NATIONAL GANGA RIVER BASIN AUTHORITY (NGRBA)

Environmental and Social Management Framework (ESMF)

Volume I - Environmental and Social Analysis

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Executive Summary

The river Ganga has significant economic, environmental and cultural value in India. Despite its importance, extreme pollution pressures from increasing population and industrialisation pose a great threat to the biodiversity and environmental sustainability of the Ganga, with detrimental effects on both the quantity and quality of its flows. As a major first step in achieving the Ganga Clean up Initiatives, the Government of India (GoI) constituted the National Ganga River Basin Authority (NGRBA), on 20th February 2009, for the comprehensive management of the river. The World Bank has been formally requested by GOI to provide long-term support to NGRBA through several phases of substantive financing and knowledge support. The first project of several phases of support aims at

i. Establishing and operationalizing central and state level NGRBA institutions capable of planning and implementing a multi sectoral river water quality improvement program
ii. Reducing pollution loads into the river through selected investments.

The specific investments under the first project will focus on the main stem of Ganga flowing through five basin states of Bihar, Jharkhand, Uttar Pradesh, Uttarakhand and West Bengal in India. Specifically, pollution abatement programs will include a range of municipal investments such as sewer networks, waste water treatment facilities, industrial pollution control measures, river front management, solid waste management and other required supportive improvements.

Given the sensitive environmental nature of the project and distributed nature of proposed project investments of NGRBP over a large area in multiple states, the investments under the project are anticipated to encounter a variety of environmental and social issues, including acquisition of private land and resettlement issues. The NGRBP recognizes these issues and is preparing itself to address their mitigation through a set of management procedures elaborated in this Environmental & Social Management Framework (ESMF). The framework identifies the level of safeguard due-diligence required for all categories of sub-projects of NGRBP and provides specific guidance on the policies and procedures to be followed for environmental and social assessment along with roles and responsibilities of the implementing agencies.

The ESMF is broadly organized into two volumes.

- Volume I: Environmental and Social Analysis
- Volume II: Environmental and Social Management Framework

Environmental and Social Analysis

This report has detailed the Ganga basin's economic, environmental and cultural significance. It's importance to India was underscored by a variety of statistics, including the fact that it accounts for 26 per cent of India's landmass, 30 per cent of its water resources and more than 40 per cent of its population at a density nearly twice India's national average. The economic importance of the Ganga basin's rich water resources and fertile soil were evidenced by the fact that the basin supports about 300 million people over an area of approximately 800, 00 sq. km, of which some 100 million are directly dependent on the river and its tributaries. It was also seen that India's holiest river, lending it a significance that cannot be captured by numbers alone.

Despite the obvious importance described in this report, the biodiversity, environmental sustainability and both quantity and quality flows in the Ganga basin face extreme pollution pressures. This report identified industrial pollution as one of the priamry sources of pollution, accounting for 25% of contamination in the basin. Additionally, the fact that only one-third of the sewage generated in the main-stem towns and cities receives treatment before entering the Ganga waters represents another major threat. As was seen earlier, these problems can be viewed as the results of a failure to properly manage urbanization and industrialization, as well as the limited capacity of local water and wastewater utilities to monitor and regulate point source pollution. Other factors, such as non-point source pollution from agriculture and livestock and poor solid waste management, were identified as contributing to pollution levels contribute to the problem. Additionally, low flows, most frequently occuring in the dry season but also fueled by substantial water extraction for irrigation contributes, was seen as contributing to poor water quality in the critical middle stretch of the river.

The report also presented a detailed profile of the Ganga basin, focusing on salient features such as catchment area, river hydrology, relevant tributaries, physiography, environmental features such as aquatic and terrestrial flora / fauna, natural resources, ecological

characteristics, sensitive environmental components. Through these descriptions, a picture emerged of an expansive area with tremndous biodiversity and extensive, if unevenly distributed water resources. The extent of the biodiversity was underscored through detailed descriptions of fauna, as well as information pertaining to the national parks and wildlife sanctuaries in the Ganga basin. The report also presented information on human interentions through land use and water resources development, as well as the environmental impact of those projects in the form of, for example, water logging and salinity problems in irrigated command areas.

