



Susanta Kumar Chakraborty

Riverine Ecology Volume 2

Biodiversity Conservation,
Conflicts and Resolution



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*To all of my teachers and mentors
who taught me with precious academic
stimulation and exposed me in the gamut of
nature to love and learn her mysteries*

Preface

Since times immortal, rivers have been recognized as the lifeline of human civilizations by acting as the provider of almost all kinds of resources required for the sustenance of human beings. Human beings by virtue of their intelligence and innovative knowledge had tried to reap the benefits provided by rivers for centuries; neglecting and ruining the ecological balances of rivers and other associated aquatic ecosystems maintained by way of its ecosystem functioning and in the process contribute profusely in disrupting the biogeochemical cycles and cause hindrance in the sustenance of sustaining mother earth.

Biodiversity is the potential and necessary structural ingredient for the functioning of river, coping up with natural and human-mediated ecological changes. Riverine ecosystem with a network of streams exhibits ecological variability over space and time, displaying high degrees of longitudinal, lateral, and vertical connectivity among the aquatic networks.

Writing up this book had an intention to cover different dimensions of riverine ecology giving due emphasis on synergistic impact of pollution-mediated environmental perturbation on the riverine ecosystem in general and on biodiversity in particular. Simultaneously, biodiversity potential of the riverine networks in aiding the resistance and resilience of riverine ecosystem functioning and their synergistic effects on ongoing environmental perturbations have been addressed, citing case studies mostly from tropical environment of the state of West Bengal, India. More stress was laid on explaining the adaptabilities of the organisms against changing ecological conditions. Besides, several methodological tools pertaining to the studies of water and its biological wealth with underlying identification and documentation principles, eco-monitoring of environmental changes, biodiversity assessment and conservation especially by people's perceptions, ecological impacts of human intervention, restoration and conservation strategies adhering to basic ecological principles, and bio-eco-statistical formulations have been made. However, not only have the teaching and research on general biology developed at a fast pace in the past couple of decades but new methods and topics have also been adopted in subjects like ecology and limnology. Besides, burning global issues such as climate change

and biodiversity have become the focal points in research and planning, and they have finally entered into the political arena.

This book is about the distribution and abundance of different types of organisms and about the physical, chemical but especially the biological features and interactions that determine these distribution and abundances. This book explores the challenges in linking up the biodiversity wealth of rivers with other ongoing burning sociopolitical issues in the global, national, and regional perspectives in order to develop appropriate eco-management strategies for the governance of the rivers (sustainable and equitable distribution of fresh water with other resources) highlighting the advantages and disadvantages of various approaches of such management practices to make them suitable and acceptable for the coming days.

This book attempts to highlight the distinctiveness of river ecosystem, tracing troubled relations with power and politics for centuries centering on the human-mediated perturbation and onslaught on this sensitive, but productive landscape for exploitation of biodiversity. The publication of this book also has intended to draw attention to and also enlighten academicians, researchers, administrators, and planners about the multidimensional aspects of river ecology from both theoretical and practical views. This book is dedicated to those interested in the natural and social sciences, especially for the students and researchers of ecology, environmental sciences, environmental planners, and administrators, for their understanding of the elements pertaining to the functioning of river ecosystem, sensitivity, and vulnerability through different, already established relevant underlying scientific principles, hypotheses, and theories, and different strategies of eco-restoration alongside sustainable eco-management of rivers and aquatic ecosystems with an emphasis of socioecological perspective.

Considering and recognizing the critical roles played by the rivers in promoting and boosting the growth of human civilizations across the globe, human beings have been interacting with rivers and their floodplains over millennia. A multitude of different natural and human-induced stresses on different river ecosystems across the globe and the resultant harmful effects on the physical, chemical, geological, and biological components of rivers and different methods of rehabilitation, reclamation, remediation, and restoration for the integrated and holistic eco-management and nourishment have been addressed giving emphasis on socio-economic-political perspectives. Society attaches many values on the intellectual creativity as an essential component to elevate the excellence in science and that excellence in science in turn appears to become an essential factor promoting most effective and cost-efficient management of river resources.

