



THE Ganges River Basin

STATUS AND CHALLENGES IN WATER, ENVIRONMENT AND LIVELIHOODS



EDITED BY

Luna Bharati, Bharat R. Sharma and Vladimir Smakhtin



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THE GANGES RIVER BASIN

The Ganges is one of the most complex yet fascinating river systems in the world. The basin is characterized by a high degree of heterogeneity from climatic, hydrological, geomorphological, cultural, environmental and socio-economic perspectives. More than 500 million people are directly or indirectly dependent upon the Ganges River Basin, which spans China, Nepal, India and Bangladesh. While there are many books covering one aspect of the Ganges, ranging from hydrology to cultural significance, this book is unique in presenting a comprehensive interdisciplinary overview of the key issues and challenges facing the region.

Contributors from the three main riparian nations assess the status and trends of water resources, including the Himalayas, groundwater, pollution, floods, drought and climate change. They describe livelihood systems in the basin, and the social, economic, geopolitical and institutional constraints, including transboundary disputes, to achieving productive, sustainable and equitable water access. Management of the main water-use sectors and their inter-linkages are reviewed, as well as the sustainability and trade-offs in conservation of natural systems and resource development such as for hydropower or agriculture.

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COVER AND CHAPTER PHOTOS

Cover photos

Top: Arun valley on the border between Bhojpur and Sankhuswabha district, eastern Nepal, Fraser Sugden (IWMI), September 2010.

Middle left: Frozen river at 4,800m descending from the glacial Lhonak Valley in the Kanchanjunga region, Taplejung district, Nepal. Fraser Sugden (IWMI), November 2007.

Middle centre: Generating energy using solar panels to pump water for agriculture. Sukhdev Vishwakarma and his daughter Meenu, both farm workers, use water pumped from a solar water pump at the farms of Gurinder Singh, a farmer with a land-holding of 80 acres in Jagadhri, India. Prashanth Vishwanathan (IWMI), 13 November 2014.

Middle right: General view of the Ganges River at Varanasi, India. Neil Palmer (formerly IWMI), October 2014.

Bottom: Paddy cultivation in Rajarhat, located east of Kolkata, India. The skyscrapers of the modern township of Newtown can be seen in the background. Chhandak Pradhan (IWMI), 31 January 2012.

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FOREWORD

The Ganga: between faith and reality



The Ganga – one of South Asia’s largest rivers – is also undoubtedly the most revered river in the world. Its spiritual and cultural significance remains undiminished in the hearts and minds of people since time immemorial. Even today, many refer to it as ‘Ganga ji’, adding the suffix as a mark of respect. Ma, mythical, majestic, mighty – are words commonly used in conversations to describe Ganga. They derive from its multiple identities, forms, size and above all its powerful hold on the human mind across ages.

Jawaharlal Nehru, India’s much admired first Prime Minister, wrote in his will and testament: ‘The Ganga beloved of her people, round which are intertwined her racial memories, her hopes and fears, her songs of triumph, her victories and her defeats. She has been a symbol of India’s age-long culture and civilization, ever-changing, ever-flowing and ever the same Ganga.’ A statue of Ganga adorns the royal palace at Mul Chowk in Patan, Nepal, which was built by the Malla kings in the 1600s.

Most Hindus also worship the River Ganga as a goddess. She is the consort of Lord Vishnu, the progenitor in the Hindu trinity along with Brahma the creator and Shiva the destroyer. For devotees, the river is a physical manifestation of the goddess. This belief endows her waters with mythical powers. According to Hindu scriptures a mere drop of *Gangajal* (Ganga water) or the sight or even remembrance of Ganga can absolve its faithful of all sins.

This belief derives from the popular myth of Ganga narrated during childhood over millennia to most of the Basin population. According to the story, the goddess Ganga descended to Earth in response to the prayers and penances of Prince Bhagirath to liberate the souls of his ancestors by sweeping over their ashes. This story is so strongly imprinted in the Hindu mind that to this day Hindus all over the world desire that their ashes be immersed in the Ganga so that they can attain *moksha* or salvation.

