and 1 person from the consultant team) were designated voting rights and provided with a list of the 70 studies that received an initial rating score of 3 or higher.

Voting members were instructed to cast votes either to keep or discard studies among the list of 70, with the goal of trimming the list to about 50 studies. Each voting member was also granted the right to substitute/vote for up to 10 additional entries that were not included in the list of 70 studies that received a score of 3 or higher. Therefore, for reference, the entire database of 248 bibliographic entries was also provided to voting members in a separate worksheet.[8]

A tally of votes indicated that 73 studies received one or more votes and 25 studies received the maximum number of three votes. A total of 51 studies received two or more votes; these studies were retained for the development of annotations.

2.5 Design and Structure of Annotations

Appendix A contains the annotated bibliography of the screened literature sources.[9] Each annotation follows a consistent narrative structure that is comprised of four sections:

- *Purpose of the study*—provides an overview of the objectives and general emphasis of the study, including the nature and context of the planning problem
- *Model use*—describes the analytical models and procedures used to portray the planning problem, derive alternative solutions and/or to support the decision-making process
- *Involvement and collaboration*—characterizes stakeholders and the nature and extent of participation in analytical and decision-making processes
- *Outcome*—summarizes reported study results and highlights particular successes and lessons learned

[7] Out of the 70 references, 27 come from peer-reviewed journal articles, 14 come from conference papers and 21 sources are associated with government agencies and university research.

[8] Approximately 45 percent of the bibliographic entries are found in social and scientific journals and about 27 percent come from “grey” literature found primarily on websites. The remainder can be found among conference proceedings/presentations (~15 percent) and from books and official government publications (13 percent).

[9] Note that Appendix A contains 1 additional annotation that summarizes SVP concepts, which brings the total of annotations to 52.

In addition, a text box accompanies each narrative that provides descriptive criteria that can be used to categorize the studies. Aside from providing respective bibliographic references, the text boxes are designed to summarize:

- The geographical study area or extent of the problem
- The general study type or research objective
- Analytical models used in the course of the study
- The general types of stakeholders involved
- Degree, or magnitude, of stakeholder participation
- Type of conflict, if any, and a judgment on whether the problem was solved
- The study lead and/or sponsoring agencies

This summary-level information was also intended to support a limited meta-analysis and synthesis of the annotated studies, which is provided in Section 3 of this report.

Section 3
Synthesis of Reviewed Literature

3.1 Introduction

This section provides a synthesis of the nature of the studies that are annotated in Appendix A. Specifically; this section performs a limited meta-analysis by describing the papers reviewed in terms of:

- Purpose
- Sponsoring agency
- Nature of conflict
- International verses U.S. studies
- Trans-boundary issues
- Types of computer models used
- Level of stakeholder participation
- Outcomes

3.2 Study Purpose, Sponsorship and Geographical Scope

3.2.1 Study Purpose

The survey of literature predominantly focused on studies that pertained to water and environmental resource planning studies. This is reflected in Table 2, which shows that 65 percent of the annotated studies generally applied to water-resources planning and management. Water-resources planning and management studies focused on issues such as:

TABLE 2
NATURAL RESOURCES ISSUE ADDRESSED

Study Purpose	Literature Reviewed	Percent Distribution
Water-resources planning and management	34	65%
Environmental planning and management	6	12%
Ecosystem planning and management	3	6%
Landscape planning and management	2	4%
Water-quality management	2	4%
Not applicable	2	4%
Other	3	6%
TOTAL	52	100%

- Water rights and allocation disputes among various users
- Water-supply management options to ensure adequate supplies to meet future demand
- Evaluation of water-conservation alternatives
- Development of drought plans
- Water utility master planning

Six papers reviewed were classified as environmental planning and management studies, while the rest were related to ecosystem, landscape and water-quality planning and management or some other category. Environmental planning and management studies tended to focus on showing the interconnection between human activities and negative environmental consequences and possible ways of mitigating these impacts. Ecosystem, landscape and water-quality studies were generally related to establishing the interconnections between these and other systems, focusing on appropriate management decisions. Some the papers annotated did not involve real-world case studies. These papers were categorized either as "not applicable" or "other." The "other" classification generally implies that the paper described a specific decision-support system or that none of the other listed study types best described the purpose of the paper and related study.

3.2.2 Sponsoring Agencies

Funding for studies spanned several U.S. government agencies, as well as other domestic and international sponsors. The approach for selecting literature did not involve a stratification of studies across specific sponsoring agencies. Nonetheless, Table 3 shows a reasonable distribution of studies across several categories of sponsors. A distinction is made among government sponsored studies (i.e., national government agencies and universities), local and regional agencies (i.e., agencies responsible for regional resource management) and non-governmental organizations (NGOs) (e.g., privately subsidized research institutes, think-tanks and advocacy groups).

Among the studies reviewed, about one-third was sponsored by U.S. government agencies. The U.S. Army Corps of Engineers was identified to be the primary sponsor of 6 studies and co-sponsors of at least 1 other study. Studies sponsored by several other U.S. government agencies are represented in the annotated literature.

Ten reviewed studies were sponsored by European government agencies. The European Commission through its activities and funding related to its Water Framework Directive work was matched to at least 6 studies.

Eight other studies were sponsored by other international governmental organizations. Two studies were sponsored via United Nations programs, two others were sponsored by the Canadian government and two more were sponsored by Australian government.

Five studies were sponsored by local and regional management agencies, four of which are located in the U.S. Three of the four NGOs represented in the literature are based in the U.S. The Nature Conservancy sponsored 2 of the 52 studies that were annotated.

TABLE 3
SPONSORING AGENCY

Who was the sponsoring agency?	Literature Reviewed	Percent Distribution
U.S. Government Agencies	17	33%
U.S. Army Corps of Engineers	6	
U.S. Army Corps of Engineers; U.S. Forest Service (USDA)	1	
U.S. Environmental Protection Agency (EPA)	2	
U.S. Forest Service, Department of Agriculture (USDA)	1	
U.S. Geological Survey(USGS)	1	
U.S. Bureau of Reclamation (US BOR)	1	
NOAA and University of Vermont	1	
National Science Foundation	1	
Sandia National Laboratories Small Business Assistance Program; State of New Mexico	2	
University of Maryland	1	
European Government Agencies	10	19%
The European Commission	6	
Academy of Finland	2	
Swiss Federal Institute of Environmental Science and Technology	1	
Department for International Development of the United Kingdom	1	
Other Foreign Governments and Multinational Agencies	8	15%
Environment Canada	1	
Mexico National Water Commission	1	
Natural Resources Canada	1	
Land and Water Australia	1	
NATO and Russian Foundation	1	
UNESCO	1	
United Nations Development Program/Global Environment Facility	1	
The Australian National University	1	
Local and Regional Resource Management Agencies	5	10%
Lower Colorado River Authority	1	
Portland Water Bureau	1	
Regional Transportation Commission of Southern Nevada	1	
Foster Creek Conservation District (FCCD), Douglas County, Washington	1	
Wellington (NZ) Regional Council	1	
Non-Governmental Organizations	5	10%
International Institute for Applied Systems Analysis	1	
Sustainability Institute	1	
The Pew Charitable Trusts and the Beijer International institute for Ecological Economics	1	
The Nature Conservancy	2	
Not specified	3	6%
Other/Not applicable	4	7%
TOTAL	52	100%

3.2.3 Nature of the Conflict

With regard to the nature of the conflict, the studies tended to focus on water-resource allocation (including allocation to environmental purposes) or water-supply management problems. Though these two issues are related and typically not mutually exclusive, studies were generally classified into one of these categories based on a judgment about the primary purpose of the investigations. Noting the interchangeability of these classification categories, the totals presented in Table 4 should be regarded as rough approximations rather than definitive measures.

TABLE 4
GENERAL NATURE OF THE CONFLICT

What was the nature of the conflict?	Literature Reviewed	Percent Distribution
Competing uses of the water resources; environmental management issues	20	38%
Evaluation of alternative water-supply management options	13	25%
Not applicable (or no explicit conflict was identified)	19	37%
TOTAL	52	100%

Roughly 20 papers reviewed addressed conflicts between competing users of water, including provisions ensuring environmental/ecosystem sustainability. Another 13 papers primarily addressed evaluations of municipal water-supply management alternatives as it relates to planning for meeting future water demands. Finally, a catch-all category with 19 papers was used for papers where a conflict was not explicitly noted or could not be sufficiently characterized from a review of study contents.

3.2.4 U.S. versus International versus Trans-Boundary Issues

To capture a broad sense of the nature of existing applied research related to computer-aided decision making, an effort was made to identify studies from within the United States and from other countries and hemispheres. Table 5 shows that 50 percent of the studies that were reviewed pertained to U.S. issues, while, 32 percent were from outside the U.S. International studies included those focusing on planning issues in Mexico, Canada, Argentina, Australia, New Zealand, South Africa and several countries in Europe.

TABLE 5
U.S. OR INTERNATIONAL STUDY—TRANS-BOUNDARY ISSUES

Was it an international or U.S. study? Were there any Trans-Boundary issues?	Literature Reviewed	Percent Distribution
U.S.; Not trans-boundary	19	37%
International; Not trans-boundary	15	29%
U.S. study with trans-boundary issues	7	13%
International with trans-boundary issues	7	13%
Not applicable	4	8%
TOTAL	52	100%

For purposes of this study, a study was classified as dealing with trans-boundary issues if the geographical scope or sponsorship of a study spanned across international borders of countries, or where a clearly specified dispute was specified between countries.[10] Fourteen studies (7 originating from the U.S. and 7 international) were determined to have addressed identifiable trans-boundary issues. This metric could not be applied to 4 papers, because these papers did not address a particular case study.

3.3 Use and Types of Computer/Automated Models

Collaborative planning and policy making does not necessarily require the use of computers. However, computer-aided collaborative decision making has become more important in water-resources management as the scope of the studies has broadened both in terms of planning objectives and the number of interested stakeholders. From the literature reviewed, one may classify the following causes for the uptrend in the use of computers in the decision-support context:

1. Recent advancement and decreases in the cost of computing technology
2. Increased computational efficiency gained from using computers
3. Introduction of programming languages that are easier to use
4. Opportunities to standardize methods and approaches
5. Capabilities for better record keeping and tracking by means of databases
6. Usefulness of computer-assisted platforms for building trust and consensus among stakeholders
7. Diffusion of technical capabilities across a broader range of groups/stakeholders
8. Increased access to technical data and tools via low cost computers and internet connectivity (or something along those lines)

The sections below provide a summary of the types of computer-based models that were applied among the studies that were reviewed.

3.3.1 Note on Nomenclature

An observation made from reviewing the literature and which is evident in the summary of Table 6, is the lack of consistency in the terminology that is used to define models and modeling processes. Computer models used for computer-aided decision-making studies seem generally to be given study-specific names. Though the names of study-specific models are different, the overall approach is closely similar (especially in the case of system dynamics (SD) modeling). This applies to studies both in the U.S. and those from other parts of the world.

[10] Thus trans-boundary is defined to reflect the involvement of more than one country and does not include situations that are sub-national, such as interstate or inter-provincial conflicts.

TABLE 6
USE AND TYPES OF COMPUTER/AUTOMATED MODELS

Primary modeling environment used in the study	Literature Reviewed	Percent Distribution
Simulation Models	**31**	**60%**
System Dynamics Models	**25**	
STELLA	14	
POWERSIM	6	
Vensim/PLE Plus	2	
Studio Expert	2	
Simile software	1	
Other Simulation Models	**6**	
River Simulation System	1	
Catchment Simulation Shell	1	
Operational Analysis and Simulation Systems (OASIS) with OCL™ platform	1	
Adaptive Environmental Assessment and Management; QuickBASIC application	1	
Generalized Reachable Set tool; Interactive Decision Maps (IDM); Point-Associated Trade-offs (PAT)	1	
Everglades Landscape Model (ELM) and the Coastal Ecological Landscape Spatial Simulation (CELSS) model (STELLA-based)	1	
Group Modeling/Multi-Criteria Analysis Tools	**4**	**7%**
Web-HIPRE; HIPRE 3+ software; regulatory policy re-evaluation	1	
Legal-Institutional Analysis Model (LIAM) software	1	
Causal loop model	1	
Conflict Resolution Support System	1	
Other	**17**	**33%**
Integrated assessment model	2	
Agent-based integrated assessment model	1	
Multiobjective integrated assessment model	1	
Selin and Chavez conceptual model	1	
Multiple models	1	
Evaluation of methods/models	2	
Evaluation of participatory processes	6	
Not applicable	3	
TOTAL	**52**	**100%**

The term “model” appears to be used loosely to include both automated analytical (computer) models, as well as general conceptual or mental models. Some studies that used the term model broadly also to refer to a study process, within which actual analytical techniques and computer applications represent study components.

Most studies that adopted a dynamic modeling approach were associated with a conceptual framework outlining how to proceed in developing the dynamic model. These frameworks are commonly defined by a process consisting of series of steps (“three-step,” “five-step,” “seven-step process,” etc.). A general observation is that the suggested processes tend to capture the same analytical and decision-support elements and mainly differ subtly in how the elements are ordered and aggregated into specific steps. For example, one study defined a process that started with a low-resolution characterization of the system for consensus building, followed by more detailed replication of the dynamics of the system and then by development of models focused on management options and producing scenarios. As another example, a different study process began with a problem scoping phase, followed by a thorough description of the system and then by building and validation of analytical models that were subsequently used for policy analysis and public outreach.

3.3.2 Simulation Models

The studies that were reviewed employed a variety of analytical models employed around the principal of facilitating collaborative decision making or simply stakeholder participation. Simulation models of the response (input and output) properties of physical and socioeconomic systems appear to be becoming more prevalent as the analytical basis for describing and modeling complex systems.

Table 6 shows that more than half of the studies reviewed used simulation models. Furthermore, most of the studies that used simulation models adopted a SD approach to identifying and analyzing water-resources challenges. SD models are a subset of simulation models that are purported to recognize and account for feedback (or endogeneity) and nonlinearities among variables that describe a system.[11] Water resources and environmental planning problems often entail multiple objectives and interplay among (sometimes intricate) physical and social systems at spatial scales that intermingle watersheds and political jurisdictions. Thus, as supported by the literature, advantages of using SD modeling include the ability to model complex systems with temporal behaviors at varying spatial resolutions.

Several simulation and modeling platforms were used in the studies reviewed. The use of the STELLA generic modeling environment was identified as the primary model in at least 14 studies. Another 6 papers employed an SD approach using the POWERSIM modeling environment. Other SD modeling environments were mentioned, including Vensim software and Studio Expert software. Those simulation models that were not identified as SD models tended to be tailored applications that were capable of simulating specific physical processes or decision outcomes.

The literature that was reviewed provided limited information that could be used to compare the various modeling environments in terms of their advantages and disadvantages. A common justification found across all modeling environments was the ease with which the models could be developed or populated and used for scenario-building. A common goal of the applications was to promote model transparency to facilitate interaction with a broad set of stakeholders.

3.3.3 Other Models

Several of the classifications in Table 6 refer to the use of models to support group collaborative processes, through the use of tools that consider multiple preferences and decision criteria. These types of models tended to be used in mediated-modeling experiments that use analytical models to support negotiated outcomes. However, it should be noted that many of the other models classified in Table 6 were used or recommended to be used as a subcomponent to

[11] This definition is adapted from discussions on systems dynamics found at http://www.systemdynamics.org/.

simulation or SD models. In fact, reviewed literature shows that various computer applications were designed to produce different types of linkages and inputs to broader decision-support models at various stages of the investigation. For example, in one study, an optimization model (HEC-PRM) was used to identify an optimal set of water releases from the reservoirs, which were then used to simulate scenarios using a SD model in order to integrate the effects of hydrologic parameters on other factors such as the local ecology, flood damages and the economy. The term "integrated assessment model" was found to be associated with models that were designed to integrate both socioeconomic and physical systems.

3.4 Level and Types of Stakeholder Participation

Another major difference among the modeling approaches identified above is in the level of stakeholder and public participation that is involved during the application of any given process. Three basic levels of stakeholder participation were observed in the studies reviewed. One level represents cases where stakeholders are invited to participate in the evaluation of alternatives after the decision-support model had been developed by research scientists. Table 7 shows that approximately 17 percent of the papers reviewed reported this type of participation. This type of participation tends to focus on analytical model development, subsequently building group processes around the results of the models. Although stakeholder participation is sequenced nearer the end of the study process in these studies, this does not suggest that participation was necessarily small in scale, since multiple workshops with many individuals tended to be conducted to evaluate and discuss the implications of model outcomes.

TABLE 7
LEVEL AND TYPES OF STAKEHOLDER PARTICIPATION

What was the level of participation?	Literature Reviewed	Percent Distribution
Data collection, model development and evaluation of alternatives	13	25%
Model development and evaluation of alternatives	11	21%
Evaluation of alternatives	9	17%
Various unique levels of stakeholder involvement and collaboration depending on study	7	13%
Assisted in providing information	1	2%
Not discussed	2	4%
Not applicable	9	17%
TOTAL	52	100%

Another level of participation reflects cases where stakeholders are invited to participate in some way in the development of the model. Approximately 21 percent of papers reviewed exhibited this type of participation, which some papers termed "group model building." This approach usually takes the form of a series of workshop meetings where different modules of the system are developed with input from stakeholders about feedback loops and other system interrelations. The development of models was not limited to analytical computations. In several cases, stakeholders were involves in developing "mental models" that defined the roles and interrelationships of relevant organizations and institutions, as well as in identifying the relative concerns and power among those with a stake in the process. Also, some studies suggested that a smaller subset of stakeholders—those who were more technically inclined—

were more likely to participate and provide input to the development of analytical algorithms and in some cases participation in model building was restricted by design to particular people within the stakeholder group. Some studies indicated that once the initial model-building phase was completed, stakeholders helped validate the workings of the models and to verify results. As suggested above, this step would typically occur by means of dedicated workshops or focus groups, which were also commonly used as mechanism for stakeholders to participate in the simulation of policy options and to view and evaluate potential impacts.

The third and most extensive level of participation was found to involve stakeholders early on in data collection phase and to maintain involvement through model development and evaluation of alternatives. About 25 percent of the studies suggested this highly collaborative level of involvement, with the primary distinction of involving stakeholders in problem definition and in collecting information that directly supported the development of computational models. Some of the studies indicated that particular sub-groups of stakeholders were assigned or invited to participate in certain phases of the process, such as data collection and group model building. However, all stakeholders tended to be involved in problem definition and in iterative evaluation of model outputs. The high level of interaction and exposure of stakeholders across all elements of the study process suggests a great deal of effort in designing and structuring collaborative/participatory processes. Although there is not explicit reference in the literature that was reviewed, the high level of involvement implies that the design of the collaborative framework can be considered of equal or greater importance than the design of computer models, demanding considerable resources in the development of the overall research approach.

Finally, as in the case of the term "model," the term "stakeholder" is found to have many possible meanings. In some studies, the term was used in a narrow sense to define specific individuals and groups that could be immediately affected by a resource-management decision ("root" stakeholders) and those representing specific technical skills (such as biologists, economists, limnologists, etc.). In others, the term was used in much broader sense, identifying groups such as the general public, environmental interests and government agencies. Among the studies reviewed there are few instances where root stakeholders are engaged in model building and decision analysis. As implied above, in some cases this may have been by design and in other cases by self selection.

While it is likely that the geographical and jurisdictional scale of any particular study may serve as a practical constraint for precisely defining individual stakeholders in a report, it seems possible that the definition of stakeholders may be a problematic component of the study process. As noted above, however, at least one study built the definition of stakeholders and stakes into the model building exercise.

3.5 Outcomes

Participatory processes that also make use of computer models have become increasingly popular based on the argument that such approaches increase the chances of resolving disputes or developing consensus among stakeholders. However, and as acknowledged in some of the papers reviewed, these approaches do not guarantee that a problem or conflict will be solved. Table 8 shows that about 35 percent of the papers reviewed reported some form of solution to or decision about a problem. In contrast, only 6 percent of the papers reviewed mentioned that the processes failed to resolve the issue at hand.

TABLE 8
OUTCOMES

Did the study help solve the problem?	Literature Reviewed	Percent Distribution
Yes (model results were used to resolve a dispute or to make a decision about management options)	15	29%
Yes (among two of six case studies covered in three annotations)	3	6%
No	3	6%
Partially (provided clarification and recommendations)	14	27%
Study was ongoing at the time of writing	2	4%
Mixed (report referred to multiple case studies)	2	4%
Not applicable	13	25%
TOTAL	52	100%

Several of the papers that could be categorized according to this metric reported some positive results. However, these studies were not usually explicit in judging the overall success of study outcomes and in some cases reference that the study was still ongoing at the time of writing. In general these studies reported that the processes used helped provide clarification of the problem and offered meaningful recommendations regarding decisions and future work activities.

Reviewed papers that were not applicable were those that either did not involve a real applied study or did not offer an explicit or implicit judgment on study outcomes.

Section 4
Summary and Recommendations

4.1 Summary

Shared Vision Planning – a combination of traditional water-resources planning, systems modeling and public involvement – was created during the U.S. Army Corps of Engineers' National Drought Study in the early 1990s. This study represents a first attempt to collect and describe documented experiences with computer-aided decision making that have the characteristics of SVP. This study compiled and reviewed a set of literature that encompasses multiple aspects of computer-assisted decision making practices. Two stand-alone products of this effort, a reference list containing over 250 research sources and an annotated bibliography of case studies and other examples, provide a resource base that can be used and, in the future, expanded by researchers and practitioners in the Corps and others to understand the current state of practice in computer-assisted decision making.

The synthesis of literature has resulted in several findings that can assist the Corps and broader community of planning practitioners in understanding the state of practice in computer-assisted decision making.

The literature shows that the field of water and environmental resources planning and management has recognized the importance of involving stakeholders and using computer-aided analytical and decision-making processes. Although the analysis indicates some degree of success in stakeholder participation and computer modeling, no distinct and common framework seems to exist that explicitly couples collaboration with analytical modeling and decision making.

The experiments among the studies reviewed were conducted relatively independently. Authors of these papers rarely reference the other authors in this collection except for references within certain groups. This indirectly attests to the soundness of the idea of blending modeling and public involvement in water management, but suggests that the authors may have been unfamiliar with and unable to benefit from similar, contemporaneous work. If there is to be a recognized canon of techniques for this kind of work that could be tested and improved in new case studies, it will have to start with greater familiarity with what others in the same field are doing.

Few of the reviewed studies claim to have driven the decision in question and most were not explicit in judging the overall success of study outcomes. Many studies can be described as learning exercises conducted in parallel to the decision process. Involvement in such exercises clearly helped inform stakeholders who may then have been better prepared to play their role in the decision-making process.

Among the studies reviewed there are few documented cases of "root" stakeholders helping to build models that are used in decision making. Mediated modeling tends to involve root stakeholders as an educational effort; computational planning models are used in decision processes, but root stakeholders generally do not participate in model building. Furthermore, it appears that stakeholders do not necessarily need to be involved in model building as long as trust is developed with those involved in model building.

The papers are academic reductions of dynamic and sometimes hostile conflicts. This distillation removes the storytelling structure that would make the cases more accessible. This precludes more robust speculation on the effectiveness of the planning, modeling and collaboration processes. By design, the summaries are a distillation of a distillation. Unfortunately, this may leave out many experiences and subtleties that could be helpful to practitioners interested in using and improving these methods.

4.2 Recommendations

To build upon the information reviewed as part of this study and provide more direct exchange of ideas, methods and lessons learned, IWR should take steps to organize a community of practice for scientists, planners and other professionals involved in computer-aided decision making in water-resources planning. This community could be used to bring both water-resources professional and public participation experts together to reconcile not only study and planning processes, but also the language that is used in the field. The reference bibliography and list of contacts that were created for this study would serve as a direct resource for identifying people and institutions that could be interested in participating and partnering with IWR.

