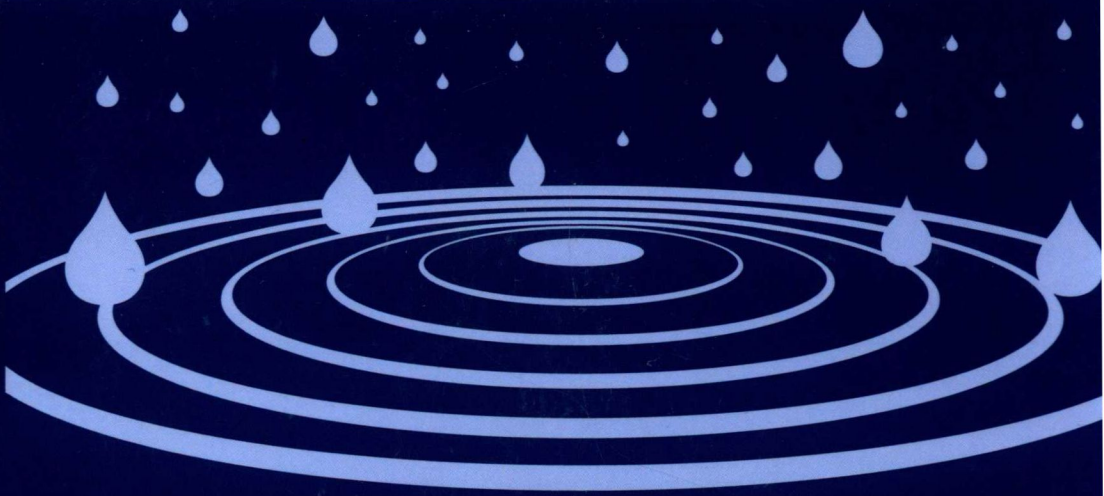

Sustainable Water Resources Management

ASCE

Edited by

Chandra S. P. Ojha
Rao Y. Surampalli
András Bárdossy
Tian C. Zhang
Chih-Ming Kao

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Civil Engineering

Sponsored by the Sustainable Water Resources Management Task Committee of the Environmental Council of the Environmental and Water Resources Institute of the American Society of Civil Engineers

Sustainable Water Resources Management presents the most current thinking on the environmental, social, and political dimensions of sustainably managing the water supply at local, regional, or basin levels. The twin challenges of ensuring an adequate water supply and the optimal allocation for different uses are compounded by changes in climate, land use, demographic patterns, and water availability.

Written by leading experts from around the world, the 33 chapters in this book provide comprehensive information about different aspects of sustainable water resources management. This book reviews various methods of data collection and describes available tools for hydrological modeling, with an emphasis on remote sensing and GIS. Chapters cover the assessment of atmospheric water, surface water, and groundwater. Other topics include urban water management, mitigation strategies for droughts and floods, the optimal use of irrigation water, and issues in water reuse. These innovative approaches are highlighted with case studies from California, India, Taiwan, and East Africa.

This collection of essays provides readers with comprehensive information on the principles of sustainable water resources management, as well as recent advances, directions for future research, and policy development for sustainable water resources management. As a reference, it will be of interest to students, scientists, engineers, government officials, and water resource managers.

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Preface

Water is a precious natural resource. However, its uneven distribution coupled with uneven demand leads to water crisis. Many nations in the world are experiencing water crisis and are already under water stress or likely to experience it in future. Unless the water resources are managed properly, it will be extremely difficult to sustain future generation. Many water related conflicts are in existence and sharing of water resources among different states/nations has become a political issue.

Frequent occurrences of droughts and unprecedented floods have catastrophic effects on food and water security. Due to climate change, precipitation intensities have increased and this has led to flooding of many cities across the globe. This is the time when water resources management has to be looked from sustainability perspectives. While short-term measures are always welcome, long term measures must be planned so that the water needs of future generation is not compromised.