Ganga is known by over 100 names based on her different forms and legends of origins and powers. Some of the more common names are *Jahnvi* (daughter of the sage Jahnu), *Vishnupadi* (emerging from the foot of Lord Vishnu), *Trilokapathagamini* (one who traverses the three worlds, Heaven, Earth and the netherworld), *Mokshadaayani* (provider of salvation), *Paapharini* or *Paapvinaashini* (sin-cleansing) and *Sursari* (river of the gods) among others. Each name and legend creates a different image in the mind of the listener.

All along the course of the River Ganga and many of its tributaries every day, in fair weather or foul, thousands of devotees can be seen worshipping at its banks, performing numerous rituals offering obeisance to the river, the sun and the Almighty. The faithful turn to the rising sun at dawn to perform the *aachaman* (the ritual purification sip before praying); having faith that *Gangajal* is pure, they take dips or bathe in the river even at Gangotri where the water is icy cold. Hindus cremate the dead on the river banks followed by the ritual purifying bath. Many devotees offer flowers and garlands to the river at the banks while some ride in boats to the middle of the river. At many pilgrim towns the main worship ritual is the evening *aarti* (prayer) when the faithful gather on the river banks to pray *en masse*. At the end they place colourful flowers and *diyas* (small earthen lamps) on leaves and release them to float on the river water. Ganga Aarti (prayer) at Haridwar, Prayag and Varanasi is the most mesmerizing. All 6,000 rivers of Nepal also eventually flow into the Ganga so are a part of the Ganges Basin. Many rivers such as the Bagmati, Kali, Gandaki etc. are considered holy by both Hindus and Buddhists. There are also many temples and shrines along the banks of the rivers such as the Pashupatinath Temple, which is an important pilgrimage site for people from both India and Nepal.

While the Ganga is worshipped by most Hindus and Buddhists, people of other faiths also revere it. Muslim artisans make *kaanwars* for millions of Hindu devotees who gather *Gangajal* at Haridwar and other towns on the banks of the river during the annual *kaanwar yatraa* festival. Many of these artisans also revere the river. In recent years hundreds of burqa-clad Muslim women in Bhagalpur have begun taking part in the *kaanwar yatraa*. In some districts of Bengal, Hindu and Muslim boatmen are known to pray to Ma Ganga. The third Sikh Guru, Guru Amar Dass, was fascinated by the Ganga. He visited Haridwar regularly during his lifetime and performed prayers on its banks. The might of the Ganga also finds reference in Buddhist narratives.

A variety of festivals sustain the legends of River Ganga and people's faith. Perhaps the most famous festival is the Kumbh Mela. It is held every four years by rotation at Haridwar and Allahabad (both on the Ganga), Nashik (Godavari) and Ujjain (Kshipra). Bathing in these rivers during the festival is said to cleanse a person of all sins. In recent years the festival has attracted tens of millions of devotees from all over the world, making the Kumbh Melas the largest human gatherings on Earth. Once in six years, an Ardh Kumbh (half Kumbh) Mela is held between the two Kumbhs at Allahabad and Haridwar.

Every year in the month of *Jyeshtha* (May–June) the Ganga Dussehra, observed all along the river's course, celebrates the descent of Ganga to Earth. Twice every year there is the *kaanwar yaatra*, a small one around *Shivratni* (around March) and then the major one during the monsoon month of *Saawan* (July–August). During the *kaanwar* festival Ganga worshippers walk back to their homes carrying *Gangajal*, without allowing the pot to touch the ground, to anoint a local Shiva *lingam*. In recent years the number of *kaanwariyaas* visiting Haridwar during *Saawan* has grown to well over a million. Thus these festivals add substantially to the local economies. They have also helped make Ganga a cradle for several important pilgrimage towns and locations.