Three specific activities could be undertaken concurrently by IWR to organize and consolidate this community of practice.

1. *Organize and sponsor a Conference/Symposium on computer-assisted decision making*. Very limited formal activities exist to exchange ideas and facilitate integration of computer based modeling tools within multi-stakeholder public decision processes. Seldom do the multiple skills and disciplines have a chance to have joint annual meetings or any established forum for interaction. A periodic conference on computer-assisted decision making could establish this forum and promote interdisciplinary and interagency collaboration. Such a conference could be used to highlight successful illustrative case examples and to add more meaning to some of the literature reviewed as part of this study. Technical sessions could be designed to attract modelers, facilitators, negotiators and decision makers along common and mixed tracks. Consolidated plenary sessions could be designed to illustrate the craft of integrating computer-based modeling tools within multi-stakeholder public decision processes.

2. *Design a Center for Computer-Aided Decision Making and Dispute Resolution in water resources*. A centralized think-tank physically located at IWR could serve as focal point for expertise in water-resources planning, computer modeling and decision support and as a clearinghouse for research and knowledge about melding model use with collaborative processes. One vision of such a Center could be to bring together multiple Federal, state and academic partners to focus on computer assisted dispute resolution techniques, through training, methodological development and technical assistance on water problems. The center could coordinate research and demonstration projects and provide linkages to tool boxes and references. A primary mission area could focus on the development of collaborative decision-support tools and frameworks for evaluating the effectiveness of combinations of various computer tools and collaborative interventions across of range of water problems

and settings. IWRs coordinated development and dissemination of principles and best practices for modeling and multi-stakeholder public processes could support the resolution of a broad range of current and future water conflicts, through the application of broadly-acceptable and sustainable solutions.

3. *Identify and design targeted "pilots" or "demonstration projects" to be studied and evaluated with the intent of developing basic principles and best practices to computer assisted multi-stakeholder approaches and methodologies*. A demonstration of computer-assisted decision-making approaches is essential for bringing focus to the benefits of integrating modeling and collaboration in an applied decision environment and in solidifying the role of the proposed Center. IWR should identify pilot applications based on tangible high priority needs and problems facing the nation, such as water supply, TMDLs and modified operations of multi-purpose reservoir systems. Using teams of experts from across academic, consulting and Federal research establishments, the demonstrations would be invaluable for improving methodologies and process design, by implementing best practices and identifying pitfalls. Demonstration projects would help define the model features or attributes that best facilitate collaborative multi-stakeholder processes, feature recommended computer technology platforms and, in real-time application, help establish a common understanding of policy options across stakeholders.

4. *Identify software that is most appropriate to support SVP and sponsor development of modeling tools that could be used for collaborative participatory modeling*. The review demonstrates that there are fairly limited modeling resources that are specifically developed for SVP. At the same time, there are suites of models developed within the Corps and elsewhere, which are rarely taking into account the needs of participatory modeling. IWR is in an excellent position to identify the architecture that is most appropriate for collaborative modeling and lead the other teams towards a unified approach based on principles of modularity, transparency, open source and flexibility—all these essential for supporting stakeholder participation and the SVP process.

Finally, the reference bibliography and annotations developed under this initial effort should become living documents that are updated periodically with new sources, perhaps via a devoted Corps-hosted website on computer-assisted decision making, following a consistent editorial structure. As a first step in this process, the people that contributed studies and contacts could be notified and asked to review the report, annotations and reference list. Establishing this early dialogue would help verify and clarify the conclusions of the studies that were reviewed and add guidance and support for the recommendations made above.

Appendix A

Annotated Bibliography of Selected Computer-Aided Collaborative Decision-Making References

Appendix A
List of Annotated References

Appendix A
Annotated Bibliography of Selected Computer-Aided Collaborative Decision-Making References

1 Systems Dynamics Approach to Conflict Resolution in Water Resources: the Model of the Lerma-Chapala Watershed

System/Study Area Name:	Lerma-Chapala Watershed, Central Mexico (States: Estado de Mexico, Queretaro, Michoacán, Guanajuato and Jalisco)
Study Type:	Applied water-resources management
Analysis/Model Type:	System dynamics; STELLA software
Stakeholders Identified:	States located within the boundaries of the basin, National Water Commission of Mexico, common citizens, agricultural organizations, environmentalists and NGOs
Level of Participation:	Expert consultation, multidisciplinary group meetings
Conflict Type:	Allocation and restoration of scarce water resources
Was Problem Solved:	Partially
International or U.S.:	International – Mexico; not a trans-boundary issue
Sponsoring Agency:	National Water Commission of Mexico
Study Lead:	Mexican Institute of Water Technology; Prospective Decision Models, Inc. and PDM de Mexico, S.A. de C.V.
Authors and Source:	Huerta, J.M. 2006. A systems dynamics approach to conflict resolution in water resources: the model of the Lerma-Chapala Watershed. Abstract retrieved August 2006, from http://www.systemdynamics.org/conf2004/SDS_2004/PAPERS/157HUERT.pdf

1.1 Purpose of the Study

To encourage rapid social and economic development, authorities in Mexico had previously encouraged the exploitation of the country's aquifers as a means to supplying its growing population and industry. However, a limited water supply led to competing users vying for the same scarce water resources. The Lerma-Chapala Watershed was one of those facing such water conflicts among users. The National Water Commission of Mexico (CNA) in conjunction with the five states located within the boundaries of the basin introduced a Surface Water Distribution Agreement. This agreement was implemented in 1991 and outlined a set of rules that would govern the yearly allocation of the river's waters.

The agreement's two main objectives were to improve the distribution of the Lerma River's water among the many users and to restore the volume of Lake Chapala and other water bodies within the basin. From an engineering standpoint, the set of rules outlined in the agreement were sustaining water levels in Lake Chapala. However, a conflict continued amongst stakeholders regarding water rights. This study was an effort to resolve these conflicts while maintaining the agreement's objectives of sustaining water levels.

1.2 Model Use

A systems dynamics (SD) approach was adopted for this project. One of the reasons stated for selecting an SD approach was the existence of previous experience in using SD modeling to examine watershed problems in Mexico. Furthermore, an SD model was found to be advantageous because of its ability to model and simulate the temporal behavior of problems and also because a reasonable spatial resolution could be achieved by decomposing the problem into smaller sub problems.

Following a request from CNA, the Mexican Institute of Water Technology developed the Lerma-Chapala Watershed SD Model. Its foundation is based on a previously built model called ProEstado-MAUA that was developed for the state of Guanajuato. The dynamic simulation environment, STELLA Research, Version 7.0, for Windows was used to build the model. The model is composed of 17 separate sub watershed models. Each of the sub watershed models are themselves represented by four basic models of the sub watershed: (1) synthetic rain, (2) rain-run-off, (3) reservoir operation and (4) agricultural production. The models interact dynamically with each other.

1.3 Involvement and Collaboration

Stakeholders identified from the study include the five states located within the boundaries of the basin, CNA, common citizens, agricultural organizations, environmentalists and NGOs. According to the study, a multidisciplinary group was formed within the Lerma-Chapala water council to develop an improved Surface Water Distribution Agreement. The multidisciplinary group was comprised of hydrologists, water engineers, sociologists and economists. The group developed the Lerma-Chapala Watershed SD Model as a policy analysis tool to examine the causes of the watershed problems. The study indicates that the model was built based on experts' knowledge and field visits to map the watershed. Beyond experts' knowledge and field visits, there is no indication stakeholders listed above were involved during the data collection and model development phase.

Once the model was built, the multidisciplinary group convened meetings that also included representatives from the five states. During these meetings, group members were presented with the model and allowed to test various policy implications using the model. The report notes however that many participants of the group meetings lacked the requisite "SD culture" that would enable them to understand precisely the functioning of the model. As a result, uneven participation by group members and misunderstandings were experienced.

1.4 Outcome

The study suggests that the project together with the model was able to bring stakeholders together and enabled them to focus on a common understanding of the time related behavior of the watershed. The study and model allowed stakeholders to test policies that they deemed most favorable to them. The intention of using the Lerma-Chapala Watershed SD Model as an analysis tool was to bring stakeholders together to agree on policy adjustments that would produce a "win-win" solution. At the time the report reviewed was produced, final model results from the multidisciplinary group had been pushed back by six months. As a result, no policy recommendations were provided in the report.

2 Using Dynamic Modeling to Scope Environmental Problems and Build Consensus

This report uses four case study examples to illustrate how a three-step dynamic modeling process has been used to collect and organize data, synthesize knowledge and build consensus about the management of complex systems. As stated in the report, it assesses the changing role of dynamic modeling for understanding and managing complex ecological economic systems. The report argues that nonlinearities and spatial and temporal lags are common features of environmental systems, yet all too often scientists make simplifying assumptions that move these features to the sideline of environmental system studies. As a result, environmental system studies with such simplifications are said to be of limited use with regard to providing insights that are necessary to make proper decisions about the management of complex ecological economic systems.

The role of model building in clarifying the interconnected operational aspects of a system and choosing among alternative actions are also highlighted in the report. Also addressed are the advantages of dynamic modeling over pure statistical or empirical models—one key advantage being dynamic models do not rely on historic or cross-sectional data to reveal relationships in a system.

The report argues that models used to support decisions on environmental investigations and problems should also be used as a tool in building a broad consensus not only across academic disciplines but also between science and policy. Models should more broadly involve a wide range of parties interested in or affected by decisions.

A three-step process is proposed for building such models. The first step in the process is to develop a high-generality, low-resolution scoping and consensus building model involving broad representation of stakeholders. The second step is to develop research models that are more detailed and make realistic attempts to replicate the dynamics of the particular system of interest. The third step is the development of management oriented models focused on producing scenarios and management options based on earlier scoping and research models. Four case study examples are used to illustrate the three-step dynamic modeling process: (1) U.S. iron and steel industry, (2) Louisiana Coastal Wetlands, (3) South African Fynbos Ecosystems and (4) Patuxent River Watershed, Maryland.

The following section describes the U.S. iron and steel industry case study. Descriptions of the other three case studies are presented separately in sections that follow.

2.1 Case Study 1 – U.S. Iron and Steel Industry

System/Study Area Name:	U.S. iron and steel industry
Study Type:	Market analysis of the industry's future likely profiles of material and energy use
Analysis/Model Type:	Dynamic modeling; STELLA software
Stakeholders Identified:	Various production stages in the industry, industry experts, members of industry associations and consultants
Level of Participation:	Expert consultation and iterative interviews with stakeholders during the modeling process
Conflict Type:	Implication of various rates of change in demand for industry's products and in technologies on material and energy use
Was Problem Solved:	Valuable insight was generated about the industry's energy mix, technology mix and time frames
International or U.S.:	Limited to U.S. iron and steel industry; not trans-boundary
Sponsoring Agency:	U.S. iron and steel industry
Study Lead:	Matthias Ruth, Center for Energy and Environmental Studies, Boston University, USA
Authors and Source:	Costanza, R. and Ruth, M. (1998). Using dynamic modeling to scope environmental problems and build consensus. Environmental Management, 22(2), 183-195.

2.1.1 Purpose of the Study

In this case study, the iron and steel industry is described as one with a high degree of interconnectedness among the various stages of production. In such a highly interconnected industry, a change in production technologies in one stage of production usually requires technological adjustments at other production stages. The study notes that technological adjustments at various stages are likely to impact the industry's energy use profile. Because the iron and steel industry is characterized by large-scale operations that require significant capital investment to change their structure, decision makers in the iron and steel industry try to anticipate long-term trends in demand for the industry's products and supply of raw materials and energy. This study was an effort to develop a scoping and consensus building model of the industry that would capture the various production stages and develop an understanding of the industry's likely future profiles of material and energy.

2.1.2 Model Use

A dynamic model of the iron and steel industry was built using STELLA software. Production stages and key materials represented in the model include mining, pig iron and raw steel production, modules for electricity generation and coke production. The model built for this study is described as a scoping and consensus building model—Step 1 of a three-step modeling process.

2.1.3 Involvement and Collaboration

The case study describes the active participation of stakeholders and describes the involvement of stakeholders in model development. Participants including industry experts, members of industry associations and consultants, were involved in model development through a series of informal iterative interviews. According to the report, the model was also set up to run in an iterative modeling mode that enabled decision makers to choose different parameter settings based on their understanding of the industry.

2.1.4 Outcome

The study was able to show that although there is no shortage of iron ore in the United States, declines in ore grade lead to increases in total energy consumption per ton of raw steel produced. The study added valuable information about the industry's energy mix, technology mix and the time frame in which these changes are likely to occur.

2.2 Case Study 2 – Louisiana Coastal Wetlands

System/Study Area Name:	Louisiana Coastal Wetlands
Study Type:	Environmental management and landscape dynamics
Analysis/Model Type:	Dynamic modeling; three-step modeling approach; STELLA software
Stakeholders Identified:	U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, local landowners and environmentalists and several disciplines within the academic community
Level of Participation:	Stakeholders were directly involved as participants in the modeling process through all three stages
Conflict Type:	Conflicting solutions to the management of the Louisiana Coastal Wetlands
Was Problem Solved:	Model results were used in making decisions about management options
International or U.S.:	U.S.; not a trans-boundary issue
Sponsoring Agency:	U.S. Army Corps of Engineers; U.S. Fish and Wildlife Service; National Center for Supercomputer Applications
Study Lead:	Coastal and Environmental Policy Program, Chesapeake Biological Laboratory, Center for Environmental and Estuarine Studies, University of Maryland; Belle Baruch Institute, University of South Carolina; Coastal Ecology Institute, Center for Wetland Resources, Louisiana State University
Authors and Source:	Costanza, R. and Ruth, M. (1998). Using dynamic modeling to scope environmental problems and build consensus. Environmental Management, 22(2), 183-195. Costanza, R., Sklar, F.H. and White, M.L. (1990). Modeling coastal landscape dynamics. BioScience, 40(2), 91-107.

2.2.1 Purpose of the Study

The Louisiana Coastal Wetland Project was intended to bring about a better understanding of factors that impact wetland loss in coastal Louisiana. It was set to study landscape dynamics by tracing the distribution of water and sediment through the landscape and provide solutions to the land loss problem in Louisiana. As contrasted to past suggested solutions which had been evaluated independent of each other, this study's goal was to arrive at a more comprehensive solution that incorporates adequate dialogue and consensus among affected stakeholders.

2.2.2 Model Use

The study was a multi-phase effort that applied a three-step modeling approach. In the first phase—Step 1, a general scoping and consensus building model was developed using STELLA software. The model was considered a unit model focusing on the basic process occurring at any point in the landscape. In the second step of the approach, an integrated spatial simulation model was developed. This model is reported to have replicated the unit model but also included horizontal flows of water, nutrients and sediments along with necessary algorithms. The third step required the development of a research and management model. This model was called the Coastal Ecological Landscape Spatial Simulation (CELSS) Model and consists of 2,479 spatial cells of 1-km^2 to simulate a rapidly changing section of the Louisiana coast.

2.2.3 Involvement and Collaboration

Stakeholders were directly involved as participants in the modeling process through all three stages. Stakeholders identified in the report included the U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, local landowners, environmentalists and several disciplines within the academic community.

2.2.4 Outcome

The paper reports that the model was user-friendly and interactive and allowed users to control inputs such as area of alien plant clearing, fire management strategy, level of wildflower harvesting and park visitation rates.

2.3 Case Study 3 – South African Fynbos Ecosystems

System/Study Area Name:	Cape Floristic Region of South Africa
Study Type:	Ecosystem management
Analysis/Model Type:	Dynamic modeling; three-step modeling approach; STELLA software
Stakeholders Identified:	U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, local landowners and environmentalists and several disciplines within the academic community
Level of Participation:	Stakeholders were directly involved as participants in the modeling process through all three stages
Conflict Type:	A need for funding and effective management options
Was Problem Solved:	Model results were used in making decisions about management options
International or U.S.:	South Africa; not a trans-boundary issue
Sponsoring Agency:	The Pew Charitable Trusts; Flora Conservation Committee of the Botanical Society of South Africa; the World Wide Fund for Nature, South Africa and B.P. South Africa
Study Lead:	Institute for Plant Conservation, Department of Botany, University of Cape Town; Coastal and Environmental Policy Program, Chesapeake Biological Laboratory, Center for Environmental and Estuarine Studies, University of Maryland
Authors and Source:	Costanza, R. and Ruth, M. (1998). Using dynamic modeling to scope environmental problems and build consensus. Environmental Management, 22(2), 183-195. Higgins, S.I., Turpie, J.K., Costanza, R., Cowling, R.M., Le Maitre, D.C., Marais, C. and Midgley, G.F. (1997). An ecological economic simulation model of Mountain Fynbos ecosystems dynamics, valuation and management. Ecological Economics, 22, 155-169.

2.3.1 Purpose of the Study

Fynbos is described as hard-leafed shrub land that is the predominant vegetation in the Cape Floristic Region of South Africa. This study is described as a scoping and consensus building project which was initiated to address issues of species diversity in the Cape Region. In order to adequately manage these ecosystems, the study suggests that questions such as, what services do these species-rich fynbos ecosystems provide, need to be answered. The purpose of this study was to generate a series of consensus-based research papers that critically assess surrounding ecosystem valuations and services derived from fynbos systems.

2.3.2 Model Use

A general dynamic model integrating ecological and economic processes in fynbos ecosystems was used. The model was developed in STELLA software and was designed to assess among other things, the potential values of ecosystem services given ecosystem controls and management options. The model was comprised of five submodels: hydrological, fire, plant, management and economic valuation.

2.3.3 Involvement and Collaboration

As part of the study, a two-week workshop was held to produce a series of consensus-based research papers. Workshop participants formed multidisciplinary, multicultural groups. One of the groups focused on producing an initial scoping model with input and feedback from the other groups. Participants at the workshop included faculty and students from different disciplines along with park managers, business people and environmentalists.

2.3.4 Outcome

The paper reports that the resultant model was a user-friendly and interactive model that allows users to control for such features as area of alien plant clearing, fire management strategy, levels of wildflower harvesting and park visitation rates. The model was expected to be a valuable tool to decision makers as they evaluated management options.

2.4 Case Study 4 – Patuxent River Watershed, Maryland

System/Study Area Name:	Patuxent River Watershed, Maryland
Study Type:	Watershed planning; environmental resources management
Analysis/Model Type:	Dynamic modeling; three-step modeling approach; STELLA software
Stakeholders Identified:	A full range of scientific, government and citizen stakeholders groups
Level of Participation:	stakeholders were involved in workshops to develop initial scoping models, communicate results and to refine/adapt the research agenda
Conflict Type:	Conflicting water use interests and ecosystem management alternatives
Was Problem Solved:	Was an ongoing project
International or U.S.:	U.S.; not a trans-boundary issue
Sponsoring Agency:	U.S. Environmental Protection Agency
Study Lead:	Center for Environmental and Estuarine Studies, University of Maryland
Authors and Source:	Costanza, R. and Ruth, M. (1998). Using dynamic modeling to scope environmental problems and build consensus. Environmental Management, 22(2), 183-195.

2.4.1 Purpose of the Study

According to the study, rapid urban development and changes in agricultural practices around the Patuxent River Watershed have resulted in adverse impacts on both terrestrial and aquatic ecosystems, leading to deterioration in water quality. This was as an ongoing project whose purpose was the development of integrated knowledge and new tools to enhance predictive understanding of watershed ecosystems and their linkage to human factors affecting water and watersheds. The goal was the establishment of effective ecosystem management at the watershed scale.

2.4.2 Model Use

An ecological economic system dynamic model was developed to scope environmental problems and build consensus. The model was developed in STELLA software and was part of a three-step modeling process that includes scoping and consensus building in step 1, detailed research and development modeling in step 2 and management alternatives modeling in step 3. The overall model consists of interrelated ecological and economic submodels. Model development was based the Coastal Ecological Landscape Spatial Simulation (CELSS) model that was developed for the Louisiana Coastal Watershed. The ecological part of the model was based on the Patuxent Landscape Model (PLM). The economic submodels were still being developed at the time of reporting.

2.4.3 Involvement and Collaboration

The report describes the use of workshops to develop initial scoping models, communicate results and to refine and adapt the research agenda. The full range of scientific, government and citizen stakeholders groups are said to have been involved in the workshops.

2.4.4 Outcome

According to the report, the integration of the ecological and economic models provides a framework for regulatory analysis in the context of risk assessment, nonpoint source pollution control, wetlands mitigation/restoration, etc. Once completed, the models were expected to allow stakeholders to evaluate the indirect effects over long time horizons of current policy options. The completed models were also expected to allow researchers to address the functional value of ecosystem services by looking at the long-term, spatial and dynamic linkages between ecosystems and economic systems.

3 System Dynamics Modeling for Community-Based Water Planning: Application to the Middle Rio Grande

System/Study Area Name:	Middle Rio Grande including Bernalillo, Sandoval and Valencia Counties of north-central New Mexico
Study Type:	Water-resource planning
Analysis/Model Type:	System dynamic modeling; five-step modeling approach; Studio Expert software
Stakeholders Identified:	Interstate Stream Commission, MRCOG, Middle Rio Grande Conservancy District, City Utilities and Water Cooperatives, Federal/state agencies, MRGWA, the cooperative modeling team and the general public
Level of Participation:	Stakeholders had varying participation, from simple viewing to actively involvement in the modeling process
Conflict Type:	Competing water use allocation and management problem
Was Problem Solved:	Model results were used in making decisions about management options
International or U.S.:	U.S.; not a trans-boundary issue
Sponsoring Agency:	Sandia National Laboratories Small Business Assistance Program; State of New Mexico
Study Lead:	Sandia National Laboratories
Authors and Source:	Tidwell, V.C., Passell, H.D., Conrad, S.H. and Thomas, R.P. (2004). System dynamics modeling for community-based water planning: Application to the Middle Rio Grande. Aquatic Sciences, 66(4), 357-372.

3.1 Purpose of the Study

This research article suggests that mounting concerns over water in the region led to a statewide water-planning process to be initiated in New Mexico in the mid 1990s. The Middle Rio Grande Study was part of this process. The study employed SD modeling to assist in community-based water planning for a three-county region in north-central New Mexico. This area is referred to as the Middle Rio Grande and includes the greater Albuquerque metropolitan area. Objectives included quantitatively exploring alternative water-management strategies, educating the public on the complexity of the regional water system and engaging the public in the decision process.

3.2 Model Use

The model developed adopted a five-step process. The five steps included defining the problem and scope of analysis in step 1, description of the system in step 2, converting the conceptual model into a system dynamic model in step 3, model review in step 4 and the use of the model by the public in step 5. The model was developed collaboratively by Sandia National Laboratories, the Middle Rio Grande Water Assembly (MRGWA), the Mid Region Council of Governments and the Utton Trans-Boundary Resources Center of the University of New Mexico. The model is a system dynamic model built using Studio Expert software. At the highest level, the model is said to be organized into two water budgets, one for surface water and the other for ground water. The model also incorporates 24 different water-conservation strategies.

3.3 Involvement and Collaboration

Various stakeholders were involved in the study and model building. They included the Interstate Stream Commission, MRCOG, Middle Rio Grande Conservancy District, City Utilities and Water Cooperatives, Federal/state agencies, MRGWA, the cooperative modeling team and the general public. Participation is reported to have varied from a simple one-time viewing of the model, to providing support by supplying data and system understanding, participation in model development, model review and model utilization in the planning process.

3.4 Outcome

According to the report, the Mid Rio Grande planning model was actively used by the MRGWA and MRCOG to develop a water plan for the three-county region.