In addition to relevant environmental data, detailed information on the socio-economic aspects of the Ganga basin are presented. The information presented revealed a large Ganga basin that is simultanously very dense and largely rural, as well as being relatievly poorer and less literate than India as a whole. On gender issues, the Ganga basin tended to fair better than the Indian average, with many key states having higher work participation and literacy rates than the country as a whole. Healthwise, the primary Ganga basin area was largely on par with India, especially in they key indicator of life expactancy.

The Ganga basin is large and diverse in all aspects imaginable – socially, culturally, geographically, etc. As such, any intervention must manage to both match the tremendous scale of the basin, while paying close attention to each area's unique characteristics. Yet as this report has indicated, the importance of the Ganga to India cannot be understated, nor can its continued need for environmental protection and socio-economic development. The information presented in this report will prove useful in guiding the necessary interventions to help steer the Ganga basin – and India as a whole – towards a more sustainable future.

Environmental and Social Management Framework

The Environmental and Social Management Framework (ESMF) document for the NGRB project outlines all the issues that the proposed project might have on the environment and the people of the Ganga main stem region. It recognizes that the implementation of the river pollution mitigation projects under the National Ganga River Basin Project (NGRBP) is anticipated to encounter a variety of environmental and social issues/problems. Further a set of management procedures are elaborated in this Environmental and Social Management Framework (ESMF) to address these issues.

Initial sections of this report detail out the various types of project portfolios that are proposed, as sub-projects under the ambit of the NGRBA such as solid waste management, sewage treatment plants, industrial pollution control initiatives as well as river front development projects. For each type of project the associated environmental and social impacts have been outlined.

This report also identifies the national, state and local environmental and social regulatory framework that will be applicable to these sub-projects, to ensure that the sub-projects are in compliance with these regulatory requirements. The following are the laws and regulations that are applicable to the environmental and social aspects of the projects to be implemented under NGRBA:

- Policy and Regulatory Framework of Government of India (GoI)
- Environmental Policy and Regulations of the respective State Governments
- Legislations applicable to construction projects
- Operational Policies and Directives of The World Bank

The key environmental laws and regulations relevant to the projects under the NGRBP are also mentioned, along with the reason for their applicability. Among other objectives the ESMF has to ensure that best environmental practices are mainstreamed and integrated during the design, implementation and operation of the sub-projects and it strives to enhance environmental conditions wherever feasible. In addition to the detailed project portfolio, this report also categorizes the sub-projects into:

• *Category I* – Sub-Projects requiring Environmental and Social Assessment and development of RAP
• *Category II* – Sub-Projects requiring implementation of generic safeguard management plans

As a part of the social management framework, the report discussed the issue of resettlement policy and land acquisition in great detail; since it is an important component of the social mandate of a project of this scale. The report clearly mentions that the Project Executing Agency (PEA) will inform the community well in advance about the project, its feature and likely adverse impact if any and also the positive impact of the project, followed by the social screening and preparation of resettlement action plan. Additionally, the report outlines the

procedure to be followed for social impact assessment (SIA) and charts out a clearly defined entitlement matrix as a part of the R&R benefits for the project affected families.

A separate section on indigenous people deals with their specific issues and preparation of an indigenous people management framework, based on National Tribal Policy 2006 of Government of India and World Bank's operational policy 4.10, has also been suggested in this document. Mainstreaming gender equity and empowerment is already a focus area in the project. A basic structure of the gender assessment and development framework and poverty and social impact assessment has also been outlined.

The implementation, monitoring and reporting arrangements for the ESMF have been worked out within the overall institutional structure for implementation of the NGRBA program, as described in the report. Within the overall implementation framework of the NGRBA, environmental and social due diligence will be carried out by the relevant agencies at each stage of the project cycle in accordance with the guidance provided in the ESMF.

The development of the ESMF is based on a consultative process that engaged key stakeholders at the national, state, and local levels and sought their feedback. Key government agencies have been consulted at the various levels to obtain their consent on the ESMF in general and specially on the land acquisition process and resettlement framework. The key insights from these public consultations have been reported in this document.

