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The Yamuna River Basin

Water Resources and Environment

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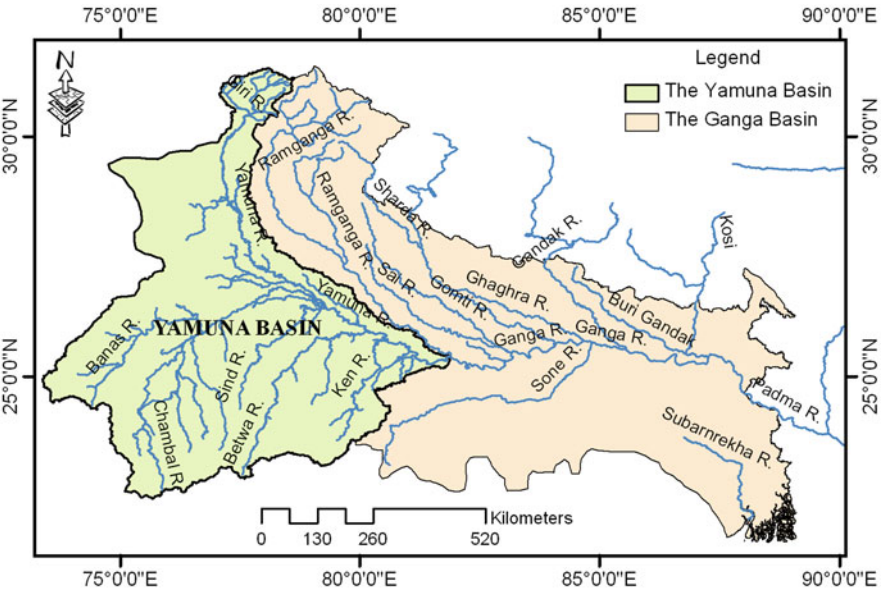

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The Yamuna River Basin

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Preface

Challenges faced by more and more countries in their struggle for economic and social development are increasingly related to water. Water shortages, quality deterioration and flood impacts are among the problems which require greater attention and action. Globally the good quality of water for various uses has been scarce. Therefore, its management and allocation to meet out the various demand such as domestic, agriculture, industrial and environmental become important. However, in many cases due to involvement of inter-state and inter-country boundaries, the water disputes have been become a common feature leading to poor management of water resources and trans-boundary issues in the basin. To overcome this issue, various river basin authorities have been come into picture worldwide. India has also constituted various river basin authorities for better integrated water resources managements (IWRM), such as Ganga River Basin Authority, Narmada Valley Development Authority, Bhagirathi River Valley Development Authority, Upper Yamuna River Board, etc under Ministry of Environment and Forests and Ministry of Water Resources of Government of India; and State Governments. The IWRM is a participatory planning and implementation process, based on sound science, which brings stakeholders together to determine how to meet the society's long term needs for water resources while maintaining the essential ecological services and economic benefits. IWRM helps to protect the world's environment, foster economic growth and sustainable agricultural development, promote democratic participation in governance, and improve the human health. In IWRM, evaluation of natural resources is one of the major components, which requires scientific approaches.

Further to this, in India several river basins exist. Among many others, the Ganga River Basin forms nearly twenty six percent of total geographical area of the country which supports forty three percent of its population; of which Yamuna basin contributes approximately 40.2% of the drainage area of the Ganga River basin. Beside this, Yamuna River is amongst the most polluted rivers of India, which carries huge magnitude of wastewater from various urban centers and industrial towns. More than 14 towns/cities are civilized along the river banks, of which National Capital Region of Delhi (NCR-Delhi) is one of them. Due to wastewater disposal in the river, water quality has been deteriorated and is further aggravated due to less water availability during the lean periods (i.e. November to June). Considering this situation, the importance of detailed study on Yamuna River Basin has been

increased, which form the basis to write a book that follows the concept of IWRM. This book "The Yamuna River Basin: Water Resources & Environment" has been designed from our continuous efforts from last three years. This book not only provides the good understanding and insight into the Yamuna River basin but also can be used as guidelines for carrying out the integrated evaluation of water resources for other river basins of India.

This book has been organized into thirteen chapters starting from the introduction to the River Basins of India to the Crop Management Plan for Yamuna basin for water resources management. Chapter 2 provides brief idea of Yamuna River basin along with inter-state water sharing. The detailed analyses of climatic characteristics of the basin have been presented in Chapter 3. This chapter also includes the development of isopluvial map along with the spatial variation of climatic parameters important to the water resources and agricultural planning. In recent years, the climate change has been come out as a major issue, and therefore, the impact of climate change is included in Chapter 4 of this book. This chapter presents detailed statistical methods for investigating the changes in climatic pattern in the Yamuna basin. The spatio-temporal variability in the climatic parameters has been adequately described through mapping and tabular results.

In Chapter 5, topography, geomorphology and geology of basin have been addressed in details. This chapter also includes the detailed analysis of geomorphological characteristics of the basin and their catchments, which are further used to derive the catchment wise unit hydrographs in Chapter 7. The soil, landuses and agriculture of the basin have been covered in Chapter 6. Detailed analyses of spatial variability of these parameters are presented in this chapter. Chapter 7 include the detailed analysis of socio-economics of the Yamuna basin starting from the demographic variation to employment followed by the poverty index and human development index (HDI) for the basin.

