Shanno devirbhistaya aapon bhavantu peetaye |
Shanyorbhi stravantu nah | |
Yajur Veda (36.12)

May beautiful waters be pleasant to us to drink
and acquire happiness,
and flow with health and strength to us.

PREFACE

In nature, the water of right quality in right quantity is usually not available at the right place at the right time. Sometimes, it is available at the wrong place and at the wrong time and its quality and quantity are not what they should be. Although in nutshell, this is the gist of the problem, this seemingly innocuous, albeit naughty interplay of words fails to convey the gravity and the magnitude of the problems that are caused by the mismatch between the availability and the demand of good quality water. Nature can indeed be very harsh and ruthless at times. However, a positive outcome of this mismatch is the development of a wide range of tools and techniques for water resources systems planning, development, operation, and management.

Since the publication of "Design of Water Resources Systems" by the Harvard Water Group in 1962, systems techniques have been commonly applied to water resources planning, design, operation and management. The results of numerous studies, applications, and practices have been reported in many monographs and books. Although the material presented in these books is undoubtedly relevant, praiseworthy, and authoritative, the practice of water resources management has undergone significant and far-reaching changes during recent years. In developed countries, for example, the emphasis these days is on conservation and sustainable development of water resources, whereas the emphasis in developing countries is more on the development of untapped water resources to meet rapidly increasing demands and for alleviation of poverty. These objectives have to be attained, while simultaneously minimizing adverse impacts on the environment and the social fabric of the society.

There is a growing call for involving stakeholders in decision-making at all levels. To that end, there is unanimity all over the world that water resources of a river basin have to be developed and managed by systematically integrating socio-economic, environmental, political and engineering considerations. Furthermore, the revolutions occurring in technology these days are having a profound influence on the practice of water resources engineering. Two glaring examples of this revolution are the Internet and electronic mail. These have provided a convenient, cheap, and rapid medium of communication and access to huge volumes of information. These days, people

physically located far away from each other can be in close contact and can frequently exchange ideas, notes, and documents almost instantaneously. Such a quick communication was unthinkable only a few years ago. These are the factors that motivated the writing of this book which provides a discussion on topics deemed relevant in the present scenario of water resources practice. Another feature, deemed important, is the employment of a real-word system as an example to illustrate application of systems concepts and techniques.

The subject matter of the book is divided into four parts. The first part, termed ***Preliminaries***, contains four chapters. Introducing the basic theme of the book, the first chapter provides an overview of the current status of water resources utilization, and the likely scenario of demands in the near future. The basic concepts, practical applications, and advantages and disadvantages of systems analysis techniques are presented. Also provided is a discussion of seven challenges for the water sector identified and debated in recent international forums. Temporal and spatial hydrologic analyses require extensive data. An understanding of how this data is measured and how the processing of this data is done is important before undertaking any water resources systems analysis. Chapter 2 presents techniques of observing and processing the data used in water resources systems. The discussion is extended to emerging techniques in Chapter 3. These techniques are Remote Sensing, GIS, Artificial Neural Networks, and Expert Systems. These techniques are versatile, highly useful, and are playing increasingly important role in water resources planning and management. Chapter 4 discusses statistical tools for deriving the desired information from these data, including commonly used probability distributions, methods of parameter estimation, regression and correlation analysis, frequency analysis, time-series analysis, and transition matrices and Markov chains.

Part 2 of the book deals with ***Decision Making*** which is a bouquet of techniques organized in 4 chapters. Optimization and simulation techniques are discussed in Chapter 5. Most of the analysis dealing with planning and management of water resources systems is carried out using these techniques. Besides technical aspects, economic analysis is essential to rank the various competing projects and the subsequent approval by the decision-maker. Chapter 6 dwells upon the techniques of economic analysis. During recent years, environmental and social aspects, and rehabilitation and resettlement of project-affected people have come to occupy a central stage in planning as well as management of water resources projects. It is now recognized that these projects may have a lasting impact on the social fabric of the area concerned. It is, therefore, necessary that while planning as well as operating a water resources system, adequate care and precautions are exercised so that adverse impacts on the society and the environment are minimized. These issues form the subject matter of Chapter 7. Using basic analytical tools and the knowledge of environmental and social aspects, the practitioner is required to take a rational and balanced decision regarding design and management of water resources systems. Since major inputs to a water resources system, such as rainfall, meteorological variables, etc. are not deterministic, these systems inherently have an element of risk. The concept of rational

decision making and the associated elements, such as the concept of risk, reliability, and uncertainty in water resources systems, are discussed in Chapter 8.

Part 3 of the book, comprising 2 chapters, deals with ***Water Resources Planning and Development.*** Chapter 9 discusses basic concepts of planning, classification and steps of the planning process, integrated planning, institutional setup, public involvement, and planning models. Chapter 10 discusses planning and sizing of reservoirs, and approaches to compute the storage capacity for conservation as well as flood control.

The fourth and last part of the book, encompassing 4 chapters, focuses on ***Systems Operation and Management.*** After a reservoir has been constructed, it is essential that it is managed in the best possible way so that benefits can be maximized. The techniques of reservoir operation are discussed in Chapter 11. It includes a detailed discussion on conventional and systems techniques for regulating a system consisting of reservoirs in series and parallel and the application of various systems analysis techniques, such as optimization and simulation. It also discusses real-time operation of reservoirs and the logistics required. Many dams around the world are experiencing a significant loss of their storage capacity every year due to sedimentation. This topic is discussed in Chapter 12, providing details of soil erosion and mathematical modeling of sediment transport, empirical techniques as well as latest satellite data-based techniques to assess reservoir sedimentation, methods to prevent the sediment from entering a reservoir, and recovery of reservoir storage by flushing and dredging.

No analysis of water resources systems is complete without consideration of water quality. Chapter 13 presents fundamentals of measurement of water quality variables and modeling of water quality in rivers. A river basin is the natural unit in which water occurs and currently a lot of emphasis is being placed on holistic management of river basins. Chapter 14, the final chapter, discusses various issues related to management of a river basin. The discussion includes integrated water quality and quantity management, water pricing, water rights, inter-basin water transfer, decision support systems, privatization, and management of international river basins.

It is hoped that the book will be useful to those engaged in practice of water resources engineering. This book is intended for senior undergraduate and beginning graduate students as well as water resources practitioners. Its purpose will be served if it provides them motivation and information in their pursuit for further search and a deeper dive in this vast reservoir of knowledge to quench their thirst.

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