Chapter 1

National Ganga River Basin Project

1.1 Introduction

The river Ganga has significant economic, environmental and cultural value in India. Rising in the Himalayas and flowing in to the Bay of Bengal, the river traverses a course of more than 2,500 km through the plains of north and eastern India. The Ganga main stem – which also extends into parts of Nepal, China and Bangladesh – accounts for 26 per cent of India's landmass, 30 per cent of its water resources and more than 40 per cent of its population. The Ganga also serves as one of India's holiest rivers whose cultural and spiritual significance transcends the boundaries of the basin.

Despite its importance, extreme pollution pressures pose a great threat to the biodiversity and environmental sustainability of the Ganga, with detrimental effects on both the quantity and quality of its flows. Due to increasing population in the basin and poor management of urbanization and industrial growth, river water quality has significantly deteriorated, particularly in dry seasons. Untreated sewage and industrial wastewater represent the primary sources of pollution, with only one-third of the sewage generated in the main-stem towns and cities receiving treatment before being discharged in the river.

Inadequate wastewater collection and treatment infrastructure/capacity provides the most immediate explanation for this failure, as evidenced by the fact that 25% of pollution in the Ganga comes from the industrial sector. Yet this issue is also intrinsically linked to the weak capacity of local water and wastewater utilities and inadequate environmental monitoring and regulation of point source pollution. Other factors, such as non-point source pollution from agriculture and livestock and poor solid waste management, also contribute to the problem. Decreased flow, common during the dry season but also fueled by substantial water extraction for irrigation contributes to poor water quality in the critical middle stretch of the river.

1.2 Ganga Clean up Initiatives

The Government of India (GoI) has undertaken clean-up initatives in the past. The most prominent of such efforts was the Ganga Action Plan, launched in 1985 later complemented

by a similar plan for the Yamuna, the biggest tributary of the Ganga. These programmes have faced significant public scrutiny and, despite some gains made in slowing the rate of water quality degradation, they have been widely perceived as failure. The main shortcomings of these initiatives were: (1) inadequate attention to institutional dimensions, including the absence of a long-tem-basin planning and implementation framework; (2) little effort made in addressing systemic weakness in the critical sectors of urban wastewater, solid waste management, environmental monitoring, regulation and water resources management; and (3) inadequate scale, coordination and prioritization of investments, with little emphasis on ensuring their sustainability. These programs also did not pay sufficient attention to the social dimensions of river clean-up, failing to recognize the importance of consultation, participation and awareness-raising.

The lessons drawn from these prior experiences indicate that improving water quality in the Ganga cannot be achieved by plugging the infrastructure gap alone. Rather, any effective initiative will have to adopt a three-pronged approach:

- Establishing a basin-level, multi-sectoral framework for addressing pollution in the river (including national/state policies and river basin management institutions);
- Making relevant institutions operational and effective (e.g. with the capacity to plan, implement and manage investments and enforce regulations); and,
- Implementing a phased program of prioritized infrastructure investments (with emphasis on sustainable operations and mobilization of community support)

1.3 The Ganga River Basin Project

As a major first step in achieving the above, the Government of India (GoI) constituted the National Ganga River Basin Authority (NGRBA), on 20th February 2009, for the comprehensive management of the river. The NGRBA will adopt a river-basin approach and has been given a multi-sector mandate to address both water quantity and quality aspects. The NGRBA has resolved that by year 2020, no untreated municipal sewage or industrial effluents will be discharged into River Ganga.

Building on the high-level dialogue with GOI on Ganga, The World Bank has been formally requested to provide long-term support to NGRBA, through several phases of substantive financing and knowledge support. While, the overall technical assistance and program development under the proposed project will focus on the entire Ganga main stem, the initial

emphasis of the specific investments under the first project will focus on main stem of Ganga flowing through five basin states of Bihar, Jharkhand, Uttar Pradesh, Uttarakhand and West Bengal in India. Specifically, pollution abatement programs in cities on the banks of these States which would include a range of municipal investments such as sewer networks, waste water treatment facilities, industrial pollution control measures, river front management and solid waste disposal in the river through improved management in these cities and other required supportive improvements. This is expected to be enabled through several phases of substantive financing and knowledge support.

The first project of such several phases of support aims at;

i) Establishing and operationalizing central and state level NGRBA institutions capable of planning and implementing a multi sectoral river water quality improvement program and;
ii) Reducing pollution loads into the river through selected investments.