4 Mediated Modeling to Support Public and Stakeholder Participation in Water-Resources Planning and Management: The Baixo Guadiana Experience, Portugal

System/Study Area Name:	The Baixo Guadiana, Portugal
Study Type:	Water-resource planning and management
Analysis/Model Type:	Mediated modeling; multi phase modeling approach; POWERSIM software
Stakeholders Identified:	A full range of scientific, government and citizen stakeholders groups
Level of Participation:	Several workshops were conducted following a mediated framework
Conflict Type:	Competing water-use allocation and management problem
Was Problem Solved:	Recommendations for a solution were generated
International or U.S.:	International - Portugal; some trans-boundary issues
Sponsoring Agency:	European Water Framework Directive
Study Lead:	Ecological Economics and Environmental Management Centre, New University of Lisbon, Portugal
Authors and Source:	Videira, N., Antunes, P., Santos, R., Borrego, D. and Lobo, G. (n.d.). Mediated modeling to support public and stakeholder participation in water resources planning and management: The Baixo Guadiana Experience, Portugal. Ecological Economics and Environmental Management Centre, New University of Lisbon, Portugal.

4.1 Purpose of the Study

This study focused on the development and testing of tools to support integrated planning and evaluation of river basin interventions, in the context of the European Water Framework Directive (WFD). In support of the WFD, a guidance document on public participation was developed. This study was one of several pilot river basin studies selected to test and validate the guidance document and was conducted in the lower part of the Guadiana River Basin, known as "Baixo Guadiana." The study was intended to support and encourage active participation of interested parties in the scoping of the Baixo Guadiana problems, pressures and impacts. It was to provide further insights on how to promote effective participation of the public and stakeholders in water-resources planning and management.

4.2 Model Use

The study adopted a mediated modeling (MM) approach. MM is a form of participatory modeling which aims for a collaborative team learning experience to raise the shared level of understanding in a stakeholder group, while fostering a broad level of consensus. MM draws on the principals of system dynamic modeling.

The modeling process for the Baixo Guadiana was a multi stage process in which key stages included problem definition, conceptualization of quantitative model and analysis of alternative scenarios. The conceptual model captured issues from six sectors: water quality and quantity, agricultural development, nature conservation, tourism, institutions and social issues. Issues from these sectors were aggregated into those associated with water salinization, increase of sediment inputs, opportunity costs of landowners due to nature restrictions and development of sustainable forms of agriculture and tourism. The conceptual model was used to establish the formal linkages between the sectors and issues and allowed for the use of POWERSIM software to develop the quantitative model.

4.3 Involvement and Collaboration

Based upon the WFD guidance document on public participation, various stakeholders were involved in the study, including participation during the initial scoping and model building phases. Stakeholder involvement and collaboration was generally conducted within guidelines outlined by the MM process. Several workshops were conducted for consensus building efforts. A group composed of key workshop organizers was established to organize the MM workshops.

Fifty-seven participants are reported to have attended the first workshop designated for problem definition and development of the qualitative model. Nine and eighteen participants respectively attended the morning and afternoon session of the second workshop designed for the conceptualization of the quantitative model. Twenty participants attended the third workshop that focused on the analysis of alternative scenarios.

4.4 Outcome

Participants of the MM process collaborated to develop a list of recommended strategic objectives and associated measures for the Baixo Guadiana River Basin. These recommendations represent a participatory contribution towards integrated planning and management of the Baixo Guadiana River Basin

5 A Policy Model to Initiate Environmental Negotiation: Three Hydropower Workshops

The Legal-Institutional Analysis Model (LIAM) is described as a tool designed for negotiation preparation. It is reported to have been developed by the U.S. Fish and Wildlife Service for water-resource management conflicts. The LIAM is designed to assist managers in systematically analyzing each party’s position in natural resource negotiations and using that analysis to prepare for bargaining. The report discusses the process and results of three LIAM workshops designed to guide hydroelectric power licensing negotiations. The following section presents an analysis of each the LIAM workshops, namely, the St. Louis River project, the Penobscot River Basin Mills project and the Cabinet Gorge-Noxon Rapids project.

5.1 Workshop 1 – St. Louis River project

System/Study Area Name:	St. Louis River project
Study Type:	Water-resource planning; Hydroelectric power licensing negotiations
Analysis/Model Type:	Legal-Institutional Analysis Model (LIAM) software
Stakeholders Identified:	Most stakeholders were not explicitly identified in the report reviewed
Level of Participation:	Stakeholder representatives participated in workshops
Conflict Type:	Competing uses of the water resources; environmental management issues
Was Problem Solved:	A settlement amongst stakeholders had been reached and a license application had been forwarded to the FERC
International or U.S.:	U.S.; no trans-boundary issues
Sponsoring Agency:	U.S. Geological Survey
Study Lead:	U.S. Geological Survey, Fort Collins Science Center
Authors and Source:	Lamb, B.L., Taylor, J.G., Burkardt, N. and Ponds, P.D. (1998). A policy model to initiate environmental negotiations: three hydropower workshops. Human Dimensions of Wildlife, 3(4), 1-17.

5.1.1 Purpose of the Study

As described in the report, the St. Louis River project was a license renewal for dams and associated power plants on the St. Louis River system. The workshop was conducted to evaluate each stakeholder's negotiation role and develop a detailed outline of a plan of study for environmental assessments of the project.

5.1.2 Model Use

The study used the LIAM model to guide consensus building exercises in preparation for negotiations. The LIAM relies on the use of questionnaires to measure respondent knowledge about an organization's likely behavior.

5.1.3 Involvement and Collaboration

Stakeholders were involved through their representatives attending the LIAM workshop. During the workshop, participants were placed in groups and asked to use LIAM to evaluate each identified stakeholder's negotiating position as a means of outlining a plan for future negotiations.

5.1.4 Outcome

The study reports that post workshop interviews were used to follow-up on the progress of negotiations following the workshop. It is reported that a settlement amongst stakeholders had been reached and a license application had been forwarded to the Federal Energy Regulation Commission (FERC). The report also suggests that the license application included substantial areas of agreement among the parties involved.

5.2 Workshop 2 – Penobscot River Basin Mills project

System/Study Area Name:	Penobscot River Basin Mills Project
Study Type:	Water-resource planning; Hydroelectric power licensing negotiations
Analysis/Model Type:	Legal-Institutional Analysis Model (LIAM) software
Stakeholders Identified:	Most stakeholders were not explicitly identified in the report reviewed
Level of Participation:	Stakeholders participated in LIAM workshops
Conflict Type:	Conflicting interests in the use of the water resource
Was Problem Solved:	Generated fruitful discussions and a general agreement to continue negotiations
International or U.S.:	U.S.; no trans-boundary issues
Sponsoring Agency:	U.S. Geological Survey
Study Lead:	U.S. Geological Survey, Fort Collins Science Center
Authors and Source:	Lamb, B.L., Taylor, J.G., Burkardt, N. and Ponds, P.D. (1998). A policy model to initiate environmental negotiations: three hydropower workshops. Human Dimensions of Wildlife, 3(4), 1-17.

5.2.1 Purpose of the Study

The report describes the Penobscot River Basin Mills project as a proposed new hydropower project that was preparing to apply for a license. Conflicting interest among stakeholders led to stalled negotiations and a near complete breakdown in communication. The LIAM workshop was an attempt to salvage the negotiations. The precise purpose of the workshop was to (1) assess the degree to which the parties shared a willingness to negotiate and (2) examine their preferred outcomes.

5.2.2 Model Use

The study used the LIAM model to map the negotiating role of each stakeholder.

5.2.3 Involvement and Collaboration

Stakeholders were involved through their representatives attending the LIAM workshop. During the workshop, participant rated stakeholders as having a wide variety of strengths and needs.

5.2.4 Outcome

Participation in the workshop generated fruitful discussions and a general agreement that the talks should continue. Despite the obvious divisions among participants, the LIAM workshop is reported to have helped participants clarify the roles and perspectives of all stakeholders.

5.3 Workshop 3 – Cabinet Gorge-Noxon Rapids project

System/Study Area Name:	Cabinet Gorge-Noxon Rapids project
Study Type:	Water-resource planning; Hydroelectric power licensing negotiations
Analysis/Model Type:	Legal-Institutional Analysis Model (LIAM) software
Stakeholders Identified:	Most stakeholders were not explicitly identified in the report reviewed
Level of Participation:	Stakeholders participated in LIAM workshops
Conflict Type:	Conflicting interests in the use of the water resource
Was Problem Solved:	parties agreed to hire a mediator to facilitate the negotiation process
International or U.S.:	U.S.; no trans-boundary issues
Sponsoring Agency:	U.S. Geological Survey
Study Lead:	U.S. Geological Survey, Fort Collins Science Center
Authors and Source:	Lamb, B.L., Taylor, J.G., Burkardt, N. and Ponds, P.D. (1998). A policy model to initiate environmental negotiations: three hydropower workshops. Human Dimensions of Wildlife, 3(4), 1-17.

5.3.1 Purpose of the Study

A power company seeking to relicense two hydropower projects on the Clarks Fork River sought the services of the LIAM as a way to avoid anticipated opposition. The purpose of this workshop was to foster an atmosphere of mutual trust and problem solving that might endure throughout the consultation.

5.3.2 Model Use

The workshop used the LIAM model to map the negotiating role of each stakeholder.

5.3.3 Involvement and Collaboration

Stakeholders were involved through their representatives attending the LIAM workshop. During the workshop, participants were placed in groups and asked to use LIAM to evaluate each identified stakeholder's negotiating position as a means of outlining a plan for future negotiations. A wide distribution of stakeholder positions was revealed. A significant number of the stakeholders preferred an arbitrated position due to low levels of trust among the parties.

5.3.4 Outcome

The report indicates that participants at the workshop used information from the exercise to determine what kind of a negotiation was likely to follow, given stakeholders' placement on the role map. It is reported that the negotiating parties agreed to hire a mediator to facilitate the negotiation process.

6 Interplay of Science and Stakeholder Values in Neuse River Total Maximum Daily Load Process

System/Study Area Name:	Interplay of science and stakeholder values in Neuse River total maximum daily load process. Journal of Water Resources Planning and Management
Study Type:	Water-resource planning and management
Analysis/Model Type:	Mediated modeling; multi phase modeling approach; POWERSIM software
Stakeholders Identified:	Point-source discharge permit holders, municipal and industrial users; nonpoint source contributors of nitrogen, urban development interests, environmental groups, recreation, fishing and onsite waste treatment interests.
Level of Participation:	Stakeholders had varying roles and contributions to all four models and the to the Neuse River TDML regulatory process
Conflict Type:	Water-quality degradation and pollution control
Was Problem Solved:	Partially
International or U.S.:	U.S.; not trans-boundary
Sponsoring Agency:	U.S. Environmental Protection Agency
Study Lead:	North Carolina Division of Water Quality
Authors and Source:	Maguire, L.A. (2003). Interplay of science and stakeholder values in Neuse River total maximum daily load process. Journal of Water Resources Planning and Management, 129(4), 1-10.

6.1 Purpose of the Study

This study evaluates the interactions between stakeholders, water quality, modelers and regulatory decision makers to determine whether stakeholders and scientists were successfully engaged during the Neuse River Total Maximum Daily Load (TDML) regulatory process. The study uses a list of what is described as standard of good practice determinants of public involvement in regulatory process to make this evaluation. The key requirements determining good public involvement in regulatory process were identified to include (1) stakeholder interaction with model development, (2) interaction of scientists and stakeholders, (3) integration of stakeholder values with science and (4) interplay of science and stakeholders with regulatory decision making. The study identifies aspects of this interaction that went well and those that did not go so well. The study concludes that the most serious shortcomings of the Neuse River TDML regulatory process was not with the scientists or the stakeholders but rather with the too narrow structure of the regulatory process itself.

6.2 Model Use

The study identifies at least four models that were used in the Neuse River TDML regulatory process: a Bayes' net probability model, a two dimensional simulation model, a three dimensional simulation model and a spatial regression model. The first three models are described as estuary water-quality models, whereas the fourth model was developed for estimating nitrogen contribution from various locations in the Neuse watershed.

6.3 Involvement and Collaboration

Stakeholders were invited to comment on the three estuary water-quality models and the more technically skilled stakeholders were sometimes solicited for scientific insights or data to offer the modeling process. Stakeholder "ownership" of these models was however reported to have been limited. Stakeholder involvement in the development of the three estuary water-quality models is reported to have been generally limited to a few interactions between stakeholder and the modelers. In contrast, stakeholders were more actively involved in developing the spatial regression model for estimating nitrogen contributions. Stakeholder involvement in development of the spatial regression model is reported to have included a role in drafting a strategy for allocating responsibility for limiting nitrogen inputs among sources in various parts of the watershed.

6.4 Outcome

The interplay of science and stakeholders was a useful exercise in advancing the Neuse River TDML process. Stakeholders made important contributions to the models developed. Presentations to stakeholders by modelers and by other scientists increased stakeholder understanding of the sources and fates of nitrogen in the watershed. However not all aspects of good public involvement in regulatory process were met and the study exposed some of the shortcoming the Neuse River TDML regulatory process with respect to stakeholder involvement.

7 Water-Resources Planning Through Group Model Building in the Okanagan Valley, British Columbia, Canada

System/Study Area Name:	Okanagan Basin in south-central British Columbia, Canada
Study Type:	Water-resource planning and management
Analysis/Model Type:	Mediated modeling; system dynamic; STELLA software
Stakeholders Identified:	Fishing, agriculture and forestry industries; town councilors, irrigation district managers, mayors, public works engineers, planners and consultants
Level of Participation:	Group model building; series of workshops
Conflict Type:	Water-use planning and allocation
Was Problem Solved:	Study was in progress at the time of publication
International or U.S.:	International, Canada; some trans-boundary relevance
Sponsoring Agency:	Natural Resources Canada
Study Lead:	Institute for Resources, Environment and Sustainability, University of British Columbia
Authors and Source:	Langsdale, S., Carmichael, J., Cohen, S. and Lence, B.J. (2005). Water resources planning through group model building in the Okanagan Valley, British Columbia, Canada. Retrieved July 2006, from http://www.ascelibrary.org.

7.1 Purpose of the Study

Water stresses in the Okanagan Basin have lead to several studies evaluating water planning and management strategies. This project was one such study. At the time of publication, this study was an ongoing study that was intended to help answer questions such as: (1) how climate change impacts compare to other stressors, (2) what impact land use changes have on water demands and (3) what management strategies are most effective for maintaining a sustainable community.

7.2 Model Use

The study used a group modeling process to engage the basin's resource professionals, political leaders and special interest group representatives in an effort to develop a high-level scoping model. Group model building was expected to take place in a three-phase process using a system dynamic framework and STELLA software. The study was ongoing at the time of reporting.

7.3 Involvement and Collaboration

The study was to include a series of workshops. Participants of the workshops were to include representatives from the fishing, agriculture and forestry industries; town councilors, irrigation district managers, mayors, public works engineers, planners and consultants.

7.4 Outcome

The final outcome of the study was not available at the time of publication since it was an ongoing study. However, project team members envisioned creating a basin-wide model that demonstrates the long-term effects of climate change while providing a small enough resolution needed to test a variety of water-management strategies.

8 Experiment With Simulation Models in Water-Resources Negotiations

System/Study Area Name:	Not a case study
Study Type:	Experiment to determine simulation model impacts on water-resource negotiations
Analysis/Model Type:	Mock water-resources negotiation
Stakeholders Identified:	Senior negotiator roles for flood control interests, water-utility interests and irrigation interests
Level of Participation:	Undergraduate business students played the role of stakeholders. Thirty-five three-person negotiation groups
Conflict Type:	Not applicable
Was Problem Solved:	Not applicable
International or U.S.:	Not applicable
Sponsoring Agency:	National Science Foundation
Study Lead:	Center for Advanced Decision Support in Water Resources and Environment, University of Colorado
Authors and Source:	Reitsma, R., Zigurs, I., Lewis C, Wilson, V. and Sloane, A. (1996). Experiment with simulation models in water-resources negotiations. Journal of Water Resources Planning and Management-ASCE, 122(1), 64-70.

8.1 Purpose of the Study

This study was published in 1996 and looked at the increasing push to use computer-based simulation models in water resources operations and planning. The purpose of the study was to investigate how various kinds of access to simulation models affects water-resources negotiation outcomes. The investigation is conducted under controlled laboratory conditions and was precipitated by an observation that very few studies at the time had systematically evaluated the effects of the different ways in which models could be made available. The mock negotiation involved determining a release schedule from two reservoirs through a negotiation between subjects representing hydroelectric power, agricultural and flood-control interests.

8.2 Model Use

A modified version of the River Simulation System (RSS) was used for this study. RSS is an event-driven, object-oriented simulation system that allows the rapid creation and execution of river basin simulation models. For the experiment, five modes of access to the model were evaluated: restricted, private, shared, joint and no-model. The no-model was the control case in which negotiators had no access to a simulation model and had to rely on general negotiations skills. In the restricted model scenario, negotiators had access to the model through a third party and modeling could not be performed in real time during the negotiations. The private model scenario is described by the authors as the preferred mode among most water-resource negotiators. In this access mode, negotiators have individual and unlimited access to model. The shared access model scenario is a scenario where negotiators share their model results with other negotiators. In the joint model scenario, the model is not available to negotiators individually but instead to the group as a whole.

8.3 Involvement and Collaboration

The mock negotiation solicited the services of undergraduate business students to play the roles of the stakeholders. Participation of the students is reported to have been voluntary and each student that participated was paid $10. Thirty-five three-person negotiation groups participated in the experiment. Each three-person negotiation group consisted of one student playing the role of senior negotiator for a flood control awareness and mitigation agency, another playing the role of senior negotiator covering the interests of a utility company and the third student playing the role of senior negotiator for an irrigation cooperative's interest.

8.4 Outcome

The main conclusion drawn from the experiment is that the simulation system helped groups improve their negotiations results. This improvement occurred mainly by improving the groups understanding of task constraints rather than by an improved understanding of the environmental system for which they were formulating policies. Modeling scenarios that allowed model runs subject to group approval exhibited the most improved understanding. Several limitation and qualifications are outlined for those trying to draw real-world implications of the experiment's results.

9 An Assessment of Shared Vision Model Effectiveness in Water-Resources Planning for National Drought Study

System/Study Area Name:	Six sites across the country. Includes the Cedar and Tolt River basins in Washington, the Green River basin in Washington, the James River basin in Virginia, the Kanawha River basin in West Virginia, the Marais des Cygnes-Osage River basin in Kansas and Missouri and the Quabibin and Wachusetts River basins in Massachusetts
Study Type:	Assessment of model effectiveness
Analysis/Model Type:	System dynamics; STELLA software
Stakeholders Identified:	All types, in brief summaries of several case studies
Level of Participation:	Varying levels of participation
Conflict Type:	Planning allocation of water during drought
Was Problem Solved:	In two of six case studies
International or U.S.:	U.S. (two interstate case studies); not trans-boundary
Sponsoring Agency:	U.S. Army Corps of Engineers
Study Lead:	U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service
Authors and Source:	Keyes, A.M. and Palmer, R.N. (1995). An assessment of shared vision model effectiveness in water-resources planning. Paper presented at the meeting of the Twenty-second Annual Specialty Conference of the ASCE Water Resources Planning and Management Division.

9.1 Purpose of the Study

The National Drought Study that was sponsored by the U.S. Army Corps of Engineers aimed to improve the way water was managed for drought in the United States. As part of that study, six river basin studies were conducted. A common component of these river basin studies is the use of an object-oriented programming environment for simulation model construction. The main goal of this approach is the development of models that could be characterized as shared vision models and to effectively integrate these models into the Corps's seven-step planning process.

This paper assesses whether shared vision models were indeed produced at each site and the process by which model effectiveness was evaluated.

9.2 Model Use

Shared vision models were developed for each case study using an object-oriented programming environment (STELLA software). Specifics of each case study model were not provided in the paper.

9.3 Involvement and Collaboration

Public participation during the development of the models varied from one case study to the next. Models at three locations facilitated interagency water-management activities beyond the Corps sponsored planning effort. Models for two of the three sites have been endorsed by participating agencies. The model at the third site could not be used at the time this report was published due to one key agency not being available to participate in the model development. In two river basins, modeling objectives were not clearly established and public participation was limited.

9.4 Outcome

This paper concludes that models characterizing SVP were developed at all but two study sites at the time of publication. The two sites where shared vision models were not developed did not have clearly established objectives and had limited public participation and a sporadic model development progress. The conclusion is that adopting a modeling approach that allows for the development of a shared vision model may enhance the chances that the model will benefit a collaborative planning process.

10 Adaptive Management of Flows in the Lower Roanoke River, North Carolina, USA

System/Study Area Name:	Lower Roanoke River, North Carolina, USA
Study Type:	Adaptive ecosystem management
Analysis/Model Type:	Mediated modeling; multi phase modeling approach; POWERSIM software
Stakeholders Identified:	U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, local landowners and environmentalists and other stakeholders.
Level of Participation:	stakeholders were actively involved in the study but not clear how involved the public was during model development
Conflict Type:	Water allocation
Was Problem Solved:	successful negotiation outcomes
International or U.S.:	U.S.; not trans-boundary
Sponsoring Agency:	The Nature Conservancy
Study Lead:	U.S. Army Corps of Engineers
Authors and Source:	Pearsall, S.H., McCrodden, B.J. and Townsend, P.A. (2005). Adaptive management of flows in the lower Roanoke River, North Carolina, USA. Environmental Management 35(4), 353-367.

10.1 Purpose of the Study

The lower Roanoke River in North Carolina and its basin is identified by The Nature Conservancy and other organizations as critical resources for the conservation of bottomland hardwoods and other riparian and in-stream biota and communities. Evidence indicates that the damming of the Roanoke River upstream was causing extended flooding during the growing season resulting in the deterioration of the bottomland hardwoods ecosystem. Of key concern were river flow controls at three upstream dams. The John H. Kerr Dam is the largest of the three and is operated by the U.S. Army Corps of Engineers, both for flood control and power generation. The other two smaller dams are for power generation and are operated by utility companies collectively referred to as "Dominion" in the study.

This paper describes the regulation context, conservation objectives, models used and proposed adaptive management strategies to mitigate the impacts of the regulated flows associated with the operation of the three dams.

10.2 Model Use

The Lower Roanoke River Study made use of several models and incorporated an adaptive management approach to arriving at a management solution. Separate analyses were conducted for the privately operated dams and for the Corps operated dam due to different operational and regulatory obligations.

10.3 Involvement and Collaboration

Stakeholders were involved during the study. However, the study does not explicitly address the level of participation in actual model development.

10.4 Outcome

The study describes successful negotiation outcomes for both studies looking at the dams operated by Dominion as well as the larger dam operated by the Corps. Dominion and the two dams it operates had moved into the active adaptive management phase at the time of the report's publication. The Corps and the Kerr Dam were still in the process of negotiation to establish the applicability of already developed models to adaptive management.

11 Participatory Methods for Water-Resources Planning

System/Study Area Name:	Three case studies: the island of Naxos, Greece; Baixo Guadiana, Portugal; and the Costa del Sol, Spain
Study Type:	Water resource planning and management
Analysis/Model Type:	Varied by case study: scenario workshop, MM and social multi-criteria evaluation
Stakeholders Identified:	All types, varied by case study
Level of Participation:	Group model building; series of focus group meetings at workshops
Conflict Type:	Water-resource allocation
Was Problem Solved:	Partially
International or U.S.:	International – southern Europe; not trans-boundary
Sponsoring Agency:	European Commission
Study Lead:	Berkley University
Authors and Source:	Kallis, G., Videira, N., Antunes, P., Guimaraes, A., Pereira, A.G., Spash, C.L., Coccossis, H., Quintana, S.C., del Moral, L., Hatzilacou, D., Lobo, G., Mexa, A., Paneque, P., Pedregal, B. and Santos, R. (2005, June). Participatory methods for water-resources planning. Paper presented at the 6th International Conference of the European Society for Ecological Economics, Lisbon. Retrieved from http://www.envplan.com/epc/abstracts/c24/c04102s.html.

