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PhD Dissertation Defense

Entitled

Development of a Decision Support System for Sustainable Water Planning in Abu Dhabi, UAE

by

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Abstract

One of the main challenges for water managers is to foresee the future accurately; then, design appropriate policies and infrastructure plans accordingly. In such instances, mathematical tools can be useful in evaluating future conditions of water resources for better management and infrastructure planning. The use of decision support systems in the field of water resource management and planning is now widely implemented, but its use in sustainable water planning of a nation or state in arid and semi-arid areas, such as Middle East countries, remains limited. The main objective of this dissertation is to present a graphical software tool which can assist water planners and decision makers for long term water management and planning. The study was implemented in the Emirate of Abu Dhabi, UAE.

Sustainable planning for Abu Dhabi's future water supply is a very challenging task which requires consideration of various drivers and decision criteria. For this, a comprehensive assessment of the current status of water sources and demands in the Emirate of Abu Dhabi (EAD) was carried out through a rigorous analysis of the data obtained from published research articles, reports and through extended discussions with various stakeholders. However, to produce realistic future scenarios for the EAD, sound knowledge of the supply-side elements and demand-side elements; for existing and future usages is required. This is achieved through identifying key drivers that control the future demand-supply in the EAD. Literature review showed that parametric dynamic models are capable of producing future water scenarios if the drivers are identified properly. Therefore, Abu Dhabi Dynamic Water Budget Model (ADWBM) was developed to help water policy makers of Abu Dhabi to assess all water components. The model, which is capable of producing future scenarios of water budget, was calibrated and validated using historical data. Additionally, sensitivity of the model outputs to changes in the inputs was determined by conducting a sensitivity analysis.

This study presents four suites of water scenarios focusing on managing the demand side, namely: Business as Usual (BAU), Policy First (PF), Sustainability by conservation (SC), and Rainfall Enhanced Sustainability (RES) scenarios. Simulation results using ADWBM indicate that both SC and RES scenarios achieved balanced water budget without any water deficit throughout the entire period until 2050. The RES scenario is recommended for adoption because of the reasonable and achievable consumption reductions needed in the different demand sectors. The obtained results should be valuable for devising appropriate strategies to prevent potential future water shortages in the Emirate.

The next objective of this work was to develop a tool for managing the supply-side as part of an integrated management plan of water resources and the capacity planning of water infrastructures. For this, a novel multi-period optimization model based on mixed integer linear programming (MILP) was developed. This main aim of this model is to identify the optimal mix of water supply sources to meet current and future water demands of various quality levels. Model formulation incorporated several parameters including various types of economic and environmental costs, capacity expansion options of treatment plants and water transmission systems, and environmental aspects (such as carbon footprint and brine discharge). This model, named Abu Dhabi Water Capacity Planning Model (ADWCPM), was programmed in General Algebraic Modeling System (GAMS) using the Cplex solver. To illustrate ADWCPM approach, optimal planning solution for the BAU scenario was sought by running the GAMS code. Results showed that the solution is affected by the environmental costs and can drive technology options if the sustainability and environmental benefits are considered. It also

showed that DS plants in the EAD will have a drastic technology change from thermal processes like MED and MSF to RO even if moderate consideration is given to the environmental aspects.

Finally, a decision support system (DSS) was developed by integrating key components of ADWBM and ADWCPM, to present a graphical user interactive tool. The DSS tool is named "Sustainable Water Budgeter for Abu Dhabi" (SuWaB-AD). The ADWBM was incorporated to simulate future water scenarios and to evaluate future water balance conditions in the Emirate of Abu Dhabi. The ADWCPM is used to find cost optimal planning solutions for any water scenarios simulated by ADWBM, through the assessment of various economic and environmental constraints included in the ADWCPM. The use of SuWaB-AD is demonstrated through the case study of Abu Dhabi could help decision makers in promoting sustainable plans. The results and applications show that SuWaB-AD approach can be adapted to support long-term water decision making. The proposed tools would be helpful to water administrators, water professionals and other water management authorities for sustainable water planning worldwide.

Keywords: Water budget, Water scenarios, Sustainability, Water Planning, Abu Dhabi, DSS, GAMS, MILP