The present book deals with a variety of topics in the form of thirty-three chapters which are relevant towards sustainable water resources management. The book begins with data collection, and then describes a variety of modeling tools to achieve optimum utilization of water resources. While doing so, it lays emphasis on use of remote sensing and GIS tools. The assessment of atmospheric water, surface water and ground water are also dealt with. In addition, several case studies covering USA, India, China, Europe, etc are included to address a variety of issues relevant to sustainable water resources management.

As a reference, the book will provide readers in-depth understanding of and comprehensive information on the principles of sustainable water resources management, recent advances, directions toward future research and development of policy for sustainable water resources management. We hope that this book will be of interest to students, scientists, engineers, government officers, process managers and practicing professionals.

The editors gratefully acknowledge the hard work and patience of all the authors who have contributed to this book. The views or opinions expressed in each chapter of this book are those of the authors and should not be construed as opinions of the organizations they work for. Special thanks go to Mr. Pratyush Chaturvedi, GIEES, USA, for his thoughtful comments and invaluable support during the development of this book.

Chandra S. P. Ojha, Rao Y. Surampalli, András Bárdossy, Tian C. Zhang, and Chih-Ming Kao

About the Editors

Chandra S. P. Ojha, Ph.D., F.ASCE, is a Professor in Civil Engineering Department of Indian Institute of Technology, Roorkee. He holds a Ph.D. in Civil Engineering from Imperial College of Science, Technology and Medicine, London, U.K. He has published more than 200 research papers in peer-reviewed journals and supervised/co-supervised 43 PhD theses and 100 M.Tech. dissertations. His research interests include modeling of water resources and environmental engineering systems with a focus on Food and water security related problems. He has worked as Editor for Journal of Indian Water Resources Society and also as guest editor for couple of special issues. Dr. Ojha has been a Commonwealth Research Scholar as Imperial College of Science, Technology and Medicine, London, U.K. (Oct. 1990-Sept. 1993); Visiting Scholar at Louisiana State University, USA. (April-July 2000); Alexander Von Humboldt Fellow at Water Technology Center, Karlsruhe, Germany (Dec. 2001-July, 2002); Guest AvH Fellow, Institute for Hydromechanics, University of Karlsruhe, Germany (Jan. 2002-July, 2002); and Visiting Professor, Civil Engineering, AIT Bangkok (Aug. 2004-Nov. 2004). He has coordinated/co-coordinated several international research projects involving EU, Germany, France, Canada, U.K. and USA. He was conferred BCEEM by American Academy of Environmental Engineers in 2011 and E.M. Curtis Visiting Professorship by Purdue University in 2012. He received State of the Art of Civil Engineering Award from ASCE in 2014.

Rao Y. Surampalli, Ph.D., P.E., Dist.M.ASCE, is President and CEO of the Global Institute for Energy, Environment and Sustainability. He received M.S. and Ph.D. degrees in Environmental Engineering from Oklahoma State University and Iowa State University, respectively. He is a Registered Professional Engineer in the branches of Civil and Environmental Engineering, and also a Board Certificate Environmental Engineer (BCEE) of the American Academy of Environmental Engineers (AAEE) and Diplomate of the American Academy of Water Resources Engineers (DWRE). He is an Adjunct Professor in seven universities and distinguished/honorary professor in four universities. Currently, he serves, or has served on over 70 national and international committees, review panels, or advisory boards including the ASCE National Committee on Energy, Environment and Water Policy. He is a Distinguished Engineering Alumnus of both the Oklahoma State and Iowa State Universities, and is an elected Fellow of the American Association for the Advancement of Science, an elected Member of the European Academy of Sciences and Arts, an elected Member of the Russian Academy of Engineering, an elected Fellow of the Water Environment Federation and International Water Association, and a Distinguished Member of the American

Society of Civil Engineers. He also is Editor-in-Chief of the ASCE Journal of Hazardous, Toxic and Radioactive Waste. He has authored over 600 technical publications in journals and conference proceedings, including 14 patents, 18 books and 115 book chapters.

