Preface

Water is vital for life. It is an essential natural resource for ecological sustenance, agricultural productivity, environmental purity, industrial growth, power production, and enrichment and renewal of land and air. For easy access to water, the first human settlements occurred along the banks of rivers and ensuing civilizations flourished in river valleys. For example, the Indian civilization of Mohanjodaro and Harappa developed in the Indus valley, the Egyptian civilization in the Nile valley, the Chinese civilization in the Yangtze valley, and the Babylonian civilization between the Tigris and the Euphrates Rivers.

The supply of water at any given location is limited and the limits of the water availability vary considerably. The unprecedented economic growth, social transformation, and technological developments that have occurred in the world during the past century have been in part due to human ingenuity in providing water to various users, often through well-engineered strategies for storing water and transporting it. There is a direct correlation between the development of these strategies and national development, as exemplified by the grouping of nations of the world into developed countries, developing countries and under-developed countries. From the middle of the nineteenth century to the end of the twentieth century, hundreds of thousands of water resources projects were developed and built throughout the world, primarily for the purposes of supplying water for agricultural irrigation, hydropower generation and energy production, drought amelioration, and recreation, as well as for flood control and navigation. In India large irrigation canals were built in the nineteenth as well as twentieth centuries and a large number of multipurpose water resources projects were built in the twentieth century. These projects were either entirely funded or heavily subsidized by national governments in recognition of the crucial role that water plays in national development.

When water resources projects were developed over the past century and a half, the major emphasis was on water supply, flood control and/or power generation. But these projects have caused deleterious environmental consequences, such as degradation in the quality of drinking water, frequent occurrences of floods and droughts, upland erosion and sedimentation of reservoirs, less than designed level of power generation by hydropower plants, scarcity of drinking water, water logging and salinity of irrigated areas, saltwater intrusion into coastal areas, coastal erosion, loss of wetlands, and land subsidence due to excessive groundwater pumping. Other human activities have also contributed to environmental deterioration. For example, application of chemical fertilizers in agriculture has led to polluted ground waters; chemical industries have polluted air, land and water resources; nuclear wastes produced by military operations have caused severe ground water pollution; medical wastes have polluted land and water resources; leather industries have polluted rivers; and so on. If one critically examines the hazardous consequences of many of these industries, it becomes clear that the damage caused by them far outweighs the benefit they have produced. For example, human diseases that were unheard of about 50 or so years ago

in rural India have now become commonplace. Improper use of water resources is causing catastrophic effects. Many rivers are either dead or are dying, for we have forgotten that rivers are living entities and must be nurtured and nourished similar to any living being. In addition, there are numerous human activities which appear seemingly innocuous and insignificant but their cumulative effect is highly detrimental. This sad state of affairs has been caused by the combination of shortsighted politics, companies that seek windfall profits at the expense of societal good, federal agencies that harbor the belief that they can tame nature, lack of interdisciplinary approach to solving water resources problems, and so on. There is little interaction between the government, academia, industry and the public.

The world population has increased nearly threefold in the last 50 years. The standard of living has gone up. In India nearly 70% of the population still depends on agriculture which is the largest user of water. There is considerable uncertainty as to the climate change and its manifestation. On the other hand, the combination of the rising demand for water, increasing recognition of environmental quality and the integrity of ecosystems, sustenance of biodiversity, and the growing acceptance that the water use strategies of the past are insufficient and unsustainable have led to major conflicts over the use of water and the development and management of water resources. It is evident that the past solutions are no longer adequate for present problems and would be even more inadequate for future problems. The problems have changed but the bureaucracy managing the water resources projects have remained the same. Many times it is forgotten that the government agencies exist to serve the public for which these projects were designed and built in the first place. There is hardly any accountability, once a project is built, whether or not the project is fulfilling its intended objectives. To put it succinctly, water is too important a resource to be mired in petty politics and vested interests. Its protection and management is fundamental to the survival of our civilization.

In the past three decades or so, enormous strides have been made in the information technology sector. If teeming millions have to be properly fed and water resources have to be wisely managed and protected, then information technology has to be employed to the fullest extent. For example, the Green Revolution occurred in India in the 1960s but its full potential has not been fully utilized, primarily because of the lack of adequate infrastructure to disseminate improved agricultural production technologies in rural areas. Establishment of information infrastructure will aid the diffusion of modern agricultural technology in rural areas and in unleashing the full potential of Green Revolution. This will help improve rural economy which in turn will help establish agro-based industries, generate employment opportunities and mitigate the problem of migration from rural areas to urban areas.

