CHAPTER 11

MIXED SIMULATION-OPTIMIZATION TECHNIQUE FOR COMPLEX WATER RESOURCE SYSTEM ANALYSIS UNDER DROUGHT CONDITIONS

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Abstract: The chapter illustrates a Decision Support System (DSS) for multi-reservoir water resource systems, named WARGI (Water Resources system optimization aided by Graphical Interface). WARGI was upgraded in the SEDEMED II Project to implement a mixed approach that uses optimization and simulation techniques which identifies short and medium-term actions to be implemented in system management according to a proactive approach. Under drought conditions, the DSS aims to predict in advance the consequences of management assumptions in a predefined system configuration. The optimization module considers future hydrological and demand scenarios to modify the set of decision variables to be adopted by the simulation module. Lastly, WARGI’s application to the water resource system of Southern Sardinia (Italy) is illustrated.

Keywords: Simulation and optimization of water resource systems, Drought management

1. INTRODUCTION

Appropriate management of complex water supply systems, when operating under water scarcity conditions, requires adoption of modelling tools helping decision-makers to identify sets of actions able to mitigate the impacts of drought on users. Usually, mitigation actions translate into variations in management rules and structural actions on system configuration, following either a reactive or a proactive approach to the drought phenomenon (see for instance Yevjevich et al., 1983; Rossi, 2000).

The reactive approach consists in measures adopted both during and after the drought period, once its consequences are perceived. While this approach is still today the most common response to drought emergencies, obviously, the actions undertaken are, as a rule, of brief duration and non-structural in nature, entail high economic and environmental costs for the community and often do not reduce the system’s vulnerability to similar future events.

The proactive approach consists in a series of measures which may also include structural actions on the system, coherently developed in a planning strategy; they
are designed well in advance of the start of the drought period, and implemented also during and after. The aim of such measures is to reduce the system’s vulnerability and increase its reliability under drought conditions.

The identification of the best set of measures requires availability of appropriate modelling tools organized in Decision Support Systems (DSS). Within a proactive approach, an appropriate combination of long term and short term measures can be identified by considering alternative options whose effectiveness is evaluated with comparative analysis procedures. Usually, assessment of system performance under a predefined infrastructural setup and with assigned management techniques is, as a rule, achieved by means of simulation models, while optimization models are employed to assess “theoretical” system efficiency when management is hypothetically implemented by an ideal manager.

In previous works (Sechi and Zuddas, 2000; Sechi et al., 2004; Sechi and Sulis, 2005; Sulis, 2006) we illustrated how, in developing the WARGI DSS we had attempted to analyze complex water systems under different scenarios in a user-friendly manner through the implementation of a specialised graphical interface. WARGI combines possibilities of evaluating system efficiency by adopting a representation adhering to reality, as allowed by simulation models, with the exploratory potential afforded by optimization models. The structure of WARGI consists of various independent macro-modules (some of which were already described in Sechi et al., 2004) linked together through transfer of encoded variables (Figure 1). The toolkit is implemented in Linux environment and encoded in C++ and Tcl/Tk.

As was illustrated in Manca et al. (2004) and Sechi and Sulis (2005), the system initialisation and input module (Initialization and Hydrologic Data Input) handles value definition of the main parameters and the creation and possible modification of system elements. This module processes data coming from the Graphical User Interface module, transfers data required for formulating the optimization module (WARGI-OPT) and implements the simulation algorithm (WARGI-SIM). Software construction by means of independent modules also makes it possible to use the toolkit either for system optimization alone (WARGI-OPT) or for simulation alone (WARGI-SIM). If, moreover, analysis with scenario optimization is required, the Scenario Generation module passes to the WARGI-OPT module (Pallottino et al., 2005) parameters for model construction.

Water supply system analysis with the use of non-conventional resources is implemented in the WARGI-QUAL module (Salis et al., 2005a, Salis et al., 2005b) which links use of resources available to compliance with quality requirements. The procedure associated with solution of the optimization model determines creation of a standard .mps (mathematical programming standard) file, which is used as interface with the solving code. The WARGI-OPT module communicates model structure to the Solver module, responsible for connection with the user-selected software for resolving the optimization problem and enables management of information.