The entire book has been written putting more emphasis on five major keywords: ecology, biodiversity, pollution, sociopolitical issues and conservation (restoration and methods). An overview of the material is given at the beginning of every chapter in the form of an abstract. The subject “**river ecology**” has been dealt with by detailing its multidimensional facets with subject contents distributed in six elaborate chapters starting with **Chapter 1, Introduction**, briefly highlighting main objectives and contents of this book; **Chapter 2** discusses **physico-chemical parameters** in respect of temporal and spatial variations. **The subject biodiversity**

deals mainly with the inventory of the basic biodiversity components and ecological information of river biodiversity, which include biodiversity of macrophytes, microphytes, and microbes (bacteria and fungi). **Chapter 3** mainly discusses on **eco-ethological aspects of river fishes, and Chapter 4 attempts to project the diversity of wildlife which abound the main riverine flows, in the riparian forests, and also other terrestrial biomes in and around the river basins.** **Chapter 5** deals with **river pollution**, mostly highlighting the major sources, properties, and ecological impacts of different pollutants causing perturbation in river ecosystem; **Chapter 6** deliberates the relationships of **Land uses, flood plains, and dams with rivers**, and different anthropogenic interventions on riverine flows such as construction of dams, dikes, interlinking of rivers, irrigation channels, power plants and also attempted to point out conflicts there off because of their environmental consequences. **Chapter 7** dealing with **river-politics and conservation** focuses on sustainable river management and conservation highlighting the present state of problems and prospects. **Chapter 8** discusses **river restoration** of eco-degraded riverine systems citing case studies following existing and newly developed conservation strategies with the involvement of socio-political-economical components pertaining to river resource shadings and sustainable river management. **Chapter 9** on **methodologies** deals with river studies ranging from taxonomic documentations, statistical analyses, pumping methods for assessing water availability, biodiversity studies, and several conservation methods especially through peoples participation such as Sacred Groove, Participatory Rural Appraisal (PRA) methods, and the last chapter (**Chapter 10**), **Conclusion, elaborately sums up the entire subject matters of the book touching on the salient aspects** of river biodiversity, fish, wildlife, pollution, land uses, politics, restoration, and methods for eco-assessment and conservation.

This book is organized with an introductory chapter (Chapter 1) preceding nine other chapters detailing the subjects like biodiversity (flora, fauna-zooplankton, benthos, fishes, wildlife), fish and river, wildlife and river, land use changes, river politics, eco-restoration, sustainable conservation, and relevant bio-mathematical and action-oriented pro-peoples methodologies for eco-assessment of river ecosystem.

After Chapter 1 (Introduction), each of the next eight before an elaborate chapter as **Conclusion**, is organized as the following: it begins with an abstract, followed by the main contents presented under different headings and subheadings incorporating major developments in the subject in the international panorama substantiated by regional case studies. The entire discussion ends with a brief conclusion followed by references and recommendation for further readings. The introduction part of each chapter begins by explaining why the knowledge on the ecological functioning of rivers and their integrations with the history, culture, and economics of human beings are needed for understanding river science and management. Besides, significance of the rationality and relevance of the contents of other chapters has been highlighted to justify their inclusion in this book. Organizing the book in this application-oriented approach is expected to allow the readers to

easily access and locate information along with pertinent interpretations that are needed for their understanding of the subject matters of the relevant chapters.

Chapter 1 Introduction

This chapter pinpointedly touches the salient features of all the chapters within this book, highlighting major subjects.

Chapter 2 Biodiversity: Concept, Theories, and Significance in River Ecology

This chapter at length discusses the regional riverine system in the context of international river biodiversity research focusing on macrophytes, microphytes, zooplankton, benthos, insects, and even fishes and their diversity, distribution, trophic position, and functional roles. The role of biodiversity in the functioning of river ecosystems and providing various ecosystem services are not confined to providing water and biodiversity components, but huge biomass within the river is instrumental for the assimilation and removal of wastes dumped within the rivers by the anthropogenic activities. It is the time to develop proper understanding on the complex relationships between riverine biodiversity and ecosystem services. Besides, several conservation strategies for the riverine biodiversity have been coming up through several trial and error basis depending on the agroclimatic conditions of the regions which include natural breeding and nursery grounds for fishes and other commercially important shell fishes, the protection of pockets of habitats for induced breeding, river ranching, etc.