To achieve the above, the proposed World Bank assisted National Ganga River Basin Project (NGRBP) envisages two main components.

1.4 Project Components

The project will have two components relating to institutional development and priority infrastructure investments. The first component would seek to build the institutional capacity to effectively implement the overall NGRBA program, including infrastructure investments funded by the second component.

1.4.1 Component One: Institutional Development

1.4.1.1 Objective

The objectives of this component are to: (i) build functional capacity of the NGRBA's operational institutions at both the central and state levels; and (ii) provide support to associated institutions for implementing the NGRBA program. The activities financed under this component are grouped under the following sub-components:

(a) Sub-component A: NGRBA Operationalization and Program Management

(b) Sub-component B: Technical Assistance for ULB Service Providers

(c) Sub-component C: Technical Assistance for Environmental Regulators

1.4.1.2 Sub Component A: NGRBA Operationalization and Program Management

This sub-component is aimed at supporting the nascent operational institutions established for implementing the NGRBA program at the central and state levels on a full time basis. The operational institutions comprise the NGRBA Program Management Group (PMG) at the central level, and SGRCA Program Management Groups (SPMGs) at the state level. The following are the main NGRBA program activities included under this sub-component:

(a) *Insititutional Support to the PMG and the SPMGs*. The sub-compoment will support the initial setup costs of office infrastructure and equipment, incremental professional staffing, as well as provision of critical consultancies, training, and operation costs, for the PMG and the SPMGs. This support would therefore enable these institutions to manage the entire NGRBA program, including the activities and investments not funded under the World Bank project.

(b) *Enhancing Ganga Knowledge Resources*: The sub-component will support the establishment of a state-of-the-art Ganga Knowledge Center (GKC) with the objectives of: (i) serving as the global repository of knowledge resources pertaining to the Ganga; (ii) addressing critical gaps in knowledge; and (iii) improving information access for the public and decision-makers. The GKC will be an integral part of the PMG.

(c) *Communications and Public Participation*: The sub-component will finance a dedicated communications and public participation program, undertaken in partnership with community-based organizations, school and college student groups, and the media. The communications and outreach efforts will build upon the existing vibrant discourse and grassroots campaigns on the Ganga, including those led by some of the civil society members of the NGRBA.

1.4.1.3 Sub component B: Technical Assistance for ULB Service Provider

This sub-component will support the ULBs as well as local-level water and wastewater service providers, through provision of modern and efficient information and planning systems, training, equipment for managing physical systems, and technical assistance for improving revenue/cost recovery to ensure sustainability of local investments.

1.4.1.4 Sub-component C: Technical Assistance for Environmental Regulator

This will support capacity building of the central and state pollution control boards, to address the key constraints related to their functions regarding the Ganga, focusing on improving information systems, staff skills, laboratory accreditation, and infrastructure facilities. Some of the key activities include:

a) *Upgradation of the Water Quality Monitoring System (WQMS)* The sub-component will support a system of automatic and high quality collection of water quality data from more than 100 priority monitoring locations along the mainstem and some important tributaries of the Ganga, addressing the needs for both technical and institutional modernization.

b) *Comprehensive inventorying of pollution sources* The location, flow and pollution loading characteristics of all large point source discharge locations on the main stem of Ganga will be mapped to create a basin-level inventory. Studies will be supported to estimate the extent and relative contributions of the non-point source pollution of various origins. This work, to be implemented in the first year, will start addressing the baseline information needs for the Ganga basin.

c) Strengthening environmental compliance monitoring Surveillance for regulation compliance will be strengthened for the Central and State Pollution Control Boards, by improving information systems and support for incremental staffing.

1.4.2 Component Two: Priority Infrastructure Investments

1.4.2.1 Objective

The objective of this component is to finance demonstrative infrastructure investments[1] to reduce pollution loads in priority locations on the river. The investments are intended to exemplify, among other attributes, the high standards of technical preparation and implementation, sustainability of operations, and public participation envisaged in the NGRBA framework. This component will also support innovative pilots, for new and transformative technologies or implementation arrangements.

