High dimension dynamic programming model for water resources expansion projects

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An optimization model for High Dimension Dynamic Programming (HDDP) was developed to determine the optimal size of water resources projects within a planning period. The model uses Objective Space Dynamic Programming (OSDP) technique to determine the size of the projects and a Mixed Integer Programming (MIP) formulation to overcome the ‘inner’ and ‘outer’ problems of OSDP and to check for the global optimality of the solution. The model is applied to determine the optimal capacity of proposed desalination plants needed to satisfy a number of demand points from different cities, during a planning period of 20 years in Egypt. The model’s speed towards the optimal solution depends on the objective space bounds and search method for these bounds. The integration of OSDP and MIP is shown to be an efficient approach for solving optimization problems. Results show that the model is well suited for solving large-scale water resources expansion problems.

Keywords: Dynamic Programming; Optimization; Water resources planning; Water supply; Desalination plant size; Egypt

1. Introduction

The sizing of water resources projects presents a problem that requires a sequential set of capacity and/or capacity expansion decisions within a certain time period. This problem can be solved using a systematic approach within the framework of an optimization model. Although a number of optimization techniques have been developed that are capable of solving a wide range of problems, there remains a class of problems characterized by high dimensionality, non-linearity and non-convexity which can pose significant difficulties to existing optimization techniques.

Dynamic Programming (DP), formulated by Bellman (1957), is one of the most extensively used optimization techniques in water resources system analysis, mainly because it is ideally suited for sequential decision problems. Unfortunately, the computational burden of