11.1 Purpose of the Study

As stated in the report, the European Water Framework Directive (WFD) calls for the active involvement of all interested parties in the implementation process and particularly in the production, revision and updating of River Basin Management Plans. This report suggests that there is a lack of accumulated research critically assessing alterative participatory methods in terms of their applicability and limitations in different contexts. As part of the European Commission sponsored research supporting the WFD, this study analyzed three situations in southern Europe where different participatory methods were applied to water-resources conflict resolution and planning studies. A scenario workshop approach, MM approach and social multi-criteria evaluation were respectively used in studies on the island of Naxos, Greece; the Baixo Guadiana, Portugal; and the Costa del Sol, Spain.

The report describes each method, the site of the study, the application, results and provides a brief summary of the most relevant findings. The three methods are then compared and related to different decision-making goals and planning stages. Limitations of using participatory methods, especially the three presented in the report, are discussed. The report concludes by suggesting that a hybrid of the three methods would probably be best for aiding the water-planning process.

11.2 Model Use

A scenario workshop approach was used to encourage stakeholder participation on the Island of Naxos study. This study does not specify a model beyond the scenario building exercises. Mediated modeling using POWERSIM software was used in the Baixo Guadiana study. A social multi-criteria evaluation was adopted for the Costa del Sol study. The social multi-criteria methodology applied in the study was based on the NAIADE model.

11.3 Involvement and Collaboration

Active participation was encouraged in all three case studies, though extent and type of participation was determined by the participatory method adopted for the study. The report also notes that in participatory methods requiring multiple workshops, stakeholder participation diminished with progressive workshops.

11.4Outcome

The authors concluded that the three methods had strong procedural benefits but also had important limitations to their contribution to decision making.

12 Bringing Technology to the Table: Computer Modeling, Dispute Resolution and the Rio Grande

System/Study Area Name:	The Lower Rio Grande (Rio Grande/Rio Bravo south of Fort Quitman, Texas)
Study Type:	Water resource planning and management
Analysis/Model Type:	Operational Analysis and Simulation Systems (OASIS) with OCL™ platform
Stakeholders Identified:	Various stakeholders/participants from both countries
Level of Participation:	Various stakeholders/participants from both countries participated in the exercise
Conflict Type:	Water allocation
Was Problem Solved:	No – it was a experimental exercise
International or U.S.:	International; trans-boundary issue between the U.S. and Mexican boarder
Sponsoring Agency:	Lower Colorado River Authority
Study Lead:	University of Texas at Austin
Authors and Source:	Tate, D.E. (2002), Bringing technology to the table: Computer modeling, dispute resolution and the Rio Grande (Master's thesis, University of Texas at Austin, 2002).

12.1 Purpose of the Study

This Master's thesis report is described as an attempt to answer questions regarding whether computer technology can assist in water resources planning and management for a river basin which spans across the border of two countries (trans-boundary context). The thesis reports on a water-resources experiment including a day long exercise in water-quantity management, called the Rio Grande/Rio Bravo Operations Exercise (Operations Exercise). The thesis documents the theory behind, preparation for and execution of this experiment and is written to provide information on water-resource computer modeling and dispute resolution for a public policy audience.

12.2 Model Use

The report describes and compares several modeling alternatives considered for the study. The model selected for use in the study was built on the Operational Analysis and Simulation Systems (OASIS) with OCL™ platform. OASIS software is a product of Hydrologics, Inc.

12.3 Involvement and Collaboration

Though the model was developed by the modeling team, input from stakeholders was solicited at every stage of development. Stakeholders indentified in the report include the International Boundary and Water Commission/Comisión Internacional des Límites y Aguas (The IBWC and CILA), State of Texas, the Mexican states of Chihuahua, Coahuila, Nuevo León and Tamaulipas; Mexican Federal Government, U.S. Federal Government, Texas Irrigation Districts, Mexican Irrigation Districts, Mexican Municipalities, Texas Municipalities and Other Stakeholders.

During the Operations Exercise, participants who attended the day long exercise were presented with the model and offered opportunities to request for modification to the model. Limited active participation occurred during the modeling exercise. Most participants were later determined to have attended the exercise in the observer role.

12.4 Outcome

The report concludes by making four recommendations that are hoped will provide opportunities for technical collaborations that would lead to a shared understanding and improved relationships.

13 Ecologically Sustainable Water Management: Managing River Flows for Ecological Integrity

System/Study Area Name:	Several case study examples
Study Type:	Ecosystem management
Analysis/Model Type:	Not applicable
Stakeholders Identified:	Not applicable
Level of Participation:	Not applicable
Conflict Type:	Impact of over-appropriated water supplies on ecosystem sustainability
Was Problem Solved:	Not applicable
International or U.S.:	U.S. and international; not trans-boundary
Sponsoring Agency:	The Nature Conservancy
Study Lead:	The Nature Conservancy
Authors and Source:	Richter, B.D., Mathews, R., Harrison, D.L. and Wigington, R. (2003). Ecologically sustainable water management: Managing river flows for ecological integrity. Ecological Applications, 13(1), 206-224.

13.1 Purpose of the Study

This paper identifies the alteration of river flow regimes associated with dam operations, nonpoint source pollution and invasive species, as the leading causes of the imperilment of aquatic animals and deterioration of fresh water ecosystems. The paper warns that while fresh water ecosystems continue to provide a wealth of goods and services to society, sustaining these benefits will require a better management of fresh water flows. A six-step process is proposed for the management of freshwater flows. The steps described include (1) developing initial numerical estimates of key aspects of river flow necessary to sustain native species and natural ecosystem functions; (2) accounting for human uses of water, both current and future, through development of a computerized hydrologic simulation model that facilitates examination of human-induced alterations to river flow regimes; (3) assessing incompatibilities between human and ecosystem needs with particular attention to their spatial and temporal character; (4) collaboratively searching for solutions to resolve incompatibilities; (5) conducting water-management experiments to resolve critical uncertainties that frustrate efforts to integrate human and ecosystem needs; and (6) designing and implementing an adaptive management program to facilitate ecologically sustainable water management for the long term.

Case studies are used as illustrative examples. The paper concludes by suggesting that ecologically sustainable water management is generally attainable around the world but will increasingly be less feasible as was water supplies are further over-appropriated.

13.2 Model Use

This in itself does not make use of any models. However, paper sites several examples of how computer modeling fits within the six-step framework outlined. For example, in step-2, human influences on river flows can be determined using hydrologic simulation models. Such models are able to evaluate river flow changes that can be expected under proposed water-management approaches. In step-3, incompatibilities between human and ecosystem needs can be identified by using models to highlight the constraints.

13.3 Involvement and Collaboration

The paper advocates stakeholder participation throughout the six-step process. Case study examples highlight some of this involvement and collaboration.

13.4 Outcome

This paper concludes by suggesting that ecologically sustainable water management is attainable and uses case studies to reinforce this analytical finding. The author of the paper also concludes, based on examples, that attaining ecological sustainability is much more feasible when ecosystem flow requirements are assessed and protected before the river basin's water supplies have been extensively developed. The determination of water-system flow requirements for affected rivers is recommended.

14 Water-Resource Conflict Resolution Based on Interactive Trade-Offs Display

System/Study Area Name:	Not applicable
Study Type:	Water-resource planning and management
Analysis/Model Type:	GRS-based decision-support tool; Interactive Decision Maps (IDM); Point-Associated Trade-offs (PAT)
Stakeholders Identified:	Not applicable
Level of Participation:	Limited involvement in model development; active participation during negotiation process
Conflict Type:	Water-resources planning
Was Problem Solved:	Not applicable
International or U.S.:	International; not trans-boundary
Sponsoring Agency:	NATO Scientific and Environmental Linkage Research Project and the Russian Foundation of for the Fundamental Research
Study Lead:	Russian Academy of Sciences
Authors and Source:	Lotov, A.V., Bushenkov, V.A., Kamenev, G.K., Loucks, D.P. and Camara, A.S., (1998). Water resource conflict resolution based on interactive trade-offs display. Retrieved August 2006, from http://www.ccas.ru/mmes/mmeda/papers/arw.htm

14.1 Purpose of the Study

This paper is described as a review of applications of computer-aided approaches to water-resource conflict resolution. Specifically, the paper discusses the use of a mathematical model to perform an interactive trade-off analysis of alternative policy decisions as a means of possibly resolving water-resource conflicts. The purpose of the study was to present a mathematical simulation model that is capable of assisting negotiators by hopefully exposing attractive alternatives that may not have otherwise been considered. The mathematical model relies on the generation and analysis of efficient trade-off curves among conflicting performance criteria associated with various possible decisions

14.2 Model Use

The generation of efficient trade-off curves is described to be based on a mathematical approach named the Generalized Reachable Set (GRS). The GRS is a method for constructing and displaying a variety of attainable output vectors for a given large or infinite variety of possible input values.

A GRS-based decision-support tool called the Interactive Decision Maps (IDM) along with another GRS-based tool called Point-Associated Trade-offs (PAT) are used in the analysis. The IDM is described as a technique used to support the identification of a preferred feasible combination of criteria goals (feasible goal). The PAT technique was developed to support a single decision maker but is applied to negotiation support in the analysis described.

14.3 Involvement and Collaboration

The paper describes with examples, how the general approach and models can be used in negotiations. The models are interactive and suggest an active participation of stakeholders during the negotiation process. One requirement noted is that the model used be mutually acceptable to all stakeholders. However, there is limited discussion of stakeholder involvement in the actual development of the models.

14.4 Outcome

The IDM and PAT techniques were shown to be applicable to water-resource negotiations and suitable in supporting water-resource allocation negotiations. The techniques were also shown to be applicable to real-time water-allocation negotiations including providing a computer network-based support.

15 Computer Assisted Decision-Support System for High Level Infrastructure Master Planning: Case of the City of Portland Supply and Transmission Model (STM)

System/Study Area Name:	City of Portland, Oregon
Study Type:	Water-resource planning; infrastructure master planning
Analysis/Model Type:	Supply and Transmission Model (STM); STELLA software
Stakeholders Identified:	The modeling team included researchers from the University of Washington, water-resources engineers from a consulting firm and Portland Water Bureau staff
Level of Participation:	No public participation is discussed
Conflict Type:	water supply, water management and water transmission options
Was Problem Solved:	Model supported the planning process
International or U.S.:	U.S.; not trans-boundary
Sponsoring Agency:	Portland Water Bureau
Study Lead:	Department of Civil and Environmental Engineering of the University of Washington; Portland Water Bureau
Authors and Source:	Portland Infrastructure Plan. Water Resources Management and Drought Planning Group at the University of Washington. Abstract retrieved from http://www.tag.washington.edu/research/sharedvision.html Palmer, R.N., Mohammadi, A., Hahn, M.A., Kessler, D., Dvorak, J. and Parkinson, D. (2000). Computer assisted decision-support system for high level infrastructure master planning: case of the City of Portland Supply and Transmission Model (STM). Proc. of the ASCEs 2000 Joint Conference on Water Resources Engineering and Water Resources Planning and Management, Minneapolis, MN, August

15.1 Purpose of the Study

Following the completion of a Regional Water-Supply Plan by a consortium of Portland regional water providers, the City of Portland initiated its own water-supply study. The goal of Portland's study was to define a strategic direction for the Portland Water Bureau and determine the type of infrastructure and management policy needed to implement the bureau's chosen direction. All this was to remain within the broad planning alternatives defined by the Regional Water-Supply Plan.

The report explains that there are high stakes involved in planning for a small number of very large infrastructure investments because errors once made often can not be recouped. The Portland Water Bureau utilized a decision-support system known the Supply and Transmission Model (STM) to aid it in the formulation of decisions concerning its Infrastructure Master Plan. The STM developed to support the bureau by exploring a wide variety of water supply, water management and water transmission options for Portland. This paper provides details of the STM system and its application in the Portland area.

15.2 Model Use

As mentioned above, the Portland Water Bureau made use of a decision-support system known as the Supply and Transmission Model (STM) to evaluate various planning options. The STM is described to simulate daily system operation over a specified period using historic stream flow data and projected water demands. The model tracks water as it enters the watershed, determines reservoir operations and transmission decisions and follows the water movement to the end of the distribution system.

The STM was developed in the STELLA modeling environment and uses a daily time-step to look at daily maximum flow rates in the transmission system. The STELLA portion of the model contains the water-resource simulation component of the system, while the Excel spreadsheets that are importable and exportable from the model contain demand-related data and selected output formats. STM wasbuilt in fifty conceptual building blocks to help provide users with an organizational structure that provides an increased degree of clarity. The final model is stated to have 1,200 variables for each daily time-step.

15.3 Involvement and Collaboration

The report states that the model was built by a team of researchers from the University of Washington, water-resources engineers from a consulting firm and Portland Water Bureau staff. It was developed using an interactive process requiring three phases of construction that included the following steps: (1) Selecting the modeling environment, (2) Choosing an appropriate time-step (3) Defining the appropriate level of detail and (4) Designing the user interface. Extensive initial interviews with Portland Water Bureau staff were also conducted. The report does suggest any involvement of stakeholders outside the model development team in the model building process.

With the completed model in place, Portland Water Bureau engineering, planning and management staff are reported to have been invited to a day long meeting to review the alternatives. Participants at the meeting collaborated in suggesting system configurations and alternatives.

15.4 Outcome

One of the main uses of the STM was to provide quantitative information with which alternatives could be ranked. The STM provided such quantitative information and aided in the evaluation of alternatives and in the ranking relative to specific parameters. This process was extremely useful, enhancing the groups understanding of options available, creating more accurate intuition concerning the system and identifying alternatives for consideration that might not have been identified otherwise.

16 Agent-Based and Integrated Assessment Modeling for Incorporating Social Dynamics in the Management of the Meuse in the Dutch Province of Limburg

System/Study Area Name:	The Meuse River in the Dutch province of Limburg
Study Type:	Water resource planning and management
Analysis/Model Type:	Agent-based and integrated assessment
Stakeholders Identified:	National decision makers, provincial decision makers, four nature organizations, farmers, municipalities, citizen groups and gravel extractors
Level of Participation:	active participation during through all stages
Conflict Type:	Conflicting water management and infrastructure improvement options
Was Problem Solved:	Study was ongoing
International or U.S.:	Europe - Netherlands; not trans-boundary
Sponsoring Agency:	European Union's Framework 5 Programme for Research and Development; European Commission
Study Lead:	International Centre for Integrative Studies (ICIS), University of Maastricht; Department for Civil Engineering and Management, University of Twente
Authors and Source:	Krywkow, J., Valkering, P., Rotmans, J. and van der Veen, A. Agent-based and Integrated Assessment Modelling for Incorporating Social Dynamics in the Management of the Meuse in the Dutch Province of Limburg. International Centre for Integrative Studies (ICIS), University of Maastricht. Retrieved August, 2006, from http://www.iemss.org/iemss2002/proceedings/pdf/volume%20due/207_krywkow.pdf

16.1 Purpose of the Study

This paper discusses the impact of involving stakeholders (agents) in the water resources planning and management decision-making process. Such an approach was promoted in Europe through project FIRMA (Freshwater Integrated Resources Management with Agents). The FIRMA approach aims to improve water-resource planning by combining agent-based modeling and integrated assessment to describe physical, hydrological, social and economic aspects of water-resource management. The FIRMA approach described in this paper and is an approach that incorporates agent-based (stakeholder participation) modeling with an integrated assessment modeling (traditional planning model). This approach is applied in a case study of the Meuse River in the Dutch province of Limburg to highlight the impacts of stakeholder activities on each other as well as on the environment. The study was conducted with the ultimate aim of developing a decision-support system to assist decision makers in water-resources management.

The study of the Meuse River was referred to as the Maaswerken project and is one of several FIRMA projects. The Maaswerken project was reportedly one of the largest water-related infrastructure projects in the Netherlands and consisted of two sub-projects: the Grensmaas and Zandmaas/Maasroute. The three main activities of the combined projects were flood control, improvement of the navigation route and nature development.

16.2 Model Use

Model development and use was part of this study. The report concludes that a successful result in designing a complex model, which is a candidate for utilization as a decision-support system, can only be achieved by maintaining a clear model structure—and the interaction between the social world and the physical environment must be made explicit.

Four main components of this modeling approach were: (1) the integrated assessment model (IAM) (physical), (2) the agent-based model (ABM), (3) the involvement of stakeholders in the modeling process and (4) the conceptual framework to couple the two models.

16.3 Involvement and Collaboration

The FIRMA approach advocates stakeholder participation through out the process. During the integrated assessment stage, four tasks are identified. These are: (1) eliciting mental models of organizations and institutions plus additional data through interviews and other dialogue methods, (2) communicating and developing the model with the stakeholders through interviews and other dialogue methods, (3) validating the model structure and simulation results with the stakeholders using focus groups and (4) identifying system problems and developing new strategies for system management using focus groups and interviews. At the time this report was published, the Maaswerken project was at the initial stages of the second task from the list above.

Scientists and modelers associated with the FIRMA project played the role of observers during stakeholder participation meetings of the Maaswerken project. The planning situation was entirely designed and stakeholder participation conducted, by the Maaswerken organization. Stakeholders identified in the report included national decision makers, provincial decision makers, four nature organizations, farmers, municipalities, citizen groups and gravel extractors.

16.4 Outcome

The report concluded that the FIRMA approach was a step forward in the development of a decision-support system that enables planners not only to model the physical processes of a particular system but also incorporate social dynamics. The case study provided a tangible example of the applicability of the process and how the model can incorporate stakeholders' concerns.

17 An Open Geographic Modeling Environment

System/Study Area Name:	Not applicable
Study Type:	Modeling infrastructure for dynamic spatial simulation models
Analysis/Model Type:	Open Geographic Modeling Environment; Everglades Landscape Model (ELM); and the Coastal Ecological Landscape Spatial Simulation (CELSS) model
Stakeholders Identified:	Not applicable
Level of Participation:	Not applicable
Conflict Type:	Not applicable
Was Problem Solved:	Yes, a powerful yet easy-to-use spatial modeling environment was developed
International or U.S.:	Not applicable
Sponsoring Agency:	University of Maryland, Institute for Ecological Economics
Study Lead:	University of Maryland, Institute for Ecological Economics
Authors and Source:	Maxwell, T. and Costanza, R. (1993) An Open Geographic Modeling System. University of Maryland, Institute for Ecological Economics. Retrieved August, 2006, from http://www.ncgia.ucsb.edu/conf/landuse97/statements/maxwell_tom/sme.html

17.1 Purpose of the Study

This paper argues that effective management of human affairs in the future will require the development of complex computer models. To accommodate such model the paper recommends the development of new infrastructure supporting high performance collaborative modeling. The authors hope that such infrastructure will open the simulation arena to a much wider set of participants and facilitate the application of computer modeling to the study of complex multi-scale processes in support of policy making on many levels.

The authors report that despite the recognized importance of developing computer models when studying complex natural systems, the development of these models has historically been limited by the large amount of input data required, the difficulty in dealing with large spatial arrays and conceptual complexity involved in writing, debugging and calibrating very large simulation programs. These limitations have been eroded with the introduction of remote sensing and GIS systems and the development of parallel computer systems. However, the conceptual complexity involved in building models in a distributed computational environment a major barrier to utilizing these tools in environmental sciences.

The authors introduce a new modeling infrastructure called the Open Geographic Modeling Environment to address the problem. The new infrastructure links graphical tools for developing self-contained component models with databases and parallel code generators. The infrastructure supports modular, reusable model development and allows scientists to utilize state-of-the-art parallel processing architecture without investing unnecessary time in computer programming. This environment is described to support (1) modular, hierarchical model construction and archiving/linking of simulation modules, (2) graphical, icon-based model construction, (3) transparent distributed computing and (4) integrating multiple space-time representations.

17.2 Model Use

This paper does not in itself report on a specific study, rather, it uses case study examples to illustrate application and provide examples of models that have been build using the modeling environment described. Models described in the examples are primarily processed-based landscape models and include the Everglades Landscape Model (ELM) and the Coastal Ecological Landscape Spatial Simulation (CELSS) model.

17.3 Involvement and Collaboration

The paper does not report the results of a specific study, but describes a modeling process based upon participatory model building. The approach described utilizes a graphical approach to modeling has the advantage being able to be used as a consensus building tool in group or stakeholder meetings.

17.4 Outcome

Beyond the scientific justification, the authors presented a modeling environment that uses smaller, less expensive computers (contrasted to mainframe modeling) and reduces the time involved for both developing and running dynamic spatial simulation models. The authors conclude that the combination of parallel computer hardware and software with icon-based graphical model development tools and GIS/database tools was able to produce a powerful yet easy-to-use spatial modeling environment.

18 Participatory Multi-Criteria Decision Analysis With Web-HIPRE: a Case of Lake Regulation Policy

System/Study Area Name:	Lake Lake Paijanne in southern Finland
Study Type:	Multi-criteria decision analysis
Analysis/Model Type:	Web-HIPRE; HIPRE 3+ software; regulatory policy re-evaluation
Stakeholders Identified:	Water-resource authorities, local stakeholders, experts on regulation and researches
Level of Participation:	stakeholder were solicited for preferences and a participatory decision-making process was used to arrive a decision
Conflict Type:	Conflicting stakeholder interests
Was Problem Solved:	Analysis was able to clarify the views of the stakeholders
International or U.S.:	Europe - Finland; not trans-boundary
Sponsoring Agency:	Academy of Finland; Finnish Cultural Foundation
Study Lead:	Helsinki University of Technology, Systems Analysis Laboratory; Finnish Environment Institute
Authors and Source:	Mustajoki J., Ha¨ma¨la¨inen, R.P. and M. Marttunen (2003). Participatory Multi-criteria decision analysis with Web-HIPRE: a case of lake regulation policy. Retrieved August, 2006, from http://www.sal.hut.fi/Personnel/Homepages/JyriM/thesis/paper2.pdf#search=%22multiattribute%20decision%20analysis%20water%20model%20participation%20OR%20dispute%20OR%20stakeholders%20filetype%3Apdf%22

18.1 Purpose of the Study

Multi-criteria decision analysis (MCDA) is a means to provide transparent ways to elicit and communicate individual preferences in participatory decision making. This paper discusses Multi-criteria decision analysis and its application to environmental decision-making processes. The paper introduces software called Web-HIPRE with its ability to support remote public participation. Web-HIPRE is a web implementation of HIPRE 3+ software which is a general purpose Multi-criteria software. Web-HIPRE's ability to provide web-based Multi-criteria decision support makes it especially suitable for environmental decision support because it can support the analysis of different views of stakeholders and provide a tool for remote participation

The application and use Multi-criteria decision analysis and Web-HIPRE are illustrated through a case study example of Lake Paijanne in Finland. An extensive multi-disciplinary research project to re-evaluate the regulation policy of Lake Paijanne was carried out to assess the ecological, economic and social impacts of the regulation. This project sought the opinions of stakeholders about the current regulation and its development, comparison of new regulation policy options and recommendations to diminish the harmful impacts of the regulation.

18.2 Model Use

The Lake Paijanne study used HIPRE 3+ software to interactively model stakeholder preferences. Web-HIPRE supported this project by giving people not attending workshops the possibility of accessing models, results and conducting their own sensitivity analyses from remote locations.

18.3 Involvement and Collaboration

To gather opinions of stakeholders for the Lake Paijanne study, the Ministry of Agriculture and Forestry is reported to have formed a steering group consisting of 18 representatives of different stakeholders. Four additional working groups have been established to improve communication between stakeholders. Local press conferences and public hearings have been used to disseminate information to the public at various points during the study.