The problems of water and environment are intertwined and these problems continue to grow. The purpose of organizing this international conference was to bring together educators, researchers, practitioners, planners, managers, administrators, social and economic scientists, policy makers from all over the world for discussion of problems pertaining to water and environment in arid, semi-arid, humid, sub-humid or tropical regions. Furthermore, the Government of India is planning to undertake river linking at a national level. This will be perhaps the largest project even undertaken anywhere in

the world. Although much thought and preparation have gone into this project, it is not clear if all conceivable consequences have been explored and taken into consideration. Given its gargantuan size, it is only logical and advisable that this project is discussed in all its aspects and nothing can be a better forum to do that than an international conference. Therefore, the conference was designed to be interdisciplinary, bringing climatologists, meteorologists, engineers, hydrologists, hydraulicians, geologists, hydrogeologists, environmentalists, ecologists, agricultural scientists, environmental and water resources planners, modelers, social scientists, economists, managers, and policy and decision makers under one roof to deliberate issues related to surface water, groundwater, contamination, pollution, ecosystems, water resources planning and management, river linking, and so on; discuss solutions; and consider challenges and direction for the 21st century to reduce water and environment-related problems. To that end, specific objectives were: (1) to discuss perspectives, water and environmental problems and their solutions, (2) to assess the current state of art of environmental, water resources and watershed management technology, (3) to promote inter-disciplinary dialog and interaction, (4) to discuss the interdisciplinary approaches and models, and (5) to discuss future needs and research directions.

India has had a long tradition of excellence spanning over several millennia in the construction of water resources projects. She has produced civil engineers of the highest quality, some of whom rank among the best in the world. Because of her vast size she experiences a large climatic variation and actually enjoys six seasons. There are several major river systems. Her landscape varies from flat plains to the highest mountains in the world. There is a very long coastline and is the only country where the three seas meet. Thus, India is a rich laboratory for water resources investigations. New Delhi is the capital and the nerve center of India and is situated along the banks of Yamuna River. It is a fascinating amalgam of scenic beauty, old historic city and modern urban planning. The modern Delhi was founded in the 8th century AD by the Tomara Rajputs. Sandwiched between U.P. and Haryana stand silent sentinels that testify to the growth of the city. New Delhi today presents a multi-faceted profile; the old city, with its market places and fine old mosques and forts, still bears the aristocratic imprint of its former Muslim rulers. The new city is equally impressive, with exquisitely laid out parks and gardens, broad avenues and museums. Thus, the venue of the conference could not have been more appropriate.

We received an overwhelming response to our call for papers. The number of abstracts received exceeded 350. Each abstract was reviewed and those that were technically sound and deemed appropriate to the theme of the conference, were accepted. This led to the submission of about 300 full length papers. The subject matter of the conference was divided into 24 topics encompassing virtually all major aspects of water and environment. Each topic comprised a number of contributed papers and in many cases the state-of-the art papers. These papers provided a natural blend to reflect a body of knowledge on that topic.

The papers contained in this book, *Statistical and Systems Analysis Techniques*, represent one part of the conference proceedings. The other parts are embodied in three separate companion books entitled, *Hydrologic and Hydraulic Modelling, Water*

Quality and Environmental Considerations, and *Water Resources Planning and Management,* which are being published simultaneously. Arrangement of the contributions in these four books under different titles was a natural consequence of the diversity of the papers presented at the conference and the topics therein. These books can be treated almost independently, although considerable interconnectedness exists amongst them.

This book contains six sections reflecting on significant advances in *Statistical and Systems Analysis Techniques.* Section 1 deals with statistical analysis which constitutes the first and basic step in the analysis of any hydrologic data. Section 2 deals with floods and droughts—the two extreme events in hydrology which effects mankind all over the world. Section 3 deals with water distribution systems—a topic of immense social importance. Uncertainty analysis constitutes the subject matter of Section 4. Systems analysis techniques are dealt with in Section 5. Section 6 presents reservoir regulation and decision support system. It may be highlighted that sincere efforts are being made in India to develop and apply the decision support systems in the field of water management for sustainable use of these resources. The book will be of interest to researchers and practitioners in the field of hydrology and water resources, environmental engineering, agricultural engineering, earth sciences, and watershed and range sciences, as well as to those engaged in water resources planning and management. Graduate students as well as those wishing to conduct further research in hydrology and water resources planning, development and management will find the book to be of value.

We wish to take this opportunity to express our sincere appreciation to all the members of the Steering Committee, the Organizing Committee, Ministry of Water Resources, and the concerned Scientists and staff of National Institute of Hydrology, Roorkee.

Numerous people have contributed to the conference in one way or another, and the lack of space does not allow us to list all of them by name here. The authors, including the invited keynote speakers, contributed to the conference technically and made the conference what it was. This book is the direct result of their collective efforts and contributions.

WEES–2009 has attracted a large number of nationally and internationally well-known people who have long been at the forefront of hydrologic, groundwater, hydraulic, environmental, and water resources education, research, development, management and practice. More than 25 countries covering five continents and most of the major countries of the world active in water and environment will be represented. It is hoped that long and productive personal associations and friendships will be developed as a result of this conference.

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