Rivers support the life of galaxy of fauna including an array of wildlife (higher mammals, smaller mammals, reptiles, testudines, crocodiles, birds, etc.), both aquatic and terrestrial, inhabiting in the riparian forests within river basins. Since the 1980s, especially after the Stockholm Conference in the year 1972 on man and environment, the field of biodiversity grew and flourished forming an amalgam of several disciplines of sciences and even social sciences, especially to ensure sustainable conservation within the political and economic realms influenced by the science through policy formulation. Sustainable development is being recognized as the best option for meeting the both ends, conservation of biodiversity and elevating the standard of living of human beings by judicious utilization of bioresources.

Chapter 3 Ecology of Fishes of Rivers: Functional Roles

Although the science of fishery in the riverine ecosystem emerged around century back with the thrust areas of identification and taxonomic classification of fishes, which were followed by the studies on biology, life cycles, migration, and relationship with other aquatic organisms, the conservation approach in fishery science in India that gained momentum after the 1980s, alongside the conservation of some iconic species such as gharial and dolphin. This presenting data on fish and fisheries of river system mainly emphasize on the functional roles of the fishes toward ensuring the stability of river ecosystem, mainly by projecting several recent studies on the ecological guilds of fishes, impact of temperature stress on the fresh water carp species in view of global climate change, roles of fishes not only as the prime driver of aquatic food webs but also their roles as ecological indicators for the eco-monitoring as well as their utility for the riverine eco-restoration.

Chapter 4 Diversity and Conservation of Wildlife Associated with Rivers: An Eco-ethological Analysis

This chapter deals with wildlife (amphibians, reptiles, birds, and mammals), not only restricted on projecting the diversity of wildlife with brief classificatory scheme but also attempted to provide information on their evolutionary origin, geological background of their distribution, relationships among the existing wildlife of different continents, behavioral manifestations and the determining eco-physiological reasons, and conservation strategies. It should be realized that rhinos, swamp deer, and elephants and many other large herbivores dependent upon the rivers are as much a part of the river's biodiversity as the fish and dolphin. It is surprising that the birds entirely dependent upon the rivers have received little attention.

Chapter 5 River Pollution and Perturbation: Perspectives and Processes

The river ecosystems all over the world have been greatly perturbed by human activities. The chapter at length discusses on the sources, and properties of the pollutants and their mode of action on the living and nonliving structural components of rivers. In order to deal with the scarcity and deteriorating qualities of freshwater of rivers, water in view of ongoing industrialization and urbanization, as well as high input from modern agriculture, may lead to considerable changes in water quality characteristics in urban areas as well as in rural areas. The needs and principles for monitoring such changes are discussed

Chapter 6 Landuse Changes: Floodplains, Dams, and Reservoirs – Integrated River Basins Management

It is also shown that large-scale water regulation projects, for example, dams, may create conflicts between proponents for a utilization of the regulation capacity for hydropower generation policies and those favoring the use of the regulating capacity for agricultural purposes.

Chapter 7 Ecobiopolitics, Policies, and Conservation Strategies of Rivers

Besides formal procedures, a number of informal tools in terms of economic sanctions and the use of nonformal institutions may be of considerable importance both for avoiding and for the handling of conflicts. Conflict management is, however, complicated by a number of circumstances. Illustrations of practical experiences from developed as well as developing countries show that political interference and well-established routines in the administrative setup might, indeed, underline conflicts or hamper a rational management. Likewise, it is argued that unpredictable conflicts may complicate a smooth conflict management. It is argued that with increasing socioeconomic development, it is necessary to pay due attention to environmentally sound planning and evaluation procedures. By applying an ecosystem view on resource utilization, the potentials and limitations can be rationally assessed with regard to a sustainable utilization. A sound conceptual framework is also relevant only from a strict environmental point of view. Such a perspective is also called for in the efforts of designing new projects and adjusting existing ones so that human efforts are not drained and financial investments become cost-effective.