Stakeholders identified in the study include the following:

- Ministry of Agriculture and Forestry
- Water-management authorities: Regional Environment Centres of South Savo, Central Finland, South-Eastern Finland and Birka land
- Provincial federations of Central Finland, South-Eastern Finland and Pa¨ija¨t-Ha¨me
- Fisheries authorities: Employment and Economic Development Centre of Ha¨me and Central Finland
- Recreational Fishermen Association
- Pa¨ija¨nne Nature Centre
- Timber Floating Association
- Hydro power companies: Regulation Committee of Lake Pa¨ija¨nne
- Local fisheries organization: North and South Pa¨ija¨nne fisheries areas
- The Central Union of Agricultural Producers and Forest Owners
- The environmental protection authority of Heinola town

18.4 Outcome

The study suggests that the use of a web-based system provided a complimentary way to support stakeholder preferences determination and a participatory decision-making process. The analysis during the case study was able to clarify the views of the stakeholders and a consensus on the new regulation policy was reached. The report also concludes that web-based communication provides an easy way to support participatory decision-making processes and provides a complementary way for stakeholders to participate. However, the report also notes that web-based communication cannot yet completely replace traditional face-to-face meetings and interactions and that full independent use of Web-HIPRE to create and evaluate preference models is not easily applicable to the general public, as it requires expertise in decision modeling.

19 Environmental Conflicts, Stakeholders and a Shared Mental Model

System/Study Area Name:	The Wellington region of New Zealand
Study Type:	Large-scale transport infrastructure evaluation; environmental conflict resolution
Analysis/Model Type:	Group model building; causal loop model
Stakeholders Identified:	Different users, environmentalists, decision makers and other stakeholders of the proposed project
Level of Participation:	Stakeholders were invited to group model building exercises
Conflict Type:	Environmental conflict
Was Problem Solved:	The objective of the study was achieved in the development of shared mental model; this consensus building exercise is hoped to lead to a resolution of the conflict
International or U.S.:	International – New Zealand; not trans-boundary
Sponsoring Agency:	Wellington Regional Council
Study Lead:	Victoria Management School, Victoria University of Wellington
Authors and Source:	Elias, A.A. Environmental Conflicts, Stakeholders and a Shared Mental Model, Victoria Management School, Victoria University of Wellington, Wellington, New Zealand.

19.1 Purpose of the Study

This report describes the usefulness of group model building in resolving conflicts amongst stakeholders in environmental conflicts. A system model built with input from various stakeholders is likely capture the different interests of participating stakeholders. The Transmission Gully project, a large-scale transport infrastructure project in the Wellington region of New Zealand is used as a case study to present the steps used to generate a shared system model. A qualitative analysis into potential system behaviors is performed and the resultant model is described as the causal loop model.

19.2 Model Use

A qualitative group model building approach was used to develop a causal loop model of the system. The method used in this study is based on the systems thinking methods Hexagons are used in the analysis. The report describes four key steps of the model building approach:

- Step 1: Hexagon generation
- Step 2: Cluster formation
- Step 3: Variable identification and
- Step 4: Causal loop development

19.3 Involvement and Collaboration

An analysis of stakeholders was conducted prior to commencing the group model building exercise. The analysis methodology involved nine steps: i) Developing a stakeholder map of the project; ii) Preparing a chart of specific stakeholders; iii) Identifying the stakes of stakeholders; iv) Preparing a power versus stake grid; v) Conducting a process level stakeholder analysis; vi) Conducting a transactional level stakeholder analysis; vii) Determining the stakeholder management capability of the project; viii) Analyzing the salience of stakeholder; and ix) Analyzing the changing positions and interests of stakeholders. A broad range of stakeholders were identified during the stakeholder analysis. Representatives of stakeholder groups were invited to take part in a group model building exercise.

19.4 Outcome

A casual loop model was developed by the end of the group model building exercise. This model is reported to have been generally endorsed by the stakeholders who participated in the exercise. The initial model is reported to have been further refined to generate a modified casual loop model with feedback loops. The report concludes that group model building was useful in revealing the various interests of stakeholders in an environmental conflict situation. The causal loop model that was developed is described to have given a solid basis to build a dynamic model of the system.

20 CRYSTAL - Cascade Regional Yield Simulation Analysis Model

System/Study Area Name:	Puget Sound Region
Study Type:	Water-resources planning and management
Analysis/Model Type:	CRYSTAL model; system dynamic modeling; POWERSIM software
Stakeholders Identified:	Various stakeholders
Level of Participation:	Agency meetings and workshops
Conflict Type:	Evaluation of proposed water-supply improvements
Was Problem Solved:	Ongoing
International or U.S.:	U.S.; not trans-boundary
Sponsoring Agency:	-
Study Lead:	Water Resources Management and Drought Planning Group at the University of Washington
Authors and Source:	CRYSTAL - Cascade Regional Yield Simulation Analysis Model. Water Resources Management and Drought Planning Group at the University of Washington. Abstract retrieved from http://www.tag.washington.edu/research/sharedvision.html

20.1 Purpose of the Study

According to information obtained from the project website maintained by the Water-Resources Management and Drought Planning Group at the University of Washington, the Cascade Regional Yield Simulation and Analysis Model (CRYSTAL) is described as an interactive modeling tool that was designed to assist water managers, planners and public officials in Pierce, King, Snohomish counties in the state of Washington to establish a shared understanding of how the region's water-supply systems operate and are managed. The model provides users a means explore the impact of alternative policy options through the simulation of the alternatives.

CRYSTAL was created as a submodel to the University-wide Puget Sound Regional integrated Synthesis Model (PRISM) project. The objective of PRISM on the University of Washington project website is to develop and sustain a dynamic and integrated understanding and description of the environmental and societal factors that will shape the Puget Sound region as it moves into the 21st century. CRYSTAL supports this effort by its ability to predict the availability and potential uses of water in the Puget Sound. The goal of the CRYSTAL model is the illustration of the value and opportunities of a regional approach to water management. The study of the Puget Sound Region used the CRYSTAL model to evaluate proposed water-supply improvements for the region.

20.2 Model Use

The Puget Sound study utilized several models including the CRYSTAL model in its integrated approach. The CRYSTAL model was created using a system dynamic modeling environment called Powersim and is described to represent the most comprehensive regional water-supply planning model yet developed for Puget Sound.

20.3 Involvement and Collaboration

Water utilities and other public resource agencies provided input during the development of the CRYSTAL model. Participation during model development is included numerous individual agency meetings and a workshop to assemble participants from the different agencies and to evaluate the underlying modeling assumptions within a Shared Vision approach.

Upon completion of the model, CRYSTAL was to be used in evaluating proposed water-supply improvements for the region. Such policy evaluations were expected to involve various stakeholders; however, information reviewed at the University of Washington project website was not updated to reflect such progress in the analysis.

20.4 Outcome

A comprehensive regional water-supply planning model was developed for Puget Sound region. This model enabled the simulation of various water-supply planning scenarios. The University of Washington project website reviewed for model did not provide updated information on the final out come from the use of the CRYSTAL model in water-supply improvement evaluations.

21 ACT-ACF (Apalachicola-Chattahoochee-Flint and Alabama-Coosa-Tallapoosa Basins) Study

System/Study Area Name:	Apalachicola-Chattahoochee-Flint and Alabama-Coosa-Tallapoosa basins spanning Alabama, Georgia and Florida
Study Type:	Water resource planning and management
Analysis/Model Type:	Dynamic modeling; STELLA software
Stakeholders Identified:	The states of Alabama, Georgia and Florida; the Corps of Engineers, environmentalists and other stakeholders
Level of Participation:	stakeholders were directly involved as participants in the modeling process
Conflict Type:	Water-allocation dispute
Was Problem Solved:	No
International or U.S.:	U.S.; interstate boundary
Sponsoring Agency:	U.S. Army Corps of Engineers
Study Lead:	Water Resources Management and Drought Planning Group at the University of Washington
Authors and Source:	ACT-ACF. Water Resources Management and Drought Planning Group at the University of Washington. Abstract retrieved from http://www.tag.washington.edu/research/sharedvision.html

21.1 Purpose of the Study

Water conflicts between the states of Alabama, Georgia and Florida over water-allocation rights in the Apalachicola-Chattahoochee-Flint and Alabama-Coosa-Tallapoosa basins (ACT-ACF) threatened lengthy litigation in the courts in the mid 1990s. The three states opted to collaboratively conduct a comprehensive study of the water-allocation problem. According to information obtained from the University of Washington website, a SVP approach was adopted after other planning efforts failed. The study is reported to have integrated water-use forecasting, economic studies and environmental analysis.

21.2 Model Use

A system dynamic model of the entire ACT-ACF basin was constructed using STELLA software. This model operated on a monthly time-step.

21.3 Involvement and Collaboration

The model developed for the study was a collaborative effort between the three states and other stakeholders. The study established three circles of influence. The first circle included modelers and planners who were part of the modeling team. These individuals held weekly teleconference meetings and one working meeting per month. The second circle of influence is reported to have included state water departments and natural resource agencies, electric power companies, city/municipal water agencies, lake managers and representatives from the navigation industry. The third circle of influence was described as including the most interested members of the public, such as farmers, fishermen and technical experts from closely related studies.

21.4 Outcome

Despite the collaborative effort, the study failed to bring the conflicting parties to an allocation agreement.

22 Drought Management Plan for the State of Georgia

System/Study Area Name:	The State of Georgia
Study Type:	Drought management
Analysis/Model Type:	Dynamic modeling; STELLA software
Stakeholders Identified:	Various water users across the state
Level of Participation:	Virtual drought exercises and workshops
Conflict Type:	Efficient use of water during drought
Was Problem Solved:	A drought plan was developed
International or U.S.:	U.S.; not trans-boundary
Sponsoring Agency:	State of Georgia
Study Lead:	State Georgia personnel, researchers from the University of Washington, the Georgia Institute of Technology and the National Drought Mitigation Center
Authors and Source:	Drought Management Plan for the State of Georgia. Water Resources Management and Drought Planning Group at the University of Washington. Retrieved from http://www.tag.washington.edu/research/sharedvision.html Palmer, R.N, Kutzing, S.L and Steinemann, A.C. (2002). Developing drought triggers and drought responses: an application in Georgia. Proc. of the World Water and Environmental Resources Congress, ASCE, Roanoke, Virginia, May 19-22.

22.1 Purpose of the Study

The drought management plan for the state of Georgia is listed as one of several projects completed by the Water-Resources Management and Drought Planning Group at the University of Washington. This project is reported to have been in response severe droughts that had struck the region. The state of Georgia responded by investing the development of a statewide drought management plan. As part of this effort, computer models of water supply were developed in shared vision context. One of the objectives of developing models was to collaboratively identify drought indicators, drought triggers and responses that would be incorporated into the plan.

22.2 Model Use

This drought management research study utilized several models including one called the Atlanta Regional Drought Model (ARDM). ARDM was developed specifically for this study and is based upon a broader model that was constructed for the ACT-ACF basin study. The ARDM is reported to have been constructed using the STELLA software and operated on a weekly time-step. The model allowed for a wide range of system alternatives and also allowed the water-use restrictions to be initiated county by county based on a wide variety of drought indicators and drought triggers.

22.3 Involvement and Collaboration

The ARDM model was demonstrated in a series of workshops to ensure the accuracy of the results. However, the material reviewed does not discuss the level of participation during the actual development of the model. Stakeholders involved in the drought management study are reported to have included the Sate of Georgia, local utility managers, the Army Corps of Engineers and academic researchers from universities.

22.4 Outcome

A drought management plan that included drought indicators, drought triggers and responses is reported to have been created for the state of Georgia and the Atlanta region.

23 Portland Climate Change Impacts

System/Study Area Name:	The Bull Run Basin in Portland
Study Type:	Water-resource planning and management; climate change impacts
Analysis/Model Type:	Dynamic modeling; STELLA software; other
Stakeholders Identified:	not explicitly discussed
Level of Participation:	not explicitly discussed
Conflict Type:	Not applicable
Was Problem Solved:	Study provided insights about potential impacts of climate change on water supply
International or U.S.:	U.S.; not trans-boundary
Sponsoring Agency:	Portland Water Bureau
Study Lead:	Water Resources Management and Drought Planning Group at the University of Washington; Portland Water Bureau
Authors and Source:	Portland Climate Change Impacts. Water Resources Management and Drought Planning Group at the University of Washington. Abstract retrieved from http://www.tag.washington.edu/research/sharedvision.html VanRheenen, N.T., Palmer, R.N. and Hahn, M.A. (2003). Evaluating Potential Climate Change Impacts on Water Resources Systems Operations: Case Studies of Portland, Oregon and Central Valley, California. Water Resources Update, 124, 35-50.

23.1 Purpose of the Study

A study to estimate potential impacts of climate change on water supplies in the Portland area was conducted by the Water-Resources Management and Drought Planning Group at the University of Washington). The study was conducted collaboratively with staff from the Portland Water Bureau and consultants. The study was especially important in the Portland area because of the interplay of two factors, rainfall and temperature. According to information obtained from the project website, changes in temperature and precipitation are said to alter the delicate interaction between the amount of precipitation that falls as either rain or snow, the eventual accumulation of snow during winter and temporal variability with which this snow melts and flows through the watershed.

The purpose of this study was exploration of the impact that climate change may have on the hydrology of the Bull Run basin and Portland Water Bureau's ability to provide reliable water to its customers.

23.2 Model Use

Information on the project website suggests that a series of models were used for this analysis. These models simulated three aspects of the process: the climate, the hydrologic cycle and water-supply system management. The climatic aspect was simulated based of four different Global Circulation Models (GCMs). These models were the Department of Energy's Parallel Climate Model (PCM), the Max Planck Institute's ECHAM model and the Hadley Centre's HadCM2 and HadCM3 models. The hydrologic aspects were simulated using the Distributed Hydrology Soil Vegetation Model (DHSVM). The water-supply management system was simulated using the Storage and Transmission Model (STM).

23.3 Involvement and Collaboration

The research team relied on published results from the GCMs. These results were scaled down by the research team to provide input into the watershed model. Researchers used the DHSVM framework to establish a model reflective of the Bull Run study area. Results from the watershed model provided input into the Water-Supply System and Management Model. This model (STM) was developed by the research team specifically for the Portland Water Bureau.

The documents reviewed from the project website do not explicitly discuss the level of participation and collaboration with stakeholders during model development nor during the development and analysis of impact scenarios. However, a SVP approach is suspected in the development of impact scenarios.

23.4 Outcome

The study demonstrated that climate change will alter the basic hydrology of the Bull Run River Basin and the demands of the Portland Water Bureau. The study showed that the climate impacts will result in a decrease in the system safe yield.

24 Seattle Virtual Drought Exercise, September 2000

System/Study Area Name:	Puget Sound Region
Study Type:	Water resources planning and management
Analysis/Model Type:	SVP
Stakeholders Identified:	water mangers from the cities of Everett, Seattle and Tacoma; representatives from the U.S. Geological Survey and the U.S. Army Corps of Engineers
Level of Participation:	stakeholders participated in drought exercises
Conflict Type:	Conflicting management alternatives
Was Problem Solved:	Model results were used in making decisions about management options
International or U.S.:	U.S.; not trans-boundary
Sponsoring Agency:	Not specified in report
Study Lead:	Water Resources Management and Drought Planning Group at the University of Washington
Authors and Source:	Seattle Virtual Drought Exercise, September 2000. Water Resources Management and Drought Planning Group at the University of Washington. Abstract retrieved from http://www.tag.washington.edu/research/sharedvision.html

24.1 Purpose of the Study

The Seattle drought exercise that was held in Sept 2000 is reported to have implemented a shared vision approach. The drought exercise was conducted during a workshop. Its purpose was to (1) promote a regional approach to drought management, (2) review the events of 2001, (3) investigate the benefits of a regional water-supply system and (4) explore the use of weather driven forecasts in management.

During the workshop, experts presented and discussed regional challenges and opportunities, as well as issues relating to managing drought in the Puget Sound. Regional water-supply forecasts were presented and their value in managing water supplies was discussed. An extreme drought scenario was presented and researchers described how regional water supply would respond to such an extreme event. Water-resources managers and other participants were engaged to discuss management options to address identified water-supply shortfalls.

24.2 Model Use

Several regional water-supply forecasting models were discussed including the National Center for Environmental Prediction (NCEP) model, which was used to forecast water supply for the study. Models by the U.S. Geological Survey and the U.S. Army Corps of Engineers were discussed comparatively. Forecasts from the regional water-supply model were adjusted, scaled to reflect the study area and incorporated into the Distributed Hydrology Soil Vegetation Model (DHSVM) to determine stream flows in the region.

24.3 Involvement and Collaboration

Participants at the drought exercise included the research team, water mangers from the cities of Everett, Seattle and Tacoma; representatives from the U.S. Geological Survey and the U.S. Army Corps of Engineers. Participants collaboratively discussed regional challenges and opportunities in water-supply management. Regional water mangers in attendance were also presented with water-supply scenarios and asked how they would use this information and what types of management decisions they would make based such information.

24.4 Outcome

A final summary of the workshop was produced that includes a list of lessons learned based on comments of participants. The workshop and drought management exercise also helped participants come to a general consensus on (1) the desire for more opportunities for regional water supply and resource managers to meet in a relaxed atmosphere and (2) updated regional water-supply forecasts.

25 Participatory Processes: A Tool to Assist the Wise Use of Catchments

System/Study Area Name:	Five river catchments areas: the Forth Catchment, Scotland; Fenlands, England; Erne Catchment, The Republic of Ireland and Northern Ireland; Somerset Levels and Moors, England Val de Charente – France
Study Type:	River basin management
Analysis/Model Type:	Participatory Processes including several study area models
Stakeholders Identified:	Various Stakeholders
Level of Participation:	Stakeholders were involved at varying degrees from the early stages of the studies
Conflict Type:	Not applicable
Was Problem Solved:	Recommendations were made on how to best engage stakeholders and the public
International or U.S.:	International- Europe; has trans-boundary issues
Sponsoring Agency:	European Commission
Study Lead:	Wise Use of Floodplains project team
Authors and Source:	Cuff, J. (2001). Participatory processes: A tool to assist the wise use of catchments a guide based on experience. Retrieved August 2006, from http://www.floodplains.org/pdg/technical_reports/Participatory%20Processes%20Report.pdf

25.1 Purpose of the Study

This study was conducted as part of the Wise Use of Floodplains project (WUF project) in Europe. The aim of the WUF project is the demonstration of how best floodplain wetlands can contribute to sustainable integrated and multi-functional management of water resources within river basins. This report on public participation contributed to the WUF project by providing a comprehensive review of participatory methods that were used at different river catchment areas of the WUF study. Such participatory methods were evaluated in the context of the European Water Framework Directive (WFD) that advocates for an active participation of all interested stakeholders in river basin planning. This study investigated the effectiveness of different participatory methods and derived conclusions and recommendations based on experience from five river catchment areas covered by the WUF project. The five river catchment areas were:

- Forth Catchment – Scotland
- Fenlands – England
- Erne Catchment – The Republic of Ireland and Northern Ireland
- Somerset Levels and Moors (Parrett Catchment) – England
- Val de Charente – France

These areas are reported to have been selected because they exhibited contrasting socio-economic, administrative and physical characteristics.

25.2 Model Use

The study discusses participation methods but none of the studies appear to have used consensus based modeling during participatory meetings.

25.3 Involvement and Collaboration

The focus of this study was the evaluation of participatory methods. The report discusses the theoretical concept of participation and the different levels of participation. The study used a 10-point evaluation framework to evaluate the type of participation that took place at each of the five project areas. The most appropriate level of participation in all five studies was at the catchment scale. A diverse group of stakeholders took part from the onset of each study.

25.4 Outcome

The participatory study provided useful information to the WUF project in terms of how to actively involve the public/stakeholders during studies so as to be consistent with WFD requirements. The study concluded that participation need not require a high expenditure. The WUF established a road map for future researchers on the role and implementation of participation in their studies and how this would fit in the WFD context.

26 Public Participation and the European Water Framework Directive – Role of the Information and Communication Tools

System/Study Area Name:	Not applicable
Study Type:	River basin management
Analysis/Model Type:	Evaluation of various information and communication tools
Stakeholders Identified:	Not applicable
Level of Participation:	Not applicable
Conflict Type:	Not applicable
Was Problem Solved:	Not applicable
International or U.S.:	International- Europe; trans-boundary issues- not applicable
Sponsoring Agency:	European Commission
Study Lead:	HarmoniCOP
Authors and Source:	Maurel, P., (Ed.), (2003). Public participation and the European water framework directive – Role of the information and communication tools. Prepared under contract from the European Commission Contract No EVK1-CT-2002-00120. Retrieved August 2006, from http://www.harmonicop.info/_files/_down/ICTools.pdf

26.1 Purpose of the Study

This study was part of the HarmoniCOP project (HARmonising Collaborative Planning which was established within the 5th European Framework Program for Research and Technological Development. The HarmoniCOP project focused on understanding the role of public participation (PP) in river basin management planning within the European Water Framework Directive. The HarmoniCOP project was made up of seven interrelated work-packages to which specific objectives included:

- Prepare a "Handbook on PP methodologies"
- Provide insight into Social Learning in a multi-phase multi-level context
- Increase the understanding of the role of information and communication tools
- Compare and assess national PP experiences and their background
- Involve governments and stakeholder groups.

The study, Public participation and the European water framework directive – Role of the Information and Communication Tools represents the Work Package 3 (WP3) and was dedicated to increasing the understanding of the role of information and communication tools (ICTools) in river basin management. WP3 focuses on the role of ICTools as a facilitating mechanism to support public participation and a collaborative decision-making process.

26.2 Model Use

The study identified twenty ICTools from a review of literature and experience. These tools were categorized based on four main criteria: communication direction (top-down, bottom-up, bi-directional), public size (small working group, general public), usage purpose (management of information and knowledge, elicitation of perspectives, interaction support and simulation) and phases in the PP process. Three types of ICTools identified are described in detail. These are (1) maps and other spatial representations, (2) simulations models (Decision-Support Systems, Integrated Assessment Models, Qualitative Models and Fuzzy Cognitive Mapping) and (3) Role Playing Games.

The ICTools were evaluated from three general perspectives: (1) the technical characteristics of the tools themselves and the usage situations, (2) their relational and substantive impacts on public participation and social learning, (3) their usability as perceived by the users.

26.3 Involvement and Collaboration

Though the study was more research based rather than applied, it is reported that stakeholder input was solicited as part of the research.

26.4 Outcome

The study provides valuable information to anyone interested in the role on ICTools for participatory river basin management.

27 Cooperative Water-Resources Modeling in the Middle Rio Grande Basin

System/Study Area Name:	Middle Rio Grande including Bernalillo, Sandoval and Valencia Counties of north-central New Mexico
Study Type:	Community based water resource planning
Analysis/Model Type:	System dynamic modeling; five-step modeling approach; Studio Expert software
Stakeholders Identified:	Middle Rio Grande Water Assembly, the Mid-Region Council of Governments, the Utton Trans-boundary Resources Center at the University of New Mexico, numerous regional agencies and experts and Sandia National Laboratories
Level of Participation:	Stakeholders had varying participation, from simple viewing to actively involvement in the modeling process
Conflict Type:	Competing water use allocation and management problem
Was Problem Solved:	Model results were used in making decisions about management options
International or U.S.:	U.S.; not a trans-boundary issue
Sponsoring Agency:	Sandia National Laboratories Small Business Assistance Program; State of New Mexico
Study Lead:	Sandia National Laboratories
Authors and Source:	Passell, H.D., Tidwell, V.C., Conrad, S.H., Thomas, R.P. and Roach, J. (2003). Cooperative water resources modeling in the Middle Rio Grande Basin. Retrieved August 2006, from http://www.sandia.gov/water/docs/ModelingSANDrprtFINAL.pdf

27.1 Purpose of the Study

This report describes how a community-based water-resource planning model for a three-county region along the Rio Grande was developed. The model was built using a systems dynamic approach with the following objectives: (1) quantitatively explore alternative water-management strategies in terms of costs and water savings; (2) educating the public on the complexity of the regional water system; and (3) engaging the public in the decision process. The final model developed was expected to provide a means of screening alternative water-management strategies and gauging public/political acceptance of the measures.