[1] Given the generally large size of individual sub-projects that are needed in the priority locations on the Ganga, the available funding is expected to finance a small number of sub-projects (around 10-15 major investments in at most 10 towns/cities).

1.4.2.2 Four Investment Sectors

This component will support demonstrative investments in all the main sectors that are key to addressing the pollution in the Ganga. The majority of investments are expected to be in the wastewater sector, particularly in wastewater treatment plants and sewerage networks. Investments will also be supported in industrial pollution control and prevention (e.g. common effluent treatment plants), solid waste management (e.g. collection, transport and disposal systems), and river front management (e.g. improvement of the built environment along river stretches, improvement of small ghats and electric crematoria, and the conservation and preservation of ecologically sensitive sites). Many investments are likely to combine elements of more than one of these sectors.

1.4.2.3 The Framework Approach

In lieu of defining and appraising specific investments, the project preparation has focused on developing investments framework covering all four key sectors of intervention under the NGRBA program. This single framework will apply to all investments under the NGRBA program, including investments to be financed with the government's own resources. The objectives of the investments framework are to:

a) provide a filter for all the NGRBA investments, for ensuring that the selected investments are well-prepared and amongst the most effective in reducing the pollution loads;
b) make transparent the decision-making process on investments selection; and
c) ensure that the investments are implemented in a sustainable manner.

Given the long-term nature of the NGRBA program and the fact that universe of potential investments is large, the adoption of the framework approach effectively sets the "rules of the game", and will allow infrastructure investments to be selected on a dynamic and ongoing basis.

1.4.2.3.1 Framework Criteria

The investments framework prescribes the criteria and quality assurance standards covering various aspects including eligibility, prioritization, planning, technical preparation, financial and economic analyses, environmental and social management, long term O&M

sustainability, community participation, and local institutional capacity. Examples of key criteria are presented below:

a) Explicit Consent of ULBs No NGRBA investments will be appraised without explicit and informed consent of the relevant ULB. This consent will indicate a clear recognition of the nature, scale and cost of the investment, and the ULB's own roles and responsibilities with regards to asset ownership and long-term O&M

b) Technology Selection Technology selection for wastewater treatment will be made on lowest lifecycle cost basis, specified for the local conditions and required degree of treatment.

c) Environmental and Social Assessment All the sub-projects shall comply with the environmental and social management framework of NGRBA and integrate the ESA recommendations in the sub-project designs.

d) Design-Build-Operate (DBO) and other Long Term Contracts All investments with significant O&M costs (such as WWTPs, pumping stations, landfills and waste processing) will be developed and managed under long term contracts (either Design-Build-Operate [DBO] or other kind) including 15 years of O&M. This will bring enhanced accountability, adequate capacity and resources, and strong performance incentives to the sector.

e) Capitalization of initial O&M Costs The first 5 years of O&M costs, based on specific calculations for each investment, will be included in the total cost for each DPR and will be financed on a shared basis by the central and state governments.

f) House Connections Plans and cost of providing house connections up to property line must be included in the DPRs for sewerage investments. The ULBs will implement outreach and other actions to encourage households to connect up to these points.

g) Industry Commitment to O&M Industrial pollution DPRs must include appropriate affidavits from industries outlining commitment to ensure satisfactory operation of common facilities.

h) Area Development Wherever possible, river front management investments must take an area development approach, both to achieve spatial scale along wider and longer stretches of the river, and to integrate across sectors.

1.4.2.4 Innovative Pilots

The project will finance pilot investments in order to promote and demonstrate innovative technologies and implementation arrangements. The potential pilot areas identified so far include net-energy positive wastewater treatment technologies and innovative Public-Private Participation (PPP) financing models which have not been used in the Ganga basin states.

1.4.2.5 Investment Execution

The investments program will be planned and managed by the NGRBA PMG and SPMGs. Execution of the infrastructure investments will be done by the Executing Agencies (EAs), selected specifically for each investment. The current choice of EAs includes the existing state-level technical agencies which have the mandate of urban infrastructure (especially wastewater) management in their respective states. Most of these agencies have been working for a few decades, and have significant expertise and experience in preparation and implementation of infrastructure projects in the four key sectors of the NGRBA program. In the medium to long term, the NGRBA program intends to promote competition with these existing EAs by facilitating the establishment of new ones in each state, including public-private joint venture infrastructure companies. In future, if a new entity (in addition to the currently defined EAs) is proposed as an EA for a specific investment, it will need to undergo assessments by the PMG/SPMGs to ascertain its capacity to manage the technical, project management, procurement, financial management and safeguards aspects of the investment.