András Bárdossy, Ph.D., is a Professor in Hydrology and Geohydrology in Institut für Wasserbau. He holds a Ph.D. (Mathematics) from ELTE University of Budapest, 1981 and Dr.-Ing. in Civil Engineering from University of Karlsruhe, Germany, 1993. His major research areas are Hydrological modelling, stochastic hydrology, space-time statistics, stochastic simulations, multivariate statistics and general uncertainty quantification. He has supervised 38 PhD theses. He is member of the Scientific Committee IHP-OHP National Program (2005 onwards); Recipient of the Henry Darcy Medal of the European Geosciences Union (2006); member of the Scientific Board of the Umweltforschungszentrum Leipzig (2006–2010); Member of the Senate Commission Water of the German Science Foundation (DFG) (2006–2010); Member of the Senate Commission Sonderforschungsbereiche of the German Science Foundation (DFG) (2009 onwards) and External member of the Hungarian Academy of Sciences (2013 onwards). He has been Associate Editor of Journal of Hydrology (1997–2008), Hydrology and Earth System Sciences (2004 onwards), Hydrology Research (2000–2012) and Water Resources Research (2003–2011). He is Chief Editor of Journal of Hydrology (2008 onwards). He was Visiting Research Associate Professor at the University of Waterloo, Canada (1986–1987). Since 2013, he is Research Professor at the Newcastle University, England and since 2014, he is Honorary Professor at the University of KwaZulu Natal, Durban, South Africa.

Tian C. Zhang, Ph.D., P.E., is Professor in the department of Civil Engineering at the University of Nebraska-Lincoln (UNL), USA. He received his B.S. degree in Civil Engineering from Wuhan University of Technology, China in 1982, his M.S. degree in Environmental Engineering from Tsinghua University, China in 1985, and his Ph.D. in environmental engineering from the University of Cincinnati in 1994. He joined the UNL faculty in August 1994. Professor Zhang teaches courses related to water/wastewater treatment, remediation of hazardous wastes, and non-point pollution control. Professor Zhang's research involves fundamentals and applications of nanotechnology and conventional technology for water, wastewater, and storm water treatment and management, remediation of contaminated environments, and detection/control of emerging contaminants in the environment. Professor Zhang has published more than 110 peer-reviewed journal papers, 62 book chapters and 10 books since 1994. Professor Zhang is a member of the Water Environmental Federation (WEF), and Association of Environmental Engineering and Science Professors (AEESP). Professor Zhang is a Diplomate of Water Resources Engineer (D.WRE) of the American Academy of Water Resources Engineers, Board Certified Environmental Engineers (BCEE) of the American Academy of Environmental Engineers, Fellow of American Society of Civil Engineers (F.ASCE), and Fellow of American Association for the

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Chih-Ming (Jimmy) Kao, Ph.D., is a chair professor in the Institute of Environmental Engineering at National Sun Yat-Sen University, Taiwan. Prof. Kao is also the Coordinator of Environmental Engineering Program at Ministry of Science and Technology, President of The Chinese Institute of Environmental Engineering, and former President of The Taiwan Association of Soil and Groundwater Environmental Protection. Prof. Kao received his MS and Ph.D. degrees in Civil and Environmental Engineering from North Carolina State University in 1989 and 1993, respectively. He is a fellow member of International Water Association (IWA), American Society of Civil Engineers (ASCE), an Academician of European Academy of Sciences and Arts (EASA), a fellow member of American Association for the Advancement of Science (AAAS), a fellow member of Environment and Water Resource Institute (EWRI), a Registered Professional Engineer in the branch of Civil Engineering, a Certified Ground Water Professional, and a Professional Hydrologist in the United States. He is also a Diplomate of the American Academy of Environmental Engineers and Diplomate of American Academy of Water Resources Engineers. Prof. Kao received the "Distinguished Researcher Award" from Taiwan Ministry of Science and Technology in 2011 and 2015. He is also the receiver of the "Distinguished Engineer Professor Award" from Chinese Institute of Engineers in 2012, and receiver of the "Distinguished Honor Award" from C.T. Ho Foundation in 2013. He also received several awards from ASCE including the State of the Art of Civil Engineering Award in 2013, Samuel Arnold Greely Award in 2012, and distinguished theory-oriented paper award in 2008 and 2015.

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