27.2 Model Use

The model adopted a five-step process. The five steps included defining the problem and scope of analysis in step 1, description of the system in step 2, converting the conceptual model into a system dynamic model in step 3, model review in step 4 and the use of the model by the public in step 5. The model is a system dynamic model built using Studio Expert software. At the highest level, the model organized into two water budgets, one for surface water and the other for ground water. The model also incorporates 24 different water-conservation strategies.

27.3 Involvement and Collaboration

Various stakeholders were involved in the study. Model development included the direct cooperation and involvement of the public. Stakeholders included the Interstate Stream Commission, MRCOG, Middle Rio Grande Conservancy District, City Utilities and Water Cooperatives, Federal/state agencies, MRGWA, the cooperative modeling team and the general public.

27.4 Outcome

The model developed during this study was used by the public along with the local government to develop a 50-year water for the region.

28 Conflict Resolution Support System: A Software for the Resolution of Conflicts in Water-Resource Management

System/Study Area Name:	Not applicable
Study Type:	Dispute resolution
Analysis/Model Type:	Application of the Conflict Resolution Support System (CRSS)
Stakeholders Identified:	Not applicable
Level of Participation:	Not applicable
Conflict Type:	Water-allocation disputes
Was Problem Solved:	Not applicable
International or U.S.:	International; has trans-boundary issues
Sponsoring Agency:	UNESCO, Division of Water Sciences
Study Lead:	Department of Civil Engineering, University of Peradeniya, Sri Lanka; and Department of Civil and Environmental Engineering, Institute for Catastrophic Loss Reduction, The University of Western Ontario, Canada
Authors and Source:	Nandalal, D.D.W. and Simonovic, S.P. (2003, June). Conflict resolution support system: a software for the resolution of conflicts in water resource management. Prepared for Division of Water Sciences UNESCO. Retrieved August 2006, from http://www.unesco.org/water/wwap/pccp/phase2/crss/users_manual.pdf

28.1 Purpose of the Study

Noting that water conflicts are likely to occur when stakeholder water requirements exceed availability, this research report argues that a water allocation based on traditional optimization or simulation modeling may not lead to the resolution of the dispute if the stakeholders do not participate in the solution process. The report explains that the direct involvement of the stakeholders in the conflict resolution process provides for a better understanding of the conflict and offers a significant opportunity for its resolution.

This report describes a systemic approach to the resolution of conflicts over water which is hoped will help stakeholders to explore and resolve the underlying structural causes of conflict and thus provide a significant opportunity for its resolution. The research focuses on disputes that cross jurisdictional boundaries and it outlines what the research termed the five main functional activities for assisting the conflict resolution process. These are (1) communication, (2) problem formulation, (3) data gathering and information generation, (4) information sharing and (5) evaluation of consequences. The report includes a user's manual for a decision-support system called Conflict Resolution Support System (CRSS).

28.2 Model Use

CRSS was developed for the implementation of the systemic approach described above. This system is described in the report along with three case study examples. Principal components of the system include an artificial intelligence-based communication system (AICS), a database management system (DBMS) and a model base management system (MBMS).

The AI component of the AICS provides a connection to the database through the DBMS and interacts with the MBMS modules. The MBMS includes three modules capable in analyzing three typical conflicts encountered in water-resource management. They are described as (1) a conflict in sharing water for irrigation and/or drinking water supply, (2) a conflict between hydropower generation and drinking water supply and (3) a conflict between flood protection and irrigation.

28.3 Involvement and Collaboration

Much of the discussion in the report focuses on the inner working of the CRSS and does not elaborate on how stakeholders and the general public are brought together. The CRSS is designed to allow stakeholders to interact with the system and change the system parameters in order to view alternative solutions. This interactive process between stakeholders is hoped to lead to a general understanding of the overall dispute and a consensus on an acceptable solution.

28.4 Outcome

A decision-support system capable of assisting stakeholders in a water dispute was developed and presented. The stakeholders are assisted in coming to a general understanding of the dispute and collaboratively arriving at an acceptable solution.

29 Participation and Model-Building: Lessons Learned Fom the Bukittinggi Workshop

System/Study Area Name:	Bukittinggi, Sumatra, Indonesia
Study Type:	Land-use planning
Analysis/Model Type:	Collaborative model-building Simile software
Stakeholders Identified:	Participation restricted to those with specialist skills in relevant disciplines, modeling or facilitation
Level of Participation:	Participants were directly involved in the modeling process
Conflict Type:	Not applicable
Was Problem Solved:	Yes
International or U.S.:	International; not trans-boundary
Sponsoring Agency:	Department for International Development of the United Kingdom
Study Lead:	Southern Cross University, Australia; Worldforests, Sutherland, Scotland; and Center for International Forestry Research, Bogor, Indonesia
Authors and Source:	Vanclay, J. and Haggith, M. (2003). Participation and Model Building: Lessons learned from the Bukittinggi Workshop. Retrieved August 2006 from: http://eprint.uq.edu.au/archive/00003486/01/B2)_participation_and_model_building_-_23_Apr_03.pdf

29.1 Purpose of the Study

This paper reports on the process, the outcomes and the lessons learned from a workshop that was held in Bukittinggi, Sumatra, Indonesia in 1999. The purpose of the workshop was to test the hypothesis that simulating land use at the landscape scale for informed decision making was practical. The key objective of the workshop was the fostering of participatory modeling as a way to encourage interdisciplinary collaboration and exploration of land use options and outcomes. Proponents of the workshop anticipated that participants would work with the public, researchers and other data owners to identify activities critical to land-use decisions and community welfare.

The FLORES workshop was based on Adaptive Environmental Assessment and Management (AEAM) workshops pioneered by Holling (1978). Steps in the FLORES/AEAM approach included the following:

- Identify issues
- Identify indicators of performance (outputs)
- Define policy levers
- Establish purpose of the model
- Define overall model characteristics
- Form groups to deal with particular issues
- Agree on interfacing between groups
- Design submodels
- Test sub-models as stand-alone models
- Synthesize submodels to form a consolidated model

- Test the consolidated model
- Explore implications for management

29.2 Model Use

A model called the FLORES (the Forest Land Oriented Resource Envisioning System) was developed during the workshop and the FLORES approach to modeling was established. This approach envisioned the development of model templates for a range of sites based on standard structure of households-tenure-patches with sub-models for various biophysical components (e.g., crops, trees) and human components (e.g., resources, decision making). FLORES modeling was performed in the Simile Modeling Environment. Simile was specifically designed for ecological applications and has a graphical user interface considered suitable for FLORES modeling.

29.3 Involvement and Collaboration

The FLORES workshop was specifically setup to bring a multidisciplinary team of experts together to collaborate and explore land use options and outcomes using a dynamic model. The workshop was designed to bring 20 individuals but ended up with 50 participants attending plus another 40 individuals participating virtually via e-mail. Participation was restricted to those with specialist skills in relevant disciplines, modeling or facilitation. Participants were grouped into five teams so that each team could develop a submodel to later be incorporated into the FLORES model. Involvement and collaboration is reported to be ongoing through the FLORES Society.

29.4 Outcome

The study lists specific outcomes centered on the consolidated model. The consolidated model is reported as an important proof that:

- A model of a complex system can be constructed by a diverse team;
- It can be done with a graphically-based package such as Simile;
- The resulting model can remain reasonably accessible (at least in overview);
- Such a model does not need a supercomputer and can run on a notebook computer;
- Useful insights can be gained in building such a model and attempting to build such a model is a worthwhile exercise in itself; and
- Modeling in this way helps to foster interdisciplinary collaboration when researchers have a shared interest in a common problem or locality.

30 A Survey on the Methodology of Participatory Integrated Assessment

System/Study Area Name:	Not applicable
Study Type:	Literature survey
Analysis/Model Type:	Participatory integrated assessment; policy delphi, dialectical debate, focus group and participatory decision analysis
Stakeholders Identified:	Not applicable
Level of Participation:	Various levels of participation discussed
Conflict Type:	Not applicable
Was Problem Solved:	Not applicable
International or U.S.:	International; not trans-boundary
Sponsoring Agency:	International Institute for Applied Systems Analysis, Laxenburg, Austria
Study Lead:	Young Scientist Summer Program, Risk Modeling and Society project, International Institute for Applied Systems Analysis
Authors and Source:	van de Kerkhof, M. (2001). A survey on the methodology of participatory integrated assessment. Laxenburg, Austria, International Institute for Applied Systems Analysis: 39. http://citeseer.ist.psu.edu/cache/papers/cs/29675/http:zSzzSzwww.iiasa.ac.atzSzPublicationszSzDocumentszSzIR-01-014.pdf/vandekerkhof01survey.pdf

30.1 Purpose of the Study

The paper discusses the methodology of Participatory Integrated Assessment (PIA) study that surveyed literature on the subject. PIA allows the incorporation of non-scientific knowledge, values and preferences into a multi or interdisciplinary process of structuring the various knowledge elements. Decision making is benefited because all relevant aspects of a problem are considered in their mutual coherence. The assumption put forward is that the incorporation of non-scientific knowledge, values and preferences would improve the decision-making process and the quality of science. The paper argues that "despite the boom" of different participatory methods, no general methodology for participation exists. It argues that participatory approaches combine many different methods, which are often used without a clear argument for the chosen design or procedure. The PIA approach is aimed at providing insights to the decision-making community.

The paper provides a description of the concept of stakeholder participation. This includes a comparison of different definitions of a stakeholder and a description of the pros and cons of participation. The paper also addresses the methodological key issues that should be taken into account in the design of a PIA approach. The paper lists the following key issues: the degree of participation, the role of scientists and the type of issue that is at stake. Finally the paper provides a discussion of selected PIA approaches.

30.2 Model Use

The survey of literature did not require the use of models. However, the paper discusses with examples, various PIA approaches that relied on the use of models. These approaches include the Policy Delphi, the Dialectical Debate, the Focus Group and the Participatory Decision-

Analysis Approach. Each of these approaches is described in detail but the models used are not described in detail.

30.3 Involvement and Collaboration

The essence of the paper is to review and discuss levels or degrees of participation for each PIA approach.

30.4 Outcome

Among other conclusions, this paper sheds light on the divergence and similarities of various PIA approaches. The paper brings into focus points that need special attention by identifying key issues to consider when designing a PIA approach.

31 Participatory Modeling of Endangered Wildlife Systems: Simulating the Sage-Gouse and Land Use in Central Washington

System/Study Area Name:	Western North America; Douglas County, Washington
Study Type:	Ecosystem Management
Analysis/Model Type:	Participatory SD modeling; Integrated Sage-Grouse and Human Systems Model; Vensim PLE plus
Stakeholders Identified:	Land owners, scientific experts, Washington Fish and Wildlife, U.S. Fish and Wildlife, Bureau of Land Management, Natural Resources Conservation Service, WA Department of Natural Resources, Douglas County Farm Service Agency and The Nature Conservancy
Level of Participation:	Stakeholders were directly involved as participants in the modeling process
Conflict Type:	Land use management options to protect endangered species
Was Problem Solved:	The study and model enabled stakeholders to develop a shared understanding of the problem; study was ongoing at the time of reporting
International or U.S.:	U.S.; not trans-boundary
Sponsoring Agency:	Foster Creek Conservation District (FCCD), Douglas County, Washington
Study Lead:	Program in Environmental Science and Regional Planning Washington State University
Authors and Source:	Beall, A., Zeoli, L., Ford, A., Jackson, R., Langsdale, S., Otto, P., Seiner, W., Struben, J., Tidwell, V. and Videira, N. (2006). Participatory Modeling for Adaptive Management: Reports from the Field. Proceedings of the 24th International Conference of the Systems Dynamics Society. 23-27 July 2006. Nijmegen: The Netherlands.

31.1 Purpose of the Study

This paper reports on a land use and management study that was conducted to investigate ways of protecting an endangered species (the Greater sage-grouse or Centrocercus urophasianus) while maintaining the livelihoods of landowners and other stakeholders dependent on the land. The Greater sage-grouse is reported to inhabit the sage brush habitats of Western North America, including Douglas County, Washington. This sagebrush habitat is reported to be diminishing as a result of agricultural conversion, fire, invasion of exotic annuals, fragmentation, urbanization and inappropriate livestock management. Associated with diminishing sagebrush habitat was an observed decline in the sage-grouse population, which is described to depend on this habitat.

The U.S. Department of Fish and Wildlife (USFW) is reported to have contemplated the inclusion of the sage-grouse in the U.S. Federal threatened and endangered species list due to these observed population declines. This plan was put on hold following an agreement with local working groups to develop long-range management plans in conjunction with Federal and local agencies. The Foster Creek Conservation District, a working group from Douglas County Washington, is reported to have used SD to synthesize known sage-grouse dynamics and local land use pattern to support the development of their Habitat Conservation Plan and subsequent land management decisions. This paper describes how participatory modeling using SD was applied to this study.

31.2 Model Use

The study used a system dynamic model called the Integrated Sage-Grouse and Human Systems Model to synthesize known sage-grouse dynamics and local land use patterns. This model was to provide a system-wide perspective of how local activities including the types land use impact the sage-grouse population. The model is reported to have been constructed using Vensim PLE plus software over a twelve-week period. The model was developed with two key modules: the land use module and the sage-grouse life cycle module. The modules were each constructed in an iterative fashion and then linked using feedback loops between land use and sage-grouse. Data for the model are reported to have been obtained from a wide information spectrum that also included expert judgment and personal intuition from participants. The model is described to use a monthly time-step.

31.3 Involvement and Collaboration

The Foster Creek Conservation District working group is described to have adopted a participatory modeling approach to foster a better understanding of land management challenges posed by declining sage-grouse populations. Participation in group meetings included the following stakeholders: land owners, scientific experts, representatives from the Washington Fish and Wildlife, U.S. Fish and Wildlife, Bureau of Land Management, Natural Resources Conservation Service, WA Department of Natural Resources, Douglas County Farm Service Agency and The Nature Conservancy.

31.4 Outcome

A readily accessible model was developed that is reported to provide insights into the cropland and shrub steppe ecosystems of Douglas County and the management scenarios which may prevent the sage-grouse from an endangered status. The model was designed to facilitate and support land use management decisions through the collaborative exploration of model parameters and simulated scenarios. The paper describes the model reported to be an initial model with enough flexibility for improvement as new data or concerns present themselves.

32 Evaluation of a Collaborative Model: A Case Study Analysis of Watershed Planning in the Intermountain West

System/Study Area Name:	Intermountain West region of the United States
Study Type:	Water-resource planning
Analysis/Model Type:	Selin and Chavez model
Stakeholders Identified:	Various stakeholders for each case study in the report
Level of Participation:	Informal face-to-face dialog and watershed field tours
Conflict Type:	Not applicable
Was Problem Solved:	Not applicable
International or U.S.:	U.S.; not trans-boundary
Sponsoring Agency:	USDA Forest Service
Study Lead:	National Agroforestry Center, USDA Forest Service
Authors and Source:	Bentrup, G. (2001). Evaluation of a collaborative model: A case study analysis of watershed planning in the Intermountain West. Environmental Management, 27(5), 739-748. Retrieved August 2006, from http://www.unl.edu/nac/research/2001bentrupcollaborativemodel.pdf#search=%22%20Evaluation%20of%20a%20collaborative%20model%3A%20A%20case%20study%20analysis%20of%20watershed%20planning%20in%20the%20Intermountain%20West%22

32.1 Purpose of the Study

Recognizing the increasing popularity of collaborative planning processes in addressing environmental planning issues and the existence of several conceptual models for collaboration, this study sought to evaluate one such model. The Selin and Chavez model is reported to have been evaluated to determine whether the model encompassed the range of factors considered important for the establishment and operation of collaboration in watershed planning. This paper was an effort to provide summary of the study, including case studies from the Intermountain West where the Selin and Chavez model was used. Four main criteria are described to have used to select case studies for this evaluation: (1) groups had incorporated collaborative elements, (2) stakeholder participation was voluntary, (3) key issues involved water-related resources and (4) location in the Intermountain West region of the United States.

32.2 Model Use

The term "model" in this paper appears not to refer to a computer model but rather a conceptual approach or methodology. The Selin and Chavez model is described as a conceptual framework outlining key elements required to establish collaboration in watershed planning. The paper describes these key elements to fall within 5 categories: antecedents, problem setting, direction setting, implementation; and monitoring and evaluation. Within each element, the paper addresses important factors based on the Selin and Chavez model. Multiple case studies that used the Selin and Chavez model are described to illustrate and reinforce these concepts. The case studies are analyzed to determine the model's applicability and usefulness in different settings at different spatial scales.

32.3 Involvement and Collaboration

This paper offers a differentiation between collaboration-based planning and participatory planning. The Selin and Chavez model is described to promote collaboration through the full range of planning activities from initiation to implementation. Case studies evaluated had varying levels of stakeholder involvement and collaboration.

32.4 Outcome

This paper concludes that based on the three case studies evaluated, the Selin and Chavez model is a useful starting point in the development of an modeling approach that would adequately encompass the range of factors considered important for the establishment and operation of collaboration in watershed planning. The paper also offers recommendations to improve the Selin and Chavez model's effectiveness in bringing about collaborative watershed planning.

33 Collaborative Water-Supply Planning: A Shared Vision Approach for the Rappahannock Basin in Virginia

System/Study Area Name:	Rappahannock Basin in Virginia
Study Type:	Water-resource planning; Collaborative and SVP
Analysis/Model Type:	Shared vision model
Stakeholders Identified:	Local utility directors, state, local and Federal governmental representatives, local environmental groups and a few interested private individuals
Level of Participation:	A series of meetings were held to further refine the model
Conflict Type:	Water-use allocation
Was Problem Solved:	Study was ongoing at the time of reporting
International or U.S.:	U.S.; with trans-boundary issues
Sponsoring Agency:	U.S. Army Corps of Engineers
Study Lead:	Rappahannock River Basin Commission, Water Allocation Group; U.S. Army Corps of Engineers
Authors and Source:	Connor, J., Cartwright, L. and Stephenson, K. 2004. Collaborative water supply planning: A shared vision approach for the Rappahannock Basin in Virginia. World Water Congress

33.1 Purpose of the Study

This paper suggests that in water-supply planning, technical analysis is required to determine current and future water availability, risks and water-use patterns, while value judgments are required to determine how water will be allocated and shared between users and determine the acceptable water-shortage risk and acceptable water uses. The paper argues that water being a scarce resource, water conflicts among users occurs when there is a fundamental difference in the underlying values held by users. According to the paper, conflicts persist because stakeholders typically rely on technical aspects to try to resolve the conflict. This paper presents the SVP approach as an alternative water-supply planning approach with a higher chance of resolving conflicts among water users. SVP is described to integrate technical analysis into collaborative planning and negotiation process. The report suggests that central to SVP is a shared vision model constructed collaboratively with the aid of stakeholder input. Such an approach to constructing a model is considered advantageous because it facilitates stakeholder cooperation and aids in identifying trade-offs. The purpose of this paper is to report on a study that applied SVP for the Rappahannock Basin in eastern Virginia where conflicts over water resources were simmering.

33.2 Model Use

The study of the Rappahannock Basin applied a shared vision model built in STELLA simulation software. At the time of reporting, the model is reported to have modeled the water system upstream of Fredericksburg. The model is reported to have been constructed with a monthly time step and to consist of two main submodels: the hydrological model and the water-demand model. The hydrological model was developed using topological maps, stream gage data and consultation with local utility managers. The demand model was developed using water demand and water-withdrawal data provided by utilities. The model developed also incorporates the impact of conservation measures. Short-term conservation measures are described to be incorporated into the model thorough reducing the average water-demand factor. Long-term conservation measures are incorporated through the use of drought curtailment factors.

33.3 Involvement and Collaboration

A series of meetings with stakeholders are reported to have been held to refine the study's model. Stakeholders identified in the report included local utility directors, state, local and Federal governmental representatives, local environmental groups and a few interested private individuals.

33.4 Outcome

A SVP approach resulted in the construction of a model that combined the water-supply system and demand system of the basin. The model is considered transparent, user friendly and can continue to capture stakeholder concerns.

34 Watershed Management and the Web

System/Study Area Name:	Patuxent River Watershed, Maryland
Study Type:	Watershed planning; environmental resources management
Analysis/Model Type:	Dynamic modeling; STELLA software
Stakeholders Identified:	A full range of scientific, government and citizen stakeholders groups
Level of Participation:	Stakeholders of the case study were involved through workshop; limited public participation using the web
Conflict Type:	Conflicting water-use interests and ecosystem management alternatives
Was Problem Solved:	Was an ongoing project
International or U.S.:	U.S.; not a trans-boundary issue
Sponsoring Agency:	U.S. Environmental Protection Agency
Study Lead:	Institute for Ecological Economics, University of Maryland
Authors and Source:	Voinov, A. and Costanza, R. (1999). Watershed Management and the Web. Journal of Environmental Management (1999) 56, 231–245. Article No. jema.1999.0281, available online at http://www.idealibrary.com

34.1 Purpose of the Study

This paper was submitted in 1997 and accepted for publication in 1999. The paper was written as a review of the role of Internet and in particular the World Wide Web (the web) in watershed planning and management. The paper argues that services and features that make the web increasingly popular are highly complimentary to some goals of watershed analysis. The paper briefly reviews the concept of watershed management and proceeds to highlight how the advent of the web could benefit this field. The benefits of the web are described to fall into two major categories: methodological and educational. Key aspects that make the web attractive are described to include the fact that it is open, interactive, fast, spatially distributed and hierarchical. Watershed planning and management is applied to the Patuxent River case study where the Internet is used to compliment the study.

34.2 Model Use

This paper, a review of watershed management and the web, does not apply the use of a model in itself. However, the case study cited used dynamic modeling in STELLA software to build a watershed scale simulation model. This paper describes the Patuxent Landscape Model as an integrated ecological economic spatial model that combines general models of ecological and economic site-specific processes with remote sensing and GIS data on changes in land use and management and field monitoring measurements in both aquatic and terrestrial environments in a unique spatial modeling framework for broad applications linking science and policy. The model is described to operate at two spatial scales: 200 m and 1 km cell resolutions. The 200m resolution is described to be more detailed and thus requiring more data. The model is also described to have a hierarchy of sub watersheds aggregating into the whole watershed. The model is also discussed in terms of the various modes available over the web.

34.3 Involvement and Collaboration

Participation and collaboration was not the focus of the review of watershed management and the web. Participation and collaboration is only discussed in the context of how the web can compliment this process. The case study is understood to have involved stakeholders through workshops at various stages.

34.4 Outcome

At the time this paper was submitted, the Patuxent Watershed Management web page is reported to have been on the Internet for more than a year. The paper concludes that the inertia among web users was still quite considerable at the time and that participation of the public was very limited. The authors outline reasons for this limited participation.

35 Collaborative Models for Planning in the Mississippi Headwaters

System/Study Area Name:	Mississippi Headwaters, central northern Minnesota
Study Type:	Water-resource planning
Analysis/Model Type:	Optimization-simulation model; SD; HEC-PRM; STELLA software
Stakeholders Identified:	Various agencies, interested groups and the general public
Level of Participation:	stakeholders were directly involved as participants in the modeling process through all stages
Conflict Type:	Optimization of reservoir uses
Was Problem Solved:	model results were used in making decisions about management options
International or U.S.:	U.S.; not trans-boundary
Sponsoring Agency:	U.S. Army Corps of Engineers; U.S. Forest Service
Study Lead:	U.S. Army Corps of Engineers
Authors and Source:	Cardwell, H., Faber, B. and Spading, K. (2004). Collaborative models for planning in the Mississippi headwaters. Paper presented at the meeting of the World Water and Environmental Resources Congress, Salt Lake City, UT.