1.4.2.6 Rehabilitation of existing infrastructure

Investments involving rehabilitation of existing infrastructure will be included on priority, due to their intrinsically higher returns in terms of reductions in pollution loads entering the Ganga.

1.5 Environmental and Social Analysis (ESA) and Management Framework (ESMF)

Given the sensitive environmental nature of the project and distributed nature of proposed project investments of NGRBP over a large area in multiple States, the investments under the project may entail environmental and social impacts, including acquisition of private land and resettlement issues. To help understand, environmental and social issues associated with the project NGRBA, has commissioned The Energy and Resources Institute (TERI), New Delhi

to conduct the Environmental and Social Assessment (ESA) of the project activities. The ESA formed the basis for development of the Environmental and Social Management Framework (ESMF) that ensures compliance of all project activities with the environmental regulations of GoI and the safeguard policies of the World Bank.

The ESMF addresses the broader portfolio of projects to be implemented under the NGRBA, as relevant information for specific projects (i.e. their size, type and location) are either not yet available or are currently being prepared.

Current ESMF document is intended to help NGRBA manage the social and environmental impacts through appropriate measures during the planning, design, construction and operation of various sub-projects of NGRBP. The framework identifies the level of safeguard due-diligence required for all categories of sub-projects of NGRBP and provides specific guidance on the policies and procedures to be followed for environmental and social assessment along with roles and responsibilities of the implementing agencies.

1.5.1 Objectives of ESA and ESMF

Broad objectives of ESA and ESMF study for the project comprise the following.

- Determine key social and environmental issues associated with River Ganga and possible activities that could be initiated by NGRBA, both at national as well as state level;
- Conduct an environmental and social impact assessment of the three 'early investments' in the hot spot locations along the river, identify potential environmental and social impacts associated with such investments and recommend measures to mitigate impacts;
- Carry out an analysis of various stakeholders associated with the project, identify their concerns with regard to environmental and social aspects, and recommend measures to mainstream these aspects into the project;
- Develop an Environmental and Social Management Framework (ESMF) for the project, to ensure that environmental and social issues are effectively addressed in project design and implementation.

1.5.2 Approach to the Preparation of ESA and ESMF

The project followed a *multi-stakeholder consultative* approach for preparing the ESA and ESMF that entailed a comprehensive methodology involving various phases. The first phase

comprised of primary and secondary data collection and analysis, literature survey, expert consultations, and gathering inputs from a range of stakeholders (relevant authorities and government departments, external reviewers, financial institutions, local residents and communities, NGOs and interest groups). Subsequent to this, the key environmental and social issues in Ganga main stem were identified in consultation with the key stakeholders including the local communities.

In the second phase, the ESMF was prepared, based on issues and challenges that emerged while preparing the ESA. The ESMF was prepared through a consultative process that engaged key stakeholders at the national, state, and local levels and their feedback was considered while preparing the document. Key government agencies have been consulted at the various levels to obtain their consent on the ESMF in general and specially on the land acquisition process and resettlement framework. The issues emerged from ESA are considered in the ESMF document to ensure that it sets out the framework for the projects, to comply with the safeguard policies and procedures of the Government of India and the World Bank. This includes the project design, the legislative framework, the consultation process, the social and environmental baseline, consideration of alternatives, prediction and evaluation of significant social and environmental impacts, mitigation or offset measures, and environmental and social management and monitoring plans. The project also attempted to review the previous projects such as GAP-I, GAP-II, YAP and NRCP and the ESMF is prepared based on the key lessons learnt from these, with regard to the knowledge gaps in environment and social impact assessments.