Chapter 8 Eco-restoration of Rivers

The continuous and concerted efforts of the human beings to derive as maximum as possible economic benefits from the existing global water resources have resulted for the innovation, invention, standardization, and implementation of an array of technologies for building up numerous built structures in and around river flows, alongside conceiving, developing, and applying operating policies for controlling the river flows and non-judicious exploitations of its resources. All those developments have proved their efficiencies by facilitating navigation; providing higher quantities of reliable water for the purpose of agricultural, industries, and municipal water demands; generating hydroelectric power and energy; and providing increased flood protection, recreation, and other benefits.

In order to harvest as maximum as possible economic benefits over the past half century, many of the rivers of the world have been converted into engineered waterways with the construction of dams, dikes, reservoirs, weirs, irrigation channels, etc. However, rivers and their floodplains have appeared to be the most threatened landscape of the world because of the intimate relationships and dependence of human beings on rivers, which have become stressed from the excessive use, and misuse of their resources, as well as discharging of considerable amount of both point and nonpoint pollutants into the rivers.

Chapter 9 Methodologies for the Assessment of River Ecosystem in Southern West Bengal, India

This chapter includes several subject components pertaining to the assessment and conservation of river ecosystem highlighting some innovative research approaches, which have been developed involving the local people of the area.

Chapter 10 Conclusion

This chapter tries to accommodate the major focus of each chapter, addressing different dimensions of riverine research on biodiversity and eco-management.

Justification of Writing This Book

Ecology, basically the study of the interrelationship between species and their environment, involving such areas as predator-prey and competition interactions, renewable resource management, evolution of pesticide-resistant strains, ecological and genetically engineered control of pests, multispecies societies, plant-herbivore interacting systems, and so on is now an enormous field. The emphasis throughout this book is on the practical application of ecology with the prime objective of unraveling the underlying mechanisms involved in the biological processes for explaining and interpreting the ongoing ecological processes within and also outside of river ecosystem. The book has tried not only to accommodate several pertinent components centering around the riverine biodiversity, its ecology, environmental stresses out of pollution, changes in the land use and development of built structures, and sharing of benefits from the river in the face of ongoing international, national, and regional conflicts among the beneficiary, stakeholders, and social activists, but also to justify the inclusion of the vast canvas of issues pertaining to the biodiversity wealth, crisis, conflicts, remedies, and methods.

As the ecology of rivers all over the world, especially in the developing countries, is under peril, the protection of riverine flows along with all structural components (living and nonliving) is the need of the hour. After realizing that freshwater riverine flows representing a tiny fraction of earth's landscapes has become the lifeline of human beings, scientists, ecologists, and environmental planners have been trying to assess these threatening trends and their root causes in order to take challenge of not only identifying such deterioration of river environmental qualities but also to arrest them. **This integrated interdisciplinary approach** enables chalking out strategies toward a sustainable future of riverine ecosystems. Replacing of lost riverine ecosystem services with economic and technological development-based services has appeared to partially meet the materialistic thrust of human beings, but it seems to be increasingly difficult in the present pace of increasing economic and ecological turbulence.

Despite the monumental achievements in the fields of science and technologies applicable to rivers and associated aquatic landscapes, during the last century, natural disasters like floods and droughts leading to disruption of ecology and economies can no longer be ignored, and such experiences and knowledge derived out of it, can be used to make ecological assessment of the evil effects of pollution, habitat alteration by dam and like built structures, and constructions that jeopardize the basic ecosystem fabrics of river ecosystems. The challenge to combat the ongoing onslaught on rivers and their precious biodiversity is compounded by the unprecedented levels of change in nature which are anticipated to happen over the coming century especially by way of global climate change, population explosions paving the way for more disparity in resource sharing and demographic non-equilibrium, economy and human-centric technological development.