35.1 Purpose of the Study

This paper was written to report on on-going U.S. Army Corps of Engineers water-resources planning study where the SVP process was applied. This study is reported to have supported the long-range reservoir operating plan for the Mississippi River Headwaters reservoirs. The overall purpose of the reservoir operating plan is reported to have been the improvement of system-wide operations of the Mississippi Headwaters reservoirs for multiple uses. The paper lays out the evolution of water-resources planning approaches from the era of closed participation to the modern era of two-way communication between stakeholder/public and technical experts. According to the paper, this two-way communication involves all major stakeholders from the beginning to the end through informal deliberation and representation of all interests.

35.2 Model Use

The study adopted a SD modeling approach to support a SVP process. The planning process is reported to combine two object-oriented programming models, the HEC-PRM optimization model and a simulation model built in STELLA software. The optimization model is reported to have identified an optimal set of releases from the reservoirs from which reservoir operating rules were inferred. The simulation model is reported to have tested the potential operating rules and integrated the effects of hydrologic parameters on other factors such as the ecology, flood damage and tribal trust resources.

35.3 Involvement and Collaboration

Leadership of the shared vision process is reported to have been with the local planners. Involvement was in the form of working groups that interacted to exchange information. Stakeholders identified in the report included the U.S. Army Corps of Engineers; non-Federal dam operators in the headwaters areas; regional groups such as the Mississippi Headwaters Board and the Mille Lacs Lake and Leech Lake Band of Ojibwe; the U.S. Fish and Wildlife Service; Minnesota Pollution Control Agency; and members of the public. Workshops, newsletters and advisory committees were all used to collaboratively involve stakeholders.

35.4 Outcome

A shared vision model was developed to support the long-range reservoir operating plan for the Mississippi River Headwaters reservoirs. The SVP approach adopted in the this study is reported to have had some unique aspects compared to previous SVP applications in that (1) A committed, local project team is took the lead, both in the modeling and the interface between the technical models and the working groups; and (2) an optimization model was used to help identify new operating plans and was then linked to a simulation model. This approach is reported to have lowered the degree of contentiousness in the process and was hoped that this would increase the chances of a successful negotiated plan.

36 A System Dynamics Model to Facilitate Public Understanding of Water-Management Options in Las Vegas

System/Study Area Name:	Las Vegas, Nevada
Study Type:	Water resource planning and management; water conservation
Analysis/Model Type:	SD; simulation modeling; Vensim PLE software
Stakeholders Identified:	U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, local landowners and environmentalists and several disciplines within the academic community
Level of Participation:	Stakeholders were not directly involved in developing the model. They participated is workshops using the finished model
Conflict Type:	Conflicting water-management options
Was Problem Solved:	Model results were used in making decisions about management options
International or U.S.:	U.S.; not trans-boundary
Sponsoring Agency:	U.S. Bureau of Reclamation
Study Lead:	Department of Environmental Studies, University of Nevada
Authors and Source:	Stave, K.A. (2003). A system dynamics model to facilitate public understanding of water management options in Las Vegas, Nevada. J. of Environ Mgt 67: 303-313.

36.1 Purpose of the Study

With current expectations for public involvement and support for resource management strategies, this paper notes that water manger are increasingly faced with the challenge of having to build public or stakeholder support for water-management options. The paper uses a case study from the Las Vegas, Nevada area to evaluate the potential of using system dynamic modeling to facilitate public awareness and education efforts in the Las Vegas area. The paper suggests a six-step approach to using a system dynamic model for public communication:

- Define the problem
- Describe the system
- Develop the model
- Build confidence in the model
- Use the model for policy analysis
- Use the model for public outreach

The problem faced in the Las Vegas was how to extend the point at which water demand exceeds supply further into the future. A model of the relationship between supply and demand in the Las Vegas water system was developed and used to support efforts to increase public understanding of the value of water conservation and the effects of other management options on water supply and demand in Las Vegas.

36.2 Model Use

The study uses a systems dynamic model created in Vensim PLE software to show the relationship between supply and demand in the Las Vegas water system. The supply side of the model is described to consist of the physical flows of water, while the demand side of the system is described to focus on the water-using population and distribution of water use across water-use sectors.

36.3 Involvement and Collaboration

This study is described to have involved stakeholders at the least participatory level. Steps one through six of the model development process were generally performed with little involvement of stakeholders. The authors note that though involving stakeholders has its benefits, the completed model build without the involvement of stakeholders was still an effective tool in terms public outreach. The completed model is described to have been used in three pilot workshops and seven research workshops to test the effectiveness of using a completed system dynamic model for engaging stakeholders in discussion about management options. Eighty-three local community members were recruited to participate in iterative workshop forums.

36.4 Outcome

Following the workshops, several management alternatives are reported to have prevailed from participant suggestions:

- Increase supply
- Make hotels/casinos conserve.
- Reduce residential indoor water use
- Reduce residential outdoor water use
- Decrease population (or slow growth)
- Combination strategies

Each of the alternatives were simulated to test their impact on supply and demand. Each of the alternatives except for reducing indoor water use, are reported to have moved the point at which demand exceeds supply beyond 2025.

The study is described to have demonstrated several benefits of SD for public communication about resource management. Benefits are described to include providing a iterative simulation model that allows stakeholders to participate in the evaluation of policies and stimulating discussions among participants that can help build consensus and support resource managers need.

37 Supporting Effective Participation in the Climate Change Debate: The Role of System Dynamics Simulation Modeling

System/Study Area Name:	Global climate change
Study Type:	Global warming and climate change
Analysis/Model Type:	SD modeling is recommended
Stakeholders Identified:	A full range of scientific, government and citizen stakeholders groups are recommended
Level of Participation:	No stakeholder participation for the report but their direct involvement is recommended in developing the model
Conflict Type:	What to do about global warming
Was Problem Solved:	No
International or U.S.:	International; with trans-boundary issues
Sponsoring Agency:	Sustainability Institute
Study Lead:	Sustainability Institute
Authors and Source:	Jones, D. and Seville, D. (2002). Supporting effective participation in the climate change debate: The role of system dynamics simulation modeling. Sustainability Institute. Retrieved September 2006 from: http://www.sustainer.org/pubs/siclimate.PDF#search=%22Supporting%20effective%20participation%20in%20the%20climate%20change%20debate%3A%20%20The%20role%20of%20system%20dynamics%20simulation%20modeling%22

37.1 Purpose of the Study

This paper provides a discussion on the reasons why many people as individuals and as a collective choose the "no action" alternative in dealing with global warming and climate change when is widely acknowledged that global warming and climate change is taking place. The paper suggests through anecdotal evidence that most people in the U.S. do not believe that the scientist's conclusions necessitate much serious preventative action. The paper hypothesis that the reason for this is flawed individual mental models that are based on misconstrued understanding of a complex system. The authors believe that SD can help foster a learning experience for people to better asses the need for and adequacy of proposed solutions. This paper was written to provide an outline of what was believed would be required to help create a more informed debate on climate change from an SD perspective.

37.2 Model Use

The study does not use a model but recommends the use of participatory dynamic modeling to simulate the effects of green house gasses and other relevant variables on the climate. The recommended model is described to be one that is designed with a focus on inquiry-driven learning with attributes including: transparency, interactivity, attractiveness and a focus on causal thinking. The paper recommends a simplified climate-economy system dynamic model as a starting point. The suggested purpose of such a model would be to provide a learning model to improve a user's understanding of the system.

37.3 Involvement and Collaboration

No stakeholder participation or collaboration was involved for the paper. However, the paper's recommended application of SD to the climate change learning exercise would involve a collaborative learning process.

37.4 Outcome

The paper provided an outline for future application of SD to a study to build consensus among various stakeholder groups on the likely impact of climate change and the role of human intervention.

38 Participatory Natural Resource Management: A Comparison of Four Case Studies

System/Study Area Name:	Four case study project locations: Zurich, Switzerland, Europe; Mahuwe, Zimbabwe; Ngnith, Senegal; and Mae Chaem river catchment, Thailand
Study Type:	Natural resource management
Analysis/Model Type:	Participatory processes
Stakeholders Identified:	diverse range of stakeholders are described
Level of Participation:	Participation was at various levels depending on study objectives and process direction
Conflict Type:	Conflicting resource management options
Was Problem Solved:	no
International or U.S.:	International; not trans-boundary
Sponsoring Agency:	Not mentioned
Study Lead:	Swiss Federal Institute of Environmental Science and Technology (EAWAG); Integrated Catchment Assessment and Management Centre and Centre for Resource and Environmental Studies, The Australian National University
Authors and Source:	Hare, M., Letcher, R.A., et al. (2003). Participatory natural resources Management: A Comparison of Four Case Studies. Integrated Assessment, 4(2), 62-72. http://www.iemss.org/iemss2002/proceedings/pdf/volume%20tre/435_hare.pdf#search=%22Participatory%20modelling%20in%20natural%20resources%20Management%3A%20%20A%20Comparison%20of%20Four%20Case%20Studies%22

38.1 Purpose of the Study

The purpose of this study was to compare four case studies in the context of their participatory processes. The goal was to compare how each study differed in terms of the participatory process structure and the driving forces behind the selection of stakeholders and their involvement in the management of projects. The four projects analyzed were in Zurich, Switzerland, Europe; Mahuwe, Zimbabwe; Ngnith, Senegal; and Mae Chaem river catchment, Thailand. The projects are categorized based on some key criteria (1) the process goal, (2) participation goal, (3) adaptive management stages, (4) scales of action, (5) stakeholder numbers, (6) process direction, (7) power structure; and (8) scale of action mismatch. Each of these criteria are discussed to highlight their significance in a participatory process. The concept of project mismatch is introduced to illustrate how this can influence the potential to succeed in achieving the very objectives for using the participatory process.

38.2 Model Use

This paper compares four case studies in which the use of models is referenced as supporting the participatory processes. Not all models were computer models. The term model is used loosely to include simulation models and spidergrams drawn on paper. However, no details are provided about the models.

38.3 Involvement and Collaboration

The four case studies referenced used participatory processes. Two of the studies are described to adopted a top-down approach, while the other two used a bottom-up approach in the participatory process. A diverse range of stakeholders are described, ranging from utility representatives in Europe to local villagers in Africa. Participation was at various levels depending on study objectives and process direction.

38.4 Outcome

The study was able to work backwards from the case studies to analyze how participation is implemented in the field to provide insights into the design of future processes. Four drivers of the participatory process design were identified from the comparison: process goals, power structures, process direction and stakeholder numbers. Various other observations were made about participatory processes in natural resources management.

39 Scientist–Stakeholder Collaboration in Integrated Assessment of Climate Change: Lessons From a Case Study of Northwest Canada

System/Study Area Name:	The Mackenzie River basin of Northwest Canada
Study Type:	Climate change impacts; Environmental assessment
Analysis/Model Type:	Environmental modeling and integrated assessment
Stakeholders Identified:	Collaborative research effort involving scientists and stakeholders from governments, universities, aboriginal organizations and the private sector
Level of Participation:	Stakeholders were involved through all stages of the process
Conflict Type:	Not applicable
Was Problem Solved:	Partially
International or U.S.:	International - Canada; Some trans-boundary issues
Sponsoring Agency:	Environment Canada
Study Lead:	Environmental Adaptation Research Group, Environment Canada; Sustainable Development Research Institute, University of British Columbia
Authors and Source:	Cohen, S.J. (1997). Scientist-stakeholder collaboration in integrated assessment of climate change: lessons from a case study of Northwest Canada. Environmental Modeling and Assessment, 2(4), 281-293. Abstract retrieved August 2006, from http://www.sp

39.1 Purpose of the Study

This paper reports that most research on climate change has generally focused on the uncertainties in climate projection and calculation of mitigation factors. It argues that not enough focus has been given to the potential effects on ecosystems, resources and societies that depend on them. The paper suggests that regional effects a likely to be unique in each region and country and argues that integrated assessment (IA) studies should factor in these potential regional effects.

The paper proposes the use of a scientists-stakeholder collaborative approach as a framework for producing an IA of climate change impacts for regions or countries. Perspectives from a study in the Mackenzie River basin of Northwest Canada are used to illustrate how integrated assessment (IA) exercises can be used to combine models with sectoral analyses and stakeholder participation to provide a more holistic approach climate change assessment.

39.2 Model Use

This paper recommends adopting an IA approach that uses both modeling and non-modeling approaches. An integrated assessment multi-objective model was used to support a broader climate change assessment for the Mackenzie River basin. Other climate change assessment studies included the “resources accounting with input-output modeling and community survey” study and “land assessment framework” study. Details of the individual studies and modeling efforts are not provided in the paper. The river basin study’s final report is referenced for more details.

39.3 Involvement and Collaboration

The approach presented in this study includes stakeholder participation in the formation of research questions, the generation of new information and the discussion of results and recommendations.

39.4 Outcome

Several conclusions are drawn from the Mackenzie River basin study. Among them the paper concludes that,

- a collaborative integrated assessment effort, with stakeholder input, is an approach that can bring a complex issue to the level of the decision makers;
- integrated assessment should not constrain itself exclusively to the development of integrated assessment models;
- an integrated assessment requires a partnership of stakeholders and scientists, operating at regional and global scaled, in which visions are shared and respected and information is freely exchanged.

In concluding, this paper provides a broadened approach to conducting integrated assessments and suggests ways of addressing regional and effects of climate change. This approach makes a distinction between integrated assessment and integrated assessment modeling. The earlier concept incorporates integrated assessment modeling and other non-modeling approaches to assessing climate change.

40 A Modeling Shell for Participatory Assessment and Management of Natural Resources

System/Study Area Name:	Not applicable
Study Type:	Environmental Management; Software development
Analysis/Model Type:	Natural resources modeling; Catchment Simulation Shell
Stakeholders Identified:	Not applicable
Level of Participation:	Not applicable
Conflict Type:	Not applicable
Was Problem Solved:	Not applicable
International or U.S.:	International - Australia; not trans-boundary
Sponsoring Agency:	Land and Water Australia
Study Lead:	Centre for Environmental Applied Hydrology and Cooperative Research Centre for Catchment Hydrology, The University of Melbourne, Australia
Authors and Source:	Argent, R.M. and Grayson, R.B. (2003). A modeling shell for participatory assessment and management or natural resources. Environmental Software and Modeling, 18(6), 541-551.

40.1 Purpose of the Study

This paper provides a discussion of a modeling shell for participatory assessment and management of natural resources. This software is reported to have been in existences in one form or another for several years. The version discussed at the time of reporting was intended to upgrade the application so as to incorporate new features made possible in advances in computer technology and programming languages.

According to this paper, recent requirements for more open and inclusive management processes and the increasing popularity of participatory modeling processes led to the re-development of a software called Catchment Simulation Shell, which was to be available to the general public for free.

40.2 Model Use

Case study applications of the Catchment Simulation Shell are discussed in general terms but no specific details a provided. The Catchment Simulation Shell was designed based on the Adaptive Environmental Assessment and Management (AEAM) process and was developed in its current form to be a generic application for use in various natural resources studies. The version discussed in the paper was designed using Visual Basic and was designed to support participatory process in natural resources management. an object-oriented methodology is reported to have been used in the new version and included three separate conceptual levels: the graphical user interface, data storage and data control level. Further details of the software and components are described in the paper.

40.3 Involvement and Collaboration

The Catchment Simulation Shell was designed to support participatory process in natural resources management but this was not the subject of the paper reviewed.

40.4 Outcome

A decision-support tool called the Catchment Simulation Shell was developed to support participatory process in natural resources management. The paper outlined the advantages and limitations of the tool as well as identified where improvements could be made.

41 Participatory Modeling and the Dilemma of Diffuse Nitrogen Management in a Residential Watershed

System/Study Area Name:	Solomons Harbor watershed, Calvert County, Maryland
Study Type:	Water-quality management; spatial modeling
Analysis/Model Type:	Participatory modeling; water-quality management
Stakeholders Identified:	A range of stakeholders
Level of Participation:	Stakeholders only assisted by providing information
Conflict Type:	Not applicable
Was Problem Solved:	Model results were used in making decisions about management options
International or U.S.:	U.S.; not trans-boundary
Sponsoring Agency:	NOAA and University of Vermont
Study Lead:	Gund Institute for Ecological Economics, University of Vermont
Authors and Source:	Brown Gaddis, E.J., Vladich, H. and Voinov, A. (2006). Participatory modeling and the dilemma of diffuse nitrogen management in a residential watershed. Environmental Modeling and Software.

41.1 Purpose of the Study

This paper reports on a study that applied participatory modeling to an environmental management problem. The focus of this study is on non-point pollution of water in Calvert County Maryland. Despite society having a good handle on direct pollutants, non-point source pollutants are explained to remain a problem. Nitrogen from three sources: septic tanks, atmosphere deposition and fertilizer were suspected to be significant contributors to non-point pollution. This study used participatory modeling as a way to identify the sources and transportation of nitrogen in the Solomons Harbor watershed in Calvert County Maryland.

41.2 Model Use

Two models are used in the study. A dynamic model was developed using STELLA software to represent the septic tank and leachfield system. A landscape model called the Landscape Modeling Framework (LMF) was used to estimate the relative impacts as different nutrient sources on waters throughout the watershed.

41.3 Involvement and Collaboration

Though stakeholders and residents in the Solomons Harbor Community are reported to have been engaged in the research process, the report indicates that the study did not include a stakeholders process for building a model. Instead, stakeholders assisted by providing some information that were used to make assumptions about the watershed system. The finished model was presented to stakeholders. To engage residents, a series of community stakeholders meetings were organized. Participants at the meeting included concerned citizens, government agencies and other interested stakeholders.

41.4 Outcome

The paper reports the successful accomplishments of all study goals, including successfully determining the most important causes of nitrogen loading to the harbor. Policy recommendations reflecting study findings were provided to the county commissioner.

42 Using System Dynamics to Improve Public Participation in Environmental Decisions

System/Study Area Name:	Las Vegas, Nevada
Study Type:	Environmental management
Analysis/Model Type:	SD modeling; Vensim software
Stakeholders Identified:	Scientists and Regional Transportation Commission of Southern Nevada (RTC) representatives
Level of Participation:	A small working group developed the model which was then presented to the full group
Conflict Type:	Conflicting management alternatives
Was Problem Solved:	model results were used in making decisions about management options
International or U.S.:	U.S.; not trans-boundary
Sponsoring Agency:	Regional Transportation Commission of Southern Nevada (RTC)
Study Lead:	University of Nevada
Authors and Source:	Stave, K.A. (2002). Using SD to improve public participation in environmental decisions. System Dynamics Review, 18(2), 139-167. http://www.iap2nv.org/Documents/Stave%20SDR%202003%20RTC3%20model.pdf#search=%22Using%20system%20dynamics%20to%20improve%20public%20participation%20in%20environmental%20decisions%22

42.1 Purpose of the Study

This paper outlines the importance of public involvement in environmental decision-making processes and reports on a study whose objective was to develop environmental policy recommendations. The problem at stake was the rapidly worsening and interconnected problems of traffic congestion and regional air quality in the Las Vegas, Nevada metropolitan area.

Recognizing the importance of public involvement, a stakeholder advisory group was formed to look into this problem using an applied system dynamic approach to improve public involvement. SD is described to offer a consistent and rigorous problem solving framework for identifying the scope of the problem, eliciting participant views about the probable causes and system connections and identifying policy levels.

42.2 Model Use

A system dynamic modeling approach was adopted for the study. The goal was to develop a model that would help better understand the system and dynamics and to provide a framework for comparing management options. The model is reported to have been developed using Vensim software. The model developed is described to treat the Las Vegas metropolitan area as a whole system and calculates effects on an annual basis. Three key reference modes are described: the rising system-wide traffic congestion noted and projected, decreasing traffic flow and increasing frequency with which carbon monoxide emissions exceed the region's federally determined carbon monoxide budget.

42.3 Involvement and Collaboration

An SD approach was used as a way of improving public participation. The use of an SD approach is reported to have been endorsed by the Regional Transportation Commission of Southern Nevada (RTC) and had the full support of the transportation agency's staff. A small working group that included RTC members was formed and this group engaged in group model building. The finished model was then presented to all RTC members.

42.4 Outcome

The exercise is described to have successfully involved stakeholders and helped the advisory group develop a collective definition of the problem, identify the most critical criteria for determining good solutions and evaluate policy scenarios among other successful achievements.

43 Computer-Assisted Negotiations of Water-Resources Conflicts

System/Study Area Name:	Not applicable
Study Type:	Water-resource planning and management
Analysis/Model Type:	Mediated modeling; multi phase modeling approach; POWERSIM software
Stakeholders Identified:	None
Level of Participation:	Not applicable
Conflict Type:	Not applicable
Was Problem Solved:	Not applicable
International or U.S.:	U.S.; not trans-boundary
Sponsoring Agency:	Not specified
Study Lead:	One Accord Technologies; School of Civil and Environmental Engineering, Cornell University
Authors and Source:	Theissen, E.M. and Loucks, D.P. (1992). Computer assisted negotiation of multi objective water-resources conflicts. Water Resources Bulletin, 28(1), 163-177.

43.1 Purpose of the Study

This paper discusses a negotiation support system called Interactive Computer-Assisted Negotiation Support System (ICANS). The system is described to have been designed to assist those involved in negotiating agreements among conflicting parties. ICANS is generally designed from a negotiator's perspective. At the time of reporting, this system was still in the development phase. This paper provides a description of algorithms used for analyzing preferences and generating alternative feasible agreements.

43.2 Model Use

The paper is dedicated to ICANS algorithms.

43.3 Involvement and Collaboration

No public or stakeholder participation is discussed.

43.4 Outcome

ICANS has the potential to assist in negotiations. ICANS is described to have been developed negotiations. The conclusion to the report suggests that programs like ICANS can help negotiators find agreements which stakeholders in conflict and could judge superior to agreements they may have reached without the use of computer assistance.

44 Application of AEAM (Adaptive Environmental Assessment and Management) to Water Quality in the Latrobe River Catchment

System/Study Area Name:	Latrobe River Catchment in Victoria, Australia
Study Type:	Water-quality planning and management
Analysis/Model Type:	Adaptive Environmental Assessment and Management; QuickBASIC
Stakeholders Identified:	A Diverse range of stakeholders from government agencies and the general public
Level of Participation:	Stakeholders were involved at all stages of the process
Conflict Type:	Not applicable
Was Problem Solved:	A model was successfully developed in phase1; Phase 2 was to use the model to further evaluate scenarios and make decisions about management options
International or U.S.:	International – Australia; not trans-boundary
Sponsoring Agency:	Gippsland Lakes Implementation Council; AMCOR; The Department of Water Resources; Environmental Protection Authority; and the Land and Water Resources Research and Development Corporation
Study Lead:	University of Melbourne
Authors and Source:	Grayson, R.B., Doolan, J.M. and Blake, T. (1994). Application of AEAM (Adaptive Environmental Assessment and Management) to Water Quality in the Latrobe River Catchment. Journal of Environmental Management, 41(3), 245-258.

44.1 Purpose of the Study

This study applied the Adaptive Environmental Assessment and Management (AEAM) process to a water-quality management problem in the Latrobe River Catchment in Victoria, Australia. AEAM is defined as a process for the development and exploration of management options for complex systems. Water-quality problems included high turbidity, high nutrient loads, river bank instability, algae blooms and poor aquatic and riparian conditions.

44.2 Model Use

The application of the AEAM process for the Latrobe River Catchment included the development of a computer model to simulate the system. The model was developed in QuickBASIC and is reported to have been based on previous AEAM models applications. Submodels were developed for hydrologic, water quality, ecological and economic components. Variables simulated include total suspended solids, total P, salts, macroinvertebrates and fish habitats.