By extolling the forms, virtues and powers of River Ganga, poets, singers, philosophers and writers have kept alive its pre-eminence for millennia. While little-mentioned in the early Rig Veda, the Ganga's importance is highlighted in the later three Vedas. In ancient times Valmiki, sometimes referred to as India's first poet and author of the Ramayana epic, describes the Ganga as full of whirlpools at places, sometimes flowing gently and sometimes braided. Its banks are celestial playgrounds frequented by gods (*devaas*), demons (*daanavas*) and celestial singers (*gaandharvas*) among others. Its body is home to cranes, swans, other birds and lotuses. The poet Kalidasa has also written in praise of the Ganga.

In the medieval period Tulsidas, the sixteenth century poet-saint, lived most of his life on the banks of the Ganga in Varanasi. Here he translated Valmiki's Ramayana from Sanskrit into the vernacular *Ramacharitmanas* and composed a number of hymns. Combining his understanding of the Ganga and the Ramayana, Tulsidas intimates that the Ganga represents devotion to Rama. Almost a century earlier, Kabir, the great weaver-poet, had also lived in Varanasi. In his *dohas* (couplets) Kabir often referred to the purity of *Gangajal*. Ganga features prominently in several works of Nobel laureate Rabindranath Tagore. He considered the Ganga as a symbol of India, uniting several centuries of Indian thought and culture. More recently, River Ganga is a setting for the writings of celebrated authors like V.S. Naipaul and Amitav Ghosh. The latter often takes a critical view of the Indians' faith in the Ganga as well as the contradictions between the faith and its practice. Many Bengali authors, poets and musicians have also celebrated the Padma. Traditional *Bhatiyali* songs and *baul* singers celebrate the Ganga and the Padma besides other rivers in West Bengal and Bangladesh. In recent decades maestros like Bhupen Hazarika, S.D. Burman and Salil Choudhary have been inspired by the music of the rivers, creating several popular compositions. The Great Poet of Nepal, Laxmi Prasad Devkota, was cremated at the Ghat of Bagmati River in Pashupatinath Temple.

In the past 50 years, a very limited conception of economic development focusing on massive water extraction for chemicals-based irrigated agriculture, power generation, industries and urbanization has become a growing threat to the very existence of River Ganga – its sanctity, purity and integrity. Several commentators have highlighted the paradox of the rapidly burgeoning number of devotees and their displays of worship on one hand and the total lack of concern for the well-being of the river on the other.

The establishment of the National Ganga River Basin Authority and National Mission for Clean Ganga in 2009 and more recently *Namami Gange* by the Government of India represents recognition of River Ganga as India's civilizational identity and as an ecosystem. It has taken a few initial steps to halt some of the damage done. But piecemeal efforts focusing mainly on cleaning up the river will not be enough. The goals of economic development will have to shift from consumption-driven growth to creating a society that cares for its natural and human resources. The first step has to be the restoration of River Ganga's flows all along its length so that it can flow from its origin to the sea in a manner befitting the majestic goddess that her devotees believe her to be.

This book is a comprehensive treatment of the important aspects of the river, its basin and the millions of people inhabiting it. The scientific rigour and treatment of the varied subjects by the eminent researchers and authors from the three riparian countries – India, Nepal and Bangladesh – and those with international experience make the chapters excellent pieces for understanding and appreciation of the complex issues related to this unique river system. I consider this book as a humble offering to the service of *Ma Gange* and all those interested in its divinity, river science and technology, irrigation and hydropower, people, policies and governance, and transboundary cooperation, and more importantly restoring its health and glory, will find it very useful.