This book reviews the current scientific developments to make them useful for sustainable river management and to ascertain the society to learn its way into an uncertain future. It starts with proper evaluation of riverine water, its properties, basic ecological principles pertaining to biogeochemical cycling, assessment of the geohydrological and biodiversity potential and characteristics, and the trend of eco-degradation within riverscapes so that baseline research information can be generated to support and strengthen the mitigation measures not only to arrest the ongoing damages but also to restore the function of environmental flows and ecosystem services in riverine systems. The scientific perception, realization, and understanding considering the potential of the ecology of freshwater riverine system which was developed century years back as the biologically productive and sensitive running water ecosystem for catering to the need of human beings by providing water and food, alongside shaping the sociocultural profiles of a region. The quest of human being for unraveling the mysteries of river and its associated landscapes have not only been restricted to studies on food resources obtained from rivers but also on the changing ecological status of it with special emphasis on environmental perturbations in the backdrop of the River Continuum Concept.

This book goes a long way toward strengthening the prevailing international approach toward presenting the state-of-the-art information on ecology of riverine networks in tropical environmental condition, representing a unique

bio-geographical sector in the eastern part of the mega diversity tropical country, India. Throughout, the various chapters deal with a wide variety of directions, mainly centering on ecology, biodiversity, perturbations, and management.

In a number of ways, it is increasingly difficult to separate scientific pursuit from an emotional and aesthetic bond in unraveling the mysteries of interlinkages and interdependence of different structural components of rivers, their intricate interaction pathways, and eco-management (conservation ethos and rehabilitation practices). In the quest to develop a logical set of principles in order to interpret the diversity and complexity of the riverine environment, this book is an attempt to communicate the already developed knowledge and understanding on multidimensional subjects in a holistic but as simple as possible way. Although much emphasis was laid on depicting the regional information with an Indian flavor, much endeavor was put on global perspective for developing the concept, hypothesis, and theories pertaining to riverine ecology so that useful guidance in the development of core understanding that is required if management activities are to yield sustainable outcomes.

This book covers a wide range of topics dealing with the ecological interpretation of riverine biodiversity with special emphasis on fishes and wildlife and trend of environmental perturbation due to the harmful impacts from a multitude of toxic substances and also focuses on the fate of all those pollutants and contaminants, different challenges and methods for eco-restoration processes, societal conflicts and politics in respect of water sharing and maintenance of water quality, and different traditional and modern approaches toward the monitoring and conservation of rivers and their resources. From this book, readers are expected not only to learn about the recent outcomes of river biodiversity in an ecological perspective in the face of ongoing threats from pollution and other human-mediated developments (high-tech agriculture, urbanization, industrialization, etc.) but also to understand the basic underlying ecological principles for undertaking sustainable eco-management strategies.

Midnapore, West Bengal, India

Susanta Kumar Chakraborty

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(4) environmental perturbations, and pollution in the river ecosystem; (5) land use changes and relevant ecological consequences; (6) sociopolitical perceptions in sharing the benefits from rivers and conflicts there off; (7) modern approaches of eco-restoration process and sustainable eco-management elaborating relevant methodologies; (8) in addition, the last chapter has dealt with a brief survey of different developments pertaining to the study of riverine ecology with special emphasis on eco-monitoring and conservation. The first chapter as introduction and last chapter (Chapter 10) as conclusion have attempted to discuss most of the thrust areas that were elaborately highlighted in eight other chapters. I shall be failing in my duty not to name some of my research students such as Tridip, Manjistha, Sujoy, Kishalay, Md. Abdullah-Al Helal, Santu, Subhashree, Sayan, Sankarson, Santanu, Ram, Srinjana, Arundhuti, Arijita, Tilottama, Joydev, Sankarson, Ritabrata, Hirulal, Anindita, and Jayanti for their active support and secretarial assistance throughout the entire period of this book preparation. My special thanks are due to Dr. Tridip Dutta, my Ph.D. student, Dr. Ritabrata Roy, my post postgraduate student and Mr. Jagadish Mahata, supporting staff of Vidyasagar University, Midnapore (West), West Bengal, India.

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