United Nations
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Examples Decision Support Systems for River Basin Simulation

The following are programs designed to simulate water development and management policies in river basins. They are generic in that they are designed to be applicable to a wide variety of specific river basin water resource system configurations, institutional conditions, and management issues. Each of these example programs is based on a node-link network representation of the water resource system being simulated. Some include optimization that replaces a more detailed representation of operating policies. All contain menu-driven graphics-based interfaces that facilitate user interaction. These programs are appropriate for use in shared vision exercises involving stakeholder involvement in model building and simulations.

The brief descriptions below have been taken from the model web pages. Each model web page address is shown next to each model name. For greater detail refer to those web pages. Current demo versions and documentation of the decision support systems are available and can be downloaded from those web pages. The demo versions of RIBASIM and WEAP are included in the CD.

RIBASIM **http://www.wldelft.nl/soft/ribasim/int/index.html**

RIBASIM (River Basin Simulation Model) is a generic model package for analyzing the behavior of river basins under various hydrological conditions. The model package is a comprehensive and flexible tool which links the hydrological water inputs at various locations with the specific water-users in the basin. RIBASIM is developed and maintained by Delft Hydraulics in the Netherlands.

RIBASIM enables the user to evaluate a variety of measures related to infrastructure, operational and demand management and the results in terms of water quantity and water quality. RIBASIM generates water distribution patterns and provides a basis for more detailed water quality and sedimentation analyses in river reaches and reservoirs. It provides a source analysis, giving insight in the water's origin at any location of the basin.

RIBASIM has been applied for river basin planning and management in a great number of countries in a variety of projects. Water management organizations use it to support their management and planning activities. Large and complex river basins have been modeled and simulated with RIBASIM. Separately modeled sub-basins can be combined into one main-basin. A recent application of RIBASIM is the use of the model as flow routing component within a Flood Early Warning System (FEWS).

RIBASIM has links to other Delft Hydraulics software programs. It can link with the HYMOS hydrological database and modeling system. For detailed water quality process RIBASIM can link with the DELWAQ water quality model.

Various hydrologic routing methods are available in RIBASIM e.g. Manning formula, Flow-level relation, 2-layered multi segmented Muskingum formula, Puls method and Laurenson non-linear “lag and route” method. The flow routing is executed on daily basis starting at any selected day for any number of days ahead.

The structure of RIBASIM is based on an integrated framework with a user-friendly, graphically, GIS-oriented interface. Working with RIBASIM means applying a structured approach to river basin planning and management. Various tools from the Delft Tools library are used:

- Case Management Tool (CMT) is a tool to shape the structured approach. The working environment is a visualisation of the workflow diagram.
- Delft-GIS (Netter) software providing the user with essential features for a basin analysis which are not available in conventional GIS.
- Ods View is a tool for the presentation and export of time series results.
- The Case Analysis Tool (CAT) is a flexible tool to compare and evaluate the simulation cases.

WEAP **http://www.weap21.org/**

WEAP ("Water Evaluation And Planning" system) is a user-friendly software tool that takes an integrated approach to water resources planning. Freshwater management challenges are increasingly common. Allocation of limited water resources between agricultural, municipal and environmental uses now requires the full integration of supply, demand, water quality and ecological considerations. The Water Evaluation and Planning system, or WEAP, aims to incorporate these issues into a practical yet robust tool for integrated water resources planning. WEAP is developed by the Stockholm Environment Institute's Boston Center at the Tellus Institute.

WEAP Highlights

Integrated Approach: Unique approach for conducting integrated water resources planning assessments

Stakeholder Process: Transparent structure facilitates engagement of diverse stakeholders in an open process

Water Balance: A database maintains water demand and supply information to drive mass balance model on a link-node architecture

Simulation Based: Calculates water demand, supply, runoff, infiltration, crop requirements, flows, and storage, and pollution generation, treatment, discharge and instream water quality under varying hydrologic and policy scenarios

Policy Scenarios: Evaluates a full range of water development and management options, and takes account of multiple and competing uses of water systems
User-friendly Interface: Graphical drag-and-drop GIS-based interface with flexible model output as maps, charts and tables

WEAP is a microcomputer tool for integrated water resources planning that attempts to assist rather than substitute for the skilled planner. It provides a comprehensive, flexible and user-friendly framework for planning and policy analysis. A growing number of water professionals are finding WEAP to be a useful addition to their toolbox of models, databases, spreadsheets and other software.

Over the last decade, an integrated approach to water development has emerged which places water supply projects in the context of demand-side management, and water quality and ecosystem preservation and protection. WEAP incorporates these values into a practical tool for water resources planning and policy analysis. WEAP places demand-side issues such as water use patterns, equipment efficiencies, re-use strategies, costs, and water allocation schemes on an equal footing with supply-side topics such as stream flow, groundwater resources, reservoirs, and water transfers. WEAP is also distinguished by its integrated approach to simulating both the natural (e.g., evapotranspirative demands, runoff, baseflow) and engineered components (e.g., reservoirs, groundwater pumping) of water systems, allowing the planner access to a more comprehensive view of the broad range of factors that must be considered in managing water resources for present and future use. The result is an effective tool for examining alternative water development and management options.

- Water balance database**:** WEAP provides a system for maintaining water demand and supply information.
- Scenario generation tool**:** Scenario analysis is central to WEAP. WEAP simulates water demand, supply, runoff, streamflows, storage, pollution generation, treatment and discharge and instream water quality.
- Policy analysis tool**:** WEAP evaluates a full range of water development and management options, and takes account of multiple and competing uses of water systems.