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ACRONYMS AND ABBREVIATIONS

ADB/N	Agricultural Development Bank, Nepal
AHEC	Alternate Hydro Energy Centre
AISMR	All-India Summer Monsoon Rainfall
APP	Agriculture Perspective Plan
AR4	Fourth Assessment Report
AR5	Fifth Assessment Report
AWS	Automated Weather Stations
BCM	Billion Cubic Metres
Bgl	below ground level
BHC	Butylated Hydroxytoluene
BIWTA	Bangladesh Inland Water Transport Authority
BMDB	Bangladesh Meteorological Department Board
BOD5	Biological Oxygen Demand after 5 days
BOOT	Build, Own, Operate and Transfer
BPDB	Bangladesh Power Development Board
BWDB	Bangladesh Water Development Board
BWFMS	Bangladesh Flood and Water Management Strategy
CA	Constituent Assembly
Ca-HCO ₃	Calcium-bicarbonate
Ca-Mg-HCO ₃	Calcium-magnesium-bicarbonate
Ca-Na-HCO ₃	Calcium-sodium-bicarbonate
CEA	Central Electricity Authority
CEGIS	Centre for Environment and Geographic Information Services
CGWA	Central Ground Water Authority
CGWB	Central Ground Water Boards
CGWG	Central Ground Water Board
CMIP5	Coupled Model Intercomparison Project 5
CMORPH	Climate Prediction Center Morphing
CPC	Climate Prediction Centre
CPCB	Central Pollution Control Board
CRU	Climate Research Unit

Acronyms and abbreviations

CSE	Center for Science and Environment
CWC	Central Water Commission
DO	Dissolved Oxygen
DDC	District Development Committee
DDT	Dichlorodiphenyltrichloroethane
DFO	Dartmouth Flood Observatory
DHM	Department of Hydrology and Meteorology
DL	Danger Level
DMC	Disaster Management Centre
DoA	Department of Agriculture
DoE	Department of Environment
DoED	Department of Electricity Development
DoF	Department of Forests
DOF	Department of Fisheries
DoLIDAR	Department of Local Infrastructure Development and Agricultural Roads
DoNPWC	Department of National Parks and Wildlife
DoRH	Department of Roads and Highways
DoSC	Department of Soil Conservation
DPR	Detailed Project Report
DPSIR	Drivers-Pressures-State-Impacts-Responses
DVC	Damodar Valley Corporation
DWIDP	Department of Water Induced Disaster Prevention
DWRC	District Water Resources Committee
DWSS	Department of Water Supply and Sanitation
EDC	Electricity Development Center
EIA	Environmental Impact Assessment
ENSO	El Niño Southern Oscillation
EPADC	East Pakistan Agriculture Development Corporation
EPC	Environment Protection Council
EPWAPDA	East Pakistan Water and Power Development Authority
ETCF	Electricity Tariff Fixation Commission
ETP	Industrial Effluent Treatment Plant
EYC	Eastern Yamuna Canal
FAO	Food and Agriculture Organization of the United Nations
FEWS	Flood Early Warning System
FFWC	Flood Forecasting and Warning Centre
FMIS	Farmer Managed Irrigation Systems
FMP	Flood Management Programme
FRL	Full Reservoir Level
GAP	Ganga Action Plan
GBM	Ganga–Brahmaputra–Meghna
GBSA	Ganges Strategic Basin Assessment
GCM	General Circulation Model
GDB	Groundwater Development Board
GEC	Groundwater Estimation Committee (India)
GFCB	Ganga Flood Control Board
GFCC	Ganga Flood Control Commission
GoB	Government of Bangladesh