44.3 Involvement and Collaboration

Workshops were used to collect information required and to develop the model. Participants at the workshops are reported to have a diverse range of skills and included water resources and environmental planners, limnologists, geomorphologists, hydrologists, waterway and wastewater engineers, hydrochemists, agronomists, foresters and land managers. A total of forty people are reported to have been involved. The workshops were designed with the following objectives:

- Definition of model scope
- Formation of the modeling subgroups
- Development of submodels
- Development of the integrated model
- Gaming
- On-going development

44.4 Outcome

An integrated water quality model for the Latrobe River Catchment in Victoria, Australia was collaboratively developed following the AEAM process and multiple stakeholders. This is reported to have been a useful education tool that could be used to present technical information in a simple way. Additionally, achievable management actions and indicators to assess them were identified.

45 Evaluating a Framework for Multi-Stakeholder Decision Support in Water-Resources Management

System/Study Area Name:	Tested in the lake-river system in Finland (lakes (Päijänne, Konnivesi and Ruotsalainen and the Kymijoki River)
Study Type:	Water-resource planning and management
Analysis/Model Type:	Multi-criteria decision modeling; negotiation support
Stakeholders Identified:	Various interest groups were identified for the lake-river system study
Level of Participation:	This paper mainly discusses group meeting dynamics using students in experiments
Conflict Type:	Not applicable
Was Problem Solved:	Was an ongoing study
International or U.S.:	International - Finland; not trans-boundary
Sponsoring Agency:	Academy of Finland; Emil Aaltonen Foundation
Study Lead:	Systems Analysis Laboratory, Helsinki University of Technology; Finnish Environment Institute
Authors and Source:	Hamalainen, R., Kettunen, E., Marttunen, M. and Ehtamo, H. (2001). Evaluating a framework for multi-stakeholder decision support in water resources management. Group Decision and Negotiation, 10(4), 331-353.

45.1 Purpose of the Study

The paper reports on the evaluation and testing of various multi-criteria decision-making group decision-support tools and their relevance to decision support in water-resources management. A framework for supporting multiple criteria group decision making in water-resources management is presented and discussed. The general framework consists of four main stages:

- Framing, structuring and learning the problem
- Identifying Pareto-optimal alternatives
- Seeking group consensus
- Seeking public acceptance

The applicability of various multi-criteria decision-support tools and procedures is discussed with an emphasis on those with strong interactive participation. Role playing experiments conducted using students as a means of testing methods and procedures prior to involving actual stakeholders. A water-level management problem in the lake-river system in Finland is used as the test study. This system includes three main lakes (Päijänne, Konnivesi and Ruotsalainen) and the Kymijoki River.

45.2 Model Use

Various models are discussed in this paper in terms of applicability to the problem being addressed. The paper advocates the testing of procedures, methods and tools in order to select the most appropriate one for a particular study. For the lake-river system analyzed, software called the ISMO (Interactive analysis of dynamic water-regulation strategies by multi-criteria optimization) was used. This software application is reported to generate feasible alternatives for the regulation policy. However no details are provided in this report.

45.3 Involvement and Collaboration

The framework discussed in the paper was developed to support stakeholder participation and interaction. However, paper only discusses methodological experimentations and testing with students rather than with real stakeholders. Background discussion about the lake-river system study in Finland indicates that there was active involvement and collaboration with stakeholders through the policy and planning process.

45.4 Outcome

Following testing and experimentation, the framework for modeling and supporting multi-stakeholder, multi-criteria decision processes was determined to offer a platform for an evolving group decision setting. Some decision-support tools used during experimentation were found not suitable for supporting multi-stakeholder, multi-criteria decision processes.

46 A Consensus-Based Simulation Model for Management in the Patagonia Coastal Zone

System/Study Area Name:	The Patagonia Coastal Zone, Argentina
Study Type:	Coastal Zone Management
Analysis/Model Type:	Individual Mathematical Models
Stakeholders Identified:	Argentine government officials, , provincial officials, non-governmental officials, commercial sector representatives
Level of Participation:	stakeholders were directly involved as participants in the modeling process through all three stages
Conflict Type:	Not applicable
Was Problem Solved:	model results were used in making decisions about management options
International or U.S.:	International, Argentina
Sponsoring Agency:	UNDP/GEF
Study Lead:	Fundacion Patagonia Natural
Authors and Source:	Van den Belt, M., Deutsch, L. and Jansson, A. (1998). A consensus-based simulation model for management ion the Patagonia coastal zone. Ecological Modeling, 110, 79-103.

46.1 Purpose of the Study

The study was intended to integrate economic and ecological data of a coastal system into a model. By integrating these two types of data, important linkages could be determined. The model was intended to assist in the development of the Patagonia Coastal Zone Management Plan.

46.2 Model Use

A user friendly model was developed with which the user can change parameters and simulate a broad range of scenarios. The model consisted of a set of mathematical relationships. As an example the penguin population was estimated with the model based upon the level of oil drilling and fishing. The model then estimated tourism revenue based in part upon the penguin population.

The economic data from the fisheries, tourism and oil industry sectors was provided by the Fundacion Patagonia Natural. Macroeconomic data was gathered from official government agencies. Contingent valuation was used to establish willingness-to-pay for some ecological services Growth rates for the tourism and ecotourism industries were estimated through surveys of businesses in those industries.

The model was set for 1980 to 2020 and was calibrated with historical data. The net present value (NPV) of benefits for fisheries and tourism were estimated by the model. The benefits of the oil industry were not included in the model, but the impact of the oil industry to the fisheries and tourism industries were included in the model.

46.3 Involvement and Collaboration

Some stakeholders were involved in the development of the model. The stakeholders consisted of Argentine government officials, non-government officials and people in the commercial sector. The report does not describe in detail the roles of the stakeholders or he industries they represented.

46.4 Outcome

The model indicated that an increase in present anchovy fishing levels would increase total revenues. This version of the model helped to clarify interlinkages between different sectors. Discussions between stakeholders which occurred during development of the model contributed to a better understanding of the complexity of the Patagonia Coastal Zone.

47 Application of an Adaptive Method for Integrated Assessment of Water-Allocation Issues in the Namoi River Catchment, Austrailia

System/Study Area Name:	Namoi River Catchment, Australia
Study Type:	Water-resource planning
Analysis/Model Type:	Individual Models
Stakeholders Identified:	Corps of Engineers, U.S. Fish and Wildlife Service, local landowners and environmentalists and several disciplines within the academic community
Level of Participation:	Integrated Assessment Modeling
Conflict Type:	Not applicable
Was Problem Solved:	model results were used in making decisions about management options
International or U.S.:	International, Australia
Sponsoring Agency:	The Australian National University
Study Lead:	Integrated Catchment Assessment and Management Center
Authors and Source:	Letcher, R.A., Jakeman, A.J, (2003) Application of an Adaptive Management for Integrated Assessment of Water Allocation Issues in the Namoi River Catchment, Australia, Integrated Assessment.

47.1 Purpose of the Study

The report describes the use of integrated assessment (IA) for resource management of a river catchment area. The model is developed through an adaptive process with frequent interaction between stakeholders and modelers. The model was intended to help determine the best use of off-allocation water and groundwater. In Australia, off-allocation water is the term used to describe water above minimum river flow which in the case of the Namoi River is provided to water users at the discretion New South Wales Department of Land and Water-Conservation.

47.2 Model Use

The model was developed through an iterative process and integrated economics and hydrology. Several models were developed; including the Regional Agricultural Production Model, which is an economic model based upon profit maximizing agricultural production considering land and water constraints.

A hydrologic model was developed that estimated the impact of water use in one sub-basin upon another sub-basin. However, this hydrologic model did not consider the interaction of surface water and groundwater.

47.3 Involvement and Collaboration

Stakeholders consisted of local community members, staff at the various departmental offices and members of the various River Management Committees operating in the catchment. Committees were formed for Unregulated Water, Regulated water and groundwater.

The process of model development was open and transparent to users, including individual farmers. This transparency was important to building trust. Even with transparency, long timeframes are needed for stakeholders to develop confidence in models.

47.4 Outcome

The model clarified the impacts of changes in water allocation. The IA process is inappropriate for simple or small problems because of the cost of IA research. It is more appropriate for large problems with a long timeframe. The limitations of any model need to be understood by stakeholder, which is accomplished by close communication between stakeholders and modelers.

48 ICT Tools to Support Public Participation in Water-Resources Governance and Planning: Experiences Fom the Design and Testing of a Multi-Media Platform

System/Study Area Name:	Herault River Basin, southern France
Study Type:	Water-resource planning
Analysis/Model Type:	Mediated modeling
Stakeholders Identified:	Europe
Level of Participation:	stakeholders were directly involved as participants in the modeling process through all three stages
Conflict Type:	None
Was Problem Solved:	model results were used in making decisions about management options
International or U.S.:	International, France
Sponsoring Agency:	European Commission
Study Lead:	European Commission
Authors and Source:	Pereira, A.G., Rinaudo, J., Jeffrey, P., Blasques, J., Quintana, S.C., Courtois, N., Funtowicz, S. and Petit, V. (2003) ICT Tools to Support Public Participation in Water Resources Governance and Planning: Experiences from the Design and Testing of a Multi-Media Platform, Journal of Environmental Assessment Policy and Management

48.1 Purpose of the Study

Demonstrate the use of Information and Communication Technology (ICT) based tools to improve dialogue between stakeholders and increase public participation in the decision-making process.

Under the Water Framework Directive (WFD) of the European Union, six year River Basin Management Plans are to be developed by 2015. As explained in the report, the European Union has been shifting from informing the public of the decision-making process for resource management towards allowing public participation in the decision-making process. The

48.2 Model Use

Models were not reviewed in this report as they are not considered appropriate for participatory water planning. Tools to Inform Debates, Dialogues and Deliberations. (TIDDD) is a system developed by the European Union to help with implementation of the Water Framework Directive.

Novel Approach to Imprecise Assessment and Decisions Environments (NAIDE) is a discrete multi-criteria method which features mixed information types. NAIDE provides a ranking of alternatives based upon decision criteria and another ranking of alternatives based upon acceptability to stakeholders.

Technological tools, such as multi-media presentations, are used to transfer technical information to non-specialists who are participating in developing the plan for a complex river basin. The intention was to improve governance of the river basin, not specifically to resolve a conflict.

48.3 Involvement and Collaboration

Interviews were conducted with various categories of water users, agricultural, industrial and drinking water users

48.4 Outcome

Decision-Support Systems were not considered appropriate for this study. Rather this study was based upon the use of TIDDD to provide a rational basis for the appraisal of actions and projects. TIDDD was intended to provide an process to in include all stakeholders and improve dialogue. ICT is not exclusionary

49 Managing Water for Drought (National Drought Study Report NDS-8) September 1994

System/Study Area Name:	American water management; Washington, Kansas-Missouri, West Virginia, Virginia, Colorado basin (seven states), Massachusetts
Study Type:	How to manual on SVP for drought
Analysis/Model Type:	Systems dynamics; Stella
Stakeholders Identified:	Broad range in five case studies
Level of Participation:	Circles of influence method, varying directness
Conflict Type:	Planning allocation of water during drought
Was Problem Solved:	In two of six case studies
International or U.S.:	U.S. (two interstate conflicts)
Sponsoring Agency:	U.S. Army Corps of Engineers
Study Lead:	U.S. Army Corps of Engineers
Authors and Source:	Werick, W.J. and Whipple, Jr., W. http://www.iwr.usace.army.mil/inside/products/pub/iwrreports/94nds8.pdf

49.1 Purpose of the Study

This manual of practice came at the end of the National Study of Water Management During Drought, a five year effort led by the U.S. Army Corps of Engineers' Institute for Water Resources in Alexandria, Virginia. The study was authorized by Congress after the Droughts of 1988 stranded barges on the Mississippi, inflamed water wars in the southeast and drained reservoirs across the west. The manual focuses on drought but introduces the SVP method before it had that name; here it is called "Drought Preparedness Study (DPS) Method" after the case studies where it was first applied, tested and improved.

The first chapter is about drought, the remaining chapters describe the SVP or DPS method. One chapter is used for each step. A "DPS Planning Process Checklist" describes how the steps might be iterated through time in a study. Fourteen annexes briefly summarize information in several fields related to drought: the history of water-resources planning rules, politics and water management, computer modeling, water law, environmental and economic evaluations, hydrology, alternative dispute resolution, the history of public involvement, Circles of Influence public involvement, water-use forecasting, lessons learned from the California droughts of 1987-1992, the National Drought Atlas and summaries of five case studies (Cedar-Green Rivers (Washington), Marais des Cygnes-Osage (Kansas-Missouri), Kanawha River (West Virginia), James River (Virginia) and Boston, Massachusetts. Material contained in the annexes was provided by Hanna Cortner, Allison Keyes, Charles Lancaster, Merle Lefkoff, William Lord, Richard Palmer, Van Dyke Polhemus, Robert Waldman, Gene Willeke and Charles Yoe.

49.2 Model Use

STELLA® software is described in the manual and used in all five case studies and the Colorado River gaming exercise.

49.3 Involvement and Collaboration

The intent was to test the DPS method by applying it as uniformly as possible in a variety of water-resources situations, including riparian, appropriation and mixed legal systems of water-use rights. Stakeholder representatives were closest to the model building in the Green River (Tacoma, Washington's water supply) and Boston. There was resistance to involvement in the Cedar River (Seattle, Washington's water supply) and James River (where two difficult water-supply permit actions, for Newport News and Virginia Beach, Virginia were being contested). Stakeholders in the Kanawha River case study had a high early level of involvement (for instance, recreational rafting vendors helping build the STELLA functions) but later relied on a trusted Corps of Engineers hydrologist, Dr. Richard Punnett, to develop the model. On the Marais des Cygnes-Osage River Case Study, state officials were involved in the modeling study, but end users were not.

49.4 Outcome

The Kanawha River study led to new operating rules for the Corps of Engineers reservoirs. Stakeholders estimated the rules would save about ten million dollars in recreation revenue during the next severe drought while improving water quality. Study participants agreed that negotiations on a refill strategy for the reservoir on the Green River were shortened substantially because there was greater confidence in modeled levels and flows. The Marais des Cygnes-Osage study helped build trust in a Kansas water policy that was developed outside the Drought Preparedness Study. The Boston case study was collaborative and technically sound, but was a smaller study that was not focused on (and did not solve) any specific problem. The James River study was a failure because of the quality of the planning and modeling effort and because some principal stakeholders saw collaboration as contrary to their interests. The Colorado River Gaming Exercise was an academic comparison of three approaches to allocating water (decisions made by central authority, a basin commission and in a market). The basin commission approach worked best. In this experiment, markets tended to protect consumptive uses more than non-consumptive uses.

50 When Should Shared Vision Planning Be Used? July 2004

System/Study Area Name:	Not a case study
Study Type:	Lessons learned about when SVP is more likely to help
Analysis/Model Type:	Not applicable
Stakeholders Identified:	Not applicable
Level of Participation:	Not applicable
Conflict Type:	Not applicable
Was Problem Solved:	Not applicable
International or U.S.:	Not applicable
Sponsoring Agency:	Not applicable
Study Lead:	Not applicable
Authors and Source:	Werick, W.J. and Palmer, R.N. Consider putting on IWR website since it was not published (ASCE oversight)

50.1 Purpose of the Study

The paper is designed for water managers and others who are considering whether or not to use SVP. The authors conclude, based on review of the successes and failures of SVP after a decade of use, that "SVP is a legitimate option almost any time planning is appropriate" but also write that planning will not be effective if a decision maker or major stakeholder believes they can achieve a better outcome through some other route such as lobbying, adjudicating or stonewalling to preserve the status quo. The authors propose that people considering SVP answer five triage questions, educate themselves on the political dimension of the issues they are working on, consider how they would pursue their interests if they were the stakeholder and then decide whether planning should begin or continue. The authors write that the body of experts and expertise developed to plan large Federal water projects has generally not been applied to permitting, reallocation and re-regulation studies and local and regional water-supply projects, where most water conflicts occur now. As a result, the most important water decisions are often pursued without planning expertise and this can lead to failure to resolve conflicts.

50.2 Model Use

The paper does not describe any particular case study, but does present subjective lessons learned about the potential for modeling issues to affect the success of SVP efforts. Two illustrations, one of an Excel and the other of a STELLA model are offered as examples of the user friendliness of SVP models. The authors state that studies can be hurt by modelers who try to impose their modeling approach rather than fashioning the model to fit the problem.

50.3 Involvement and Collaboration

One of the key points of the paper is that participants may not want to be involved in a planning process because there is a better chance of getting what they want from litigation, adjudication, market transactions or some other form of water-management decision making.

50.4 Outcome

The authors are the two co-creators of SVP and they conclude that SVP resolved the primary problems in just a few of these cases, but also note that early in its development, the use of SVP was typically a “last resort” measure, which signifies the difficulty of reaching resolution through planning in these basins.

51 The Future of Shared Vision Planning, August 2000

System/Study Area Name:	Not a case study
Study Type:	Not applicable
Analysis/Model Type:	Not applicable
Stakeholders Identified:	Not applicable
Level of Participation:	Not applicable
Conflict Type:	Not applicable
Was Problem Solved:	Not applicable
International or U.S.:	Not applicable
Sponsoring Agency:	Not applicable
Study Lead:	Not applicable
Authors and Source:	Werick, W.J. and Palmer, R.N. Consider putting on IWR website since there is no ASCE copyright (government author)

51.1 Purpose of the Study

This paper briefly summarized the history of water resources, describes the development and use of SVP, then speculates about the future of SVP, including the extent of its use and likely areas for improvement from technological advances. The paper describes these possible future developments:

- There will be more attempts to broaden the scopes of planning efforts
- There will be more studies that use planning to create a foundation for a regulatory decision.
- Internet model and data repositories will become de rigueur
- Virtual simulations will be easier to do well and will be used to provide more thorough tests of plans, to improve risk assessments and make non-economic evaluations more meaningful.
- Optimization models will become more user friendly and GIS simulations will become more common planning tools.

But the author also predicts that the planning (whether shared vision or any other sort) might be used less than it has been in the past.

51.2 Model Use

The paper does not describe any particular case study, but speculates that in the future GIS and optimization models will become part of the arsenal of modeling tools used in SVP.

51.3 Involvement and Collaboration

The paper points out that some stakeholders may pretend to participate in a planning study but not be fully collaborative because the outcomes they desire can best be pursued though the courts or legislatures.

52 National Study of Water Management During Drought: The Report to the U.S. Congress (National Drought Study Report 94-NDS-12), September 1995

System/Study Area Name:	American water management (Washington, Kansas-Missouri, West Virginia, Virginia, Colorado basin (seven states), Massachusetts, Oregon, Pennsylvania
Study Type:	Report to Congress on the National Study
Analysis/Model Type:	Systems dynamics; Stella
Stakeholders Identified:	All types, in brief summaries of several case studies
Level of Participation:	Circles of influence method, varying directness
Conflict Type:	Planning allocation of water during drought
Was Problem Solved:	In two of six case studies
International or U.S.:	U.S. (two interstate case studies)
Sponsoring Agency:	U.S. Army Corps of Engineers
Study Lead:	U.S. Army Corps of Engineers
Authors and Source:	Werick, W.J. http://www.iwr.usace.army.mil/inside/products/pub/iwrreports/94-NDS-12.pdf

52.1 Purpose of the Study

The purpose of the National Study of Water Management During Drought was to improve the way water was managed for drought in the United States. SVP and the National Drought Atlas were the two principal products of the study. There is also a how-to manual (Managing Water for Drought, 94-NDS-8) that describes each step of SVP for drought (called the Drought Preparedness Study method then). NDS-8 better describes the case studies; this report summarizes the policy aspects of the national study and includes findings, an assessment of the state of drought planning in the U.S., a first description of virtual droughts and the National Drought Atlas and a short section on water conservation and trigger planning (in which water-supply investments or decisions are made incrementally at pre-determined levels of certainty about future needs).

52.2 Model Use

STELLA® software is described in the manual and used in eight case studies and the Colorado River gaming exercise.

52.3 Involvement and Collaboration

Six of these case studies are described in more detail in Managing Water for Drought, 94-NDS-8. The intent was to test the DPS method by applying it as uniformly as possible in a variety of water-resources situations, including riparian, appropriation and mixed legal systems of water-use rights. Stakeholder representatives were closest to the model building in the Green River (Tacoma, Washington's water supply) and Boston. There was resistance to involvement in the Cedar River (Seattle, Washington's water supply) and James River (where two difficult water-supply permit actions, for Newport News and Virginia Beach, Virginia were being contested). Stakeholders in the Kanawha River case study had a high early level of involvement (for instance, recreational rafting vendors helping build the STELLA functions) but later relied on a trusted Corps of Engineers hydrologist, Dr. Richard Punnett, to develop the model. On the Marais des Cygnes-Osage River Case Study, state officials were involved in the modeling study, but end users were not. Two case studies (Youghiogheny River Lake in Pennsylvania and the Rogue River, Lost Creek Lake, in Oregon) are mentioned in this report but not NDS-8. They were funded at the end of the study as an attempt to see how much of the benefit of SVP could be captured in a low budget ($10,000) study. Although system models were completed in both cases, stakeholder participation in drought planning was minimal because there was no imminent threat of a drought by 1994 and most stakeholders declined participation because it was a low priority.

52.4 Outcome

The Kanawha River study led to new operating rules for the Corps of Engineers reservoirs. Stakeholders estimated the rules would save about ten million dollars in recreation revenue during the next severe drought while improving water quality. Study participants agreed that negotiations on a refill strategy for the reservoir on the Green River were shortened substantially because there was greater confidence in modeled levels and flows. The Marais des Cygnes-Osage study helped build trust in a Kansas water policy that was developed outside the Drought Preparedness Study. The Boston case study was collaborative and technically sound, but was a smaller study that was not focused on (and did not solve) any specific problem. The James River study was a failure because of the quality of the planning and modeling effort and because some principal stakeholders saw collaboration as contrary to their interests. The Colorado River Gaming Exercise was an academic comparison of three approaches to allocating water (decisions made by central authority, a basin commission and in a market). The basin commission approach worked best. In this experiment, markets tended to protect consumptive uses more than non-consumptive uses.

Appendix B

Computer-Aided Collaborative Decision-Making References

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Computer-Aided Collaborative Decision-Making References

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Shared Vision Planning

The History of Shared Vision Planning

The Shared Vision Planning approach began in response to the U.S. Army Corps of Engineers need to revise water management strategies on the Potomac River in the late 1970s. The Interstate Commission on the Potomac River Basin made public participation a key feature of its planning process to more effectively manage water supplies in the D.C. metro area.

In 1988, in response to severe droughts across the United States, the Corps undertook the National Study of Water Management During Drought (known as the National Drought Study) to examine and improve water management practices nationwide. The method developed in this project's case studies evolved into the planning approach now known as Shared Vision Planning. The "Drought Preparedness Method," as it was named during the National Drought Study, emphasized preparedness, stakeholder involvement, and the use of collaboratively developed computer models, which remain the core aspects of Shared Vision Planning today.

Shared Vision Planning and its particular method have been applied to a number of case studies since the National Drought Study, thereby refining the process and increasing Corps scientists' familiarity with it. The Lake Ontario-St. Lawrence River Study, the James River Basin Study, and the Rappahannock River Basin Commission Water Supply Planning Project are just a few of the projects that have benefited from the Corps use of Shared Vision Planning.

To further explain the concept and method of Shared Vision Planning, and educate the wider resources planning community, IWR has created a new Shared Vision Planning web site. We invite you to visit the site at http://www.svp.iwr.usace.army.mil to learn more about this collaborative planning approach.

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