Chapter 8 include the catchment wise water budgeting for analyzing the surplus and deficit catchments in terms of water resources, so that adequate attention can be made for integrated water resources management. A brief methodology of flood estimation based on the approach suggested by Central Water Commission and Geomorphological Unit Hydrograph has been presented for hydrological design in the catchments.

Water pollution is the major concern of the Yamuna River, and therefore, thoroughly covered in Chapters 9, 10 and 11. The Chapter 9 presents the critical issues of the Yamuna River as far as the quality is concern. This chapter also includes the water quality parameters and their role on human body and aquatic system with their standard limits given by Bureau of Indian Standard (BIS), World Health Organization (WHO) and Central Pollution Control Board (CPCB). However, the wastewater analysis including the available treatment capacities, trends and gap has been discussed in Chapter 10.

The Chapter 11 gives a better insight into the water quality indices (WQI) and their application for assessing the water quality. In this chapter, little mathematical expression has been added for fast computations. Beside the use of WQI, the water quality trend in the river has been analyzed using the actual data. The water quality

analysis has been further carried out using the bio-mappings of dissolved oxygen through the river length.

In Chapter 12, a detailed methodology on the environmental flow estimation has been presented along with the applications. A methodology for polluted and over exploited rivers has been developed and applied for the Yamuna. The developed methodology is highly useful for such other rivers in India and other countries. In India, nearly 75 percent of utilizable water resources are used in irrigation. Also due to intensive agriculture and changes in climatic patterns, water scarcities are becoming frequent for agriculture, industry, energy and households. Therefore, it is imperative to implement cropping patterns that can lead to reduced agricultural water demand, while preserving farmers' economic returns. To consider this issue, a detailed analysis of crop water demand has been carried out at district level in Chapter 13, and suitable crop plan has been suggested for entire basin at district level.

For writing this book, a vast analysis of data has been done. The data agencies, such as Central Pollution Control Board (CPCB), Central Water Commission (CWC), State Pollution Control Boards (SPCBs), Planning Commission of India, Survey of India, Agricultural Departments, Indian Council of Agricultural research (ICAR), Census Department, etc are duly acknowledge for supplying the good quality of data. Published literatures and documents were also used while writing the manuscript and are duly referred at the last of each chapter. If by chance the reference is missing, we are highly acknowledged to them.

The book will be useful to the engineers, agricultural scientists, environmentalist, planners, managers and administrators who are concerned with water resources.

Authors would like to take this opportunity to express their deep gratitude to our colleagues for their constructive suggestions and encouragement throughout the work. Special thanks are also due to Dr. R. C. Trivedi, Former Director, Central Pollution Control Board; Dr. Ajay Pradhan, Managing Director, DHI (India) Water & Environment Pvt Ltd, New Delhi; Dr. R. Dalwani, Director and Mr. S. K. Srivastava, Deputy Director of National River Conservation Directorate, Ministry of Environment & Forests, Government of India; Mr. Praveen K. Gupta, Former Director, Central Water Commission; Mr. Nitin Joshi, Research Scholar, Indian Institute of Technology Roorkee; and Mr. Prashant Eknath Kadam, Mr. Pankaj Sinha and Ms. Sagarika Rath from DHI (India) Water & Environment Pvt Ltd, New Delhi for their support and kind cooperation.

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Chapter 1
River Basins of India and Water Resources

Abstract This chapter deals with a brief description of river basins of India and their water resources, including two ways of river basin classification. The basis for classification comprises geological and topographical conditions, and catchment size. Both surface and ground water resource potential are summarized in order to understand the baseline of river basins of India.

A drainage basin is defined by the point on the stream or river, meaning the land area that drains into this point, called outlet. This land area receives water from precipitation (i.e., rainfall or snowfall) and drains downhill into river, lake, reservoir, sea or ocean. The drainage basin acts like a funnel, collecting all the water within the area covered by the basin and channeling it into a waterway. It is the drainage basin where much of the hydrologic action takes place. Indeed it can be called as the natural laboratory of hydrology. India is the land of various water bodies running from north to south and east to west.

1.1 River Systems

India's rivers are classified as Himalayan, peninsular, coastal, and inland-drainage basin rivers. Himalayan rivers are snow fed and maintain a high to medium rate of flow throughout the year. The heavy annual average rainfall amounts in the Himalayan catchments further add to their flow. During the monsoon months of June to September, the catchments are prone to flooding. The peninsular rivers are rainfed, whereas coastal rivers are found in the western part of India and they are short and periodic. Coastal streams, especially in the west, are short and episodic. Rivers of the Inland system, centered in western Rajasthan, are few and frequently disappear in years of scant rainfall. The majority of South Asia's major rivers flow through broad, shallow valleys and drain into the Bay of Bengal. The river systems of India, including the Indus basin, are shown in Fig. 1.1.

1.1.1 Himalayan Rivers

The principal Himalayan Rivers are the Indus, the legendary Ganga and the Brahmaputra. These rivers are both naturally snow fed and rainfed and hence perennial throughout the year. Himalayan rivers discharge approximately 70% of

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