Acronyms and abbreviations

GoI	Government of India
GPM	Global Precipitation Mission
GRBEMP	Ganga River Basin Environment Management Plan
GW	Gigawatt
GWh	Gigawatt Hour
GWRDB	Groundwater Resources Development Board (Nepal)
HCH	Hexachlorocyclohexane
HIDC Ltd	Hydroelectricity Investment and Development Company Ltd
HP	Hydropower
I&D	Interception and Diversion
IBN	Investment Board Nepal
ICIMOD	International Centre for Integrated Mountain Development
IEE	Initial Environmental Examination
IIT	Indian Institute of Technology
IITC	Consortium of Indian Institutes of Technology
IITM	Indian Institute of Tropical Meteorology
IIT R	IIT Roorkee
IMD	India Meteorological Department
INR	Indian Rupees
IPB	Industrial Promotion Board
IPCC	Intergovernmental Panel on Climate Change
ISF	Irrigation Service Fees
ISM	Irrigation Service Markets
ISP	Irrigation Service Providers
ISRO	Indian Space Research Organization
IWM	Institute of Water Modeling
IWRM	Integrated Water Resources Management
JAXA	Japan Exploration Agency
JRC	Joint Research Centre
JRC	Joint Rivers Commission
K	Hydraulic Conductivity
KW	Kilowatt
LGC	Lower Ganga Canal
LGED	Local Government Engineering Department
Lpm	Litres per Minute
LTA	Long Term Average
MCM	Million Cubic Metres
MGC	Madhya Ganga Canal
Mg-Na-HCO ₃	magnesium-sodium-bicarbonate
Mha	Million Hectares
MoAC	Ministry of Agriculture and Cooperatives
MODIS	Moderate Resolution Imaging Spectroradiometer
MoE	Ministry of Energy
MoEF	Ministry of Environment and Forests
MoEF	Ministry of Environment, Forest and Climate Change
MoFALD	Ministry of Federal Affairs and Local Development
MoFSC	Ministry of Forest and Soil Conservation
MoI	Ministry of Industry

Acronyms and abbreviations

MoIRR	Ministry of Irrigation
MOM	Maintenance, Operation and Management
MoSTE	Ministry of Science, Technology and Environment
MoUA	Ministry of Urban Affairs
MoWR	Ministry of Water Resources
MPO	Master Plan Organization
Msl	Mean sea level
MSP	Minimum Support Price
MU	Million Units of Electricity
MW	Megawatt
NASA	National Aeronautics and Space Administration
NDC	National Development Council
NDVI	Normalized Difference Vegetation Index
NDWI	Normalized Difference Water Index
NEA	Nepal Electricity Authority
NGO	Non-Governmental Organization
NGRBA	National Ganga River Basin Authority
NMCG	National Mission for Clean Ganga
NPC	National Planning Commission
NWMP	National Water Management Plan (Bangladesh)
NWP	National Water Plan
NWRDC	National Water Resources Development Council
NWRSP	National Water Resources Policy
NWSC	Nepal Water Supply Corporation
O&M	Operation and Maintenance
PERSIANN	Precipitation Estimation from Remotely Sensed Imagery Using Artificial Neural Networks
PHED	Public Health Engineering Department (India)
PPP	Public–Private Partnership
PTA	Electrical Power Trade, Cross–Border Transmission Interconnection and Grid Connectivity Agreement
PV	Photovoltaic
R&R	Rehabilitation and Resettlement
RHWL	Recorded Highest Water Level
RIMES	Regional Integrated Multi-Hazard Early Warning System
RRI	River Research Institute
RRR	Resource Recovery and Reuse
SAARC	South Asian Association for Regional Cooperation
SANDRP	South Asian Network of Dams, Rivers and People
SAR	Synthetic Aperture Radar
SEBON	Securities Board of Nepal
SOD	Stage of Development
SPCB	State Pollution Control Board (India)
SPMG	State Program Management Group
SPV	Special Purpose Vehicle
STP	Sewage Treatment Plant
STW	Shallow Tube Wells
TRMM	Tropical Rainfall Measuring Mission

Acronyms and abbreviations

UGC	Upper Ganga Canal
ULB	Urban Local Body
UNEP	United Nations Environment Programme
USAID	United States Agency for International Development
VDC	Village Development Committee
WARPO	Water Resource Planning Organization
WASA	Water and Sewerage Authority
WCD	World Commission on Dams
WCRP	World Climate Research Programme
WEC	Water and Energy Commission
WECS	Water and Energy Commission Secretariat
WHO	World Health Organization of the United Nations
WMO	World Meteorological Organization
WRD	Water Resources Department
WRS	Water Resources Strategy Nepal
WSS	Water Supply and Sanitation
WSTFC	Water Supply Tariff Fixation Commission
WUA	Water User Association
WYC	Western Yamuna Canal

PART I

Resources and uses

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