MIKE BASIN **http://www.dhisoftware.com/mikebasin/Description/**

MIKE BASIN addresses water allocation, conjunctive use, reservoir operation, or water quality issues. It couples ArcGIS with hydrologic modeling to provide basin-scale solutions. The MIKE BASIN philosophy is to keep modeling simple and intuitive, yet provide in-depth insight for planning and management. In MIKE BASIN, the emphasis is on both simulation and visualization in both space and time, making it appropriate for building understanding and consensus. MIKE BASIN is developed by DHI in Denmark.

For hydrologic simulations, MIKE BASIN builds on a network model in which branches represent individual stream sections and the nodes represent confluences, diversions, reservoirs, or water users. The network elements can be edited by simple right-clicking. MIKE BASIN is a quasi-steady-state mass balance model, however allowing for routed river flows. The water quality solution assumes purely advective transport; decay during transport can be modeled. The groundwater description uses the linear reservoir equation.

Typical areas of application include water availability analysis, conjunctive surface and groundwater use, infrastructure planning, assessing irrigation potential and reservoir performance, estimating water supply capacity, determining waste water treatment requirements. The model has also been used to analyze multisectoral domestic, industry, agriculture, hydropower, navigation, recreation, ecological demands and find equitable trade-offs among them. It has analyzed ecosystems and water quality, minimum discharge requirements, sustainable yield, effects of global change, regulation and water rights and priorities.

MODSIM **http://modsim.engr.colostate.edu/**

MODSIM is a generalized river basin Decision Support System and network flow model developed at Colorado State University designed specifically to meet the growing demands and pressures on river basin managers today. MODSIM's graphical user interface (GUI) allows users to create any river basin system topology by simply clicking on various icons and placing system objects in any desired configuration on the display. Data structures embodied in each model object are controlled by a data base management system, which is also queried by simple mouse activation.

Formatted data files are prepared interactively and an efficient network flow optimization model is automatically executed from the interface without requiring any direct intervention by the user. Results of the network optimization are presented in useful graphical plots. MODSIM can also be used with geographic information systems for managing the intensive spatial data base requirements of river basin management.

MODSIM data sets can be developed for daily, weekly, and monthly time steps. Streamflow routing can be handled through the use of lag coefficients. There is considerable flexibility in representing consumptive use demands and flow requirements and their associated water rights, including exchanges. Reservoir operations include target storage, hydropower, tailwater effects, evaporation, and seepage.

MODSIM can simulate reservoir storage contract arrangements such as accrual rights, ownership contracts, water service contracts, and rental pool or water banking. Prioritized reservoir balancing allows the user to control the distribution of system storage throughout the simulation season. MODSIM has a Glover equation groundwater model built in the model's code that has been used in systems with fairly simple unconfined aquifer / river streamflow interactions. MODSIM has been linked with stream-aquifer models for analysis of the conjunctive use of groundwater and surface water resources, as well as water quality simulation models for assessing the effectiveness of pollution control strategies. .

The network solution algorithm along with the iteration convergence sequence for return flows and watch logic gives the model user flexibility to simulate operations of complex river systems. Watch logic is a term to describe the model's ability to define operational parameter limits for a simulated feature based on simulated results of another feature in the network. Perl scripts that tailor operation parameters while the model is running go a step further to allow for the simulation of detailed basin specific conditions. Perl scripts can also be used to customize model input and output.

WBalMo **http://www.wasy.de/english/produkte/wbalmo/index.html**

WBalMo (Water Balance Model) is an interactive simulation system for river-basin management. WaBalMo has been used to identify management guidelines for river basins, design reservoir systems and their operating policies, and perform environmental-impact studies for development projects. Using an ArcView user interface, a representation of the river basin ("system sketch") is constructed or derived from an existing digital stream network. Model data can subsequently be modified in various scenarios. WaBalMo is developed by WASY Ltd in Germany.

The natural processes of runoff and precipitation are stochastically (Monte-Carlo) simulated and the respective time series are balanced with monthly water use requirements and reservoir storage changes.

By recording of relevant system characteristics during the simulation, probability estimates can be provided for water deficits, maintaining minimum runoff levels, or reservoir levels. Simulations can be performed both for stationary and transient (e.g., changes in climate) conditions. By comparing various plausible scenarios an approximately optimal water resources management can be obtained.

A river basin is modeled in WBalMo by input of the following data:

- Stream network with desired balance profiles for accurate accounting of water uses, reservoirs, water transfer, etc.
- Catchment areas and their respective simulated runoff time series
- Location of water uses and their requirements (discharge and uptake rates, minimum runoff)
  Reservoirs and their management regime
- Desired system characteristics such as mean and extreme values, frequencies and threshold values.

Units for input and output are user-defined.

WBalMo can be coupled with other algorithms or models to supplement the provided routines. This may be useful, for instance, for specific types of resources management, to implement a flood control, or when addressing water-quality issues. Two alternatives exist for extending the capabilities of WBalMo:

- New algorithms are implemented directly in WBalMo using FORTRAN syntax
- Dynamic-link libraries (*.dll) provide the new algorithms in compiled form and are accessed by WBalMo.

In addition, the attributes of model elements can be freely extended.

Additional system components include:

- Automatic labeling of the river-basin representation
- Presentation of all data using adjustable report generators
- Comparison of scenarios with listing of differences found
- Integration of DIGITAL-Visual-Fortran
- Display of user-selected system variables during the simulation