In the third phase, following the national level consultations, public consultations have been carried out in sample sub project areas in each of the five participating states (Bihar (1), Jharkhand (1), Uttar Pradesh (2), Uttarakhand(1) and West Bengal (1)), to get stakeholders'/communities feedback and suggestions on the ESMF. The dates of these consultation meetings were announced in the local newspapers in advance so that all interested parties could participate and provide suggestions. The ESMF was translated into local language and was disclosed on the websites and also made available to the offices of the nodal agencies, prior to the consultation meetings. Representatives of the State Nodal Agencies facilitated the public consultation meetings. The key concerns and suggestions raised by the communities/stakeholders during the public consultations have been included in the final ESMF.

1.5.3 Composition of ESMF

The ESMF is broadly organized into two volumes. Volume I on Environmental and Social Analysis, based on the base line environmental and social profile of the project area, analyses the critical factors that need to be considered in the overall design and also the safeguard management strategies of the project. Further, Volume II, based on the issues / factors brought out in the ESA, presents the Environmental and Social Management Framework (ESMF) for NGRBP.

The present Volume I: Environmental and Social analysis (ESA) of the Ganga main stem is structured into five chapters. While the present chapter provides a brief back ground of NGRBP, chapter 2 provides the environmental profile of the Ganga main stem including the hydrological, physiological and ecological characteristics of the Ganga main stem. The third chapter provides a broad socio-economic profile of the five project states and potential project cities. The fourth chapter, based on the available information, analyses various sources contributing to the pollution of the River. The fifth chapter summarises the key environmental and social issues in the Ganga Basin and the way forward.

Chapter 2

Environmental Profile of Ganga Main Stem

2.1 Introduction

The profile of the Ganga main stem is presented in this section, based on the available information from various agencies, on the basin and the river with regard to the catchment, hydrology, tributaries, physiography, water uses, environmental features such as aquatic and terrestrial flora/fauna, natural resources, ecological characteristics, sensitive environmental components and other features such as land use, water resources project, water logging and salinity problems, etc.

2.2 The Ganga Main Stem

India is drained by more than 12 major river systems (basins) with a catchment area of more than 2,500,000 Sqkm. These river systems are grouped into four broad categories: the Himalayan rivers, the Peninsular rivers, the Coastal rivers and the Inland rivers. In addition to the Ganga, the Himalayan river system includes the Indus and Brahmaputra river basins.

The Ganga River (about 2525 km long) is fed by runoff from a vast land area bounded by the snow peaks of the Himalaya in the north and the peninsular highlands and the Vindhya Range in the south. The basin encompasses an area of more than a million square kilometers (1,186,000 Sqkm) spread over four countries: India, Nepal, Bangladesh and China. With 861,404 Sqkm within India itself, the Ganga is the largest river basin in India and covers approximately 25 per cent of India's total geographical area. The catchment area, length, total utilizable water of major river basins within India and the states that they cover are presented in Table 2.1.

Table 2.1 Catchment Area of Major River Basins of India

S. No.	Name of the River	Length (km.)	Catchment Area (Sq. km.)	Total Utilizable Water (BCM)
1	Indus	1114 (2880)	321289 (1165500)	72.49
2	a) Ganga	2525	861404 (1186000)	420.99
	b) Brahmaputra	916 (2900)	194413 (580000)	59.07
	c) Barak & other rivers flowing into Meghna like Gomti, Muhari, Fenny etc.		41723	
3	Sabarmati	371	21674	4.93
4	Mahi	583	34842	7.3
5	Narmada	1312	98796	45.33
6	Tapi	724	65145	22.77
7	Brahmani	799	39033	22.35
8	Mahanadi	851	141589	66.45
9	Godavari	1465	312812	116.95
10	Krishna	1401	258948	84.41
11	Pennar	597	55213	11.79
12	Cauvery	800	81155	31.3
	TOTAL		2528036	

Source: Water Data: Complete book, 2005; Status paper on river Ganga, NRCD, MoEF, 2009
Note: Figures within bracket also include the total river basin in neighbouring countries

The Ganga River Basin in India encompasses eleven states, where as the main stem of the river flows through the five states of Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal. The remainng six states in the basin are Delhi, Haryana, Himachal Pradesh, Madhya Pradesh, Chattisgarh and Rajasthan. The states of Uttar Pradesh and Uttarakhand together constitute a maximum basin area of 34%, followed by Madhya Pradesh, Bihar and Jharkhand. The distribution of drainage area in all these basin states is presented in Table 2.2 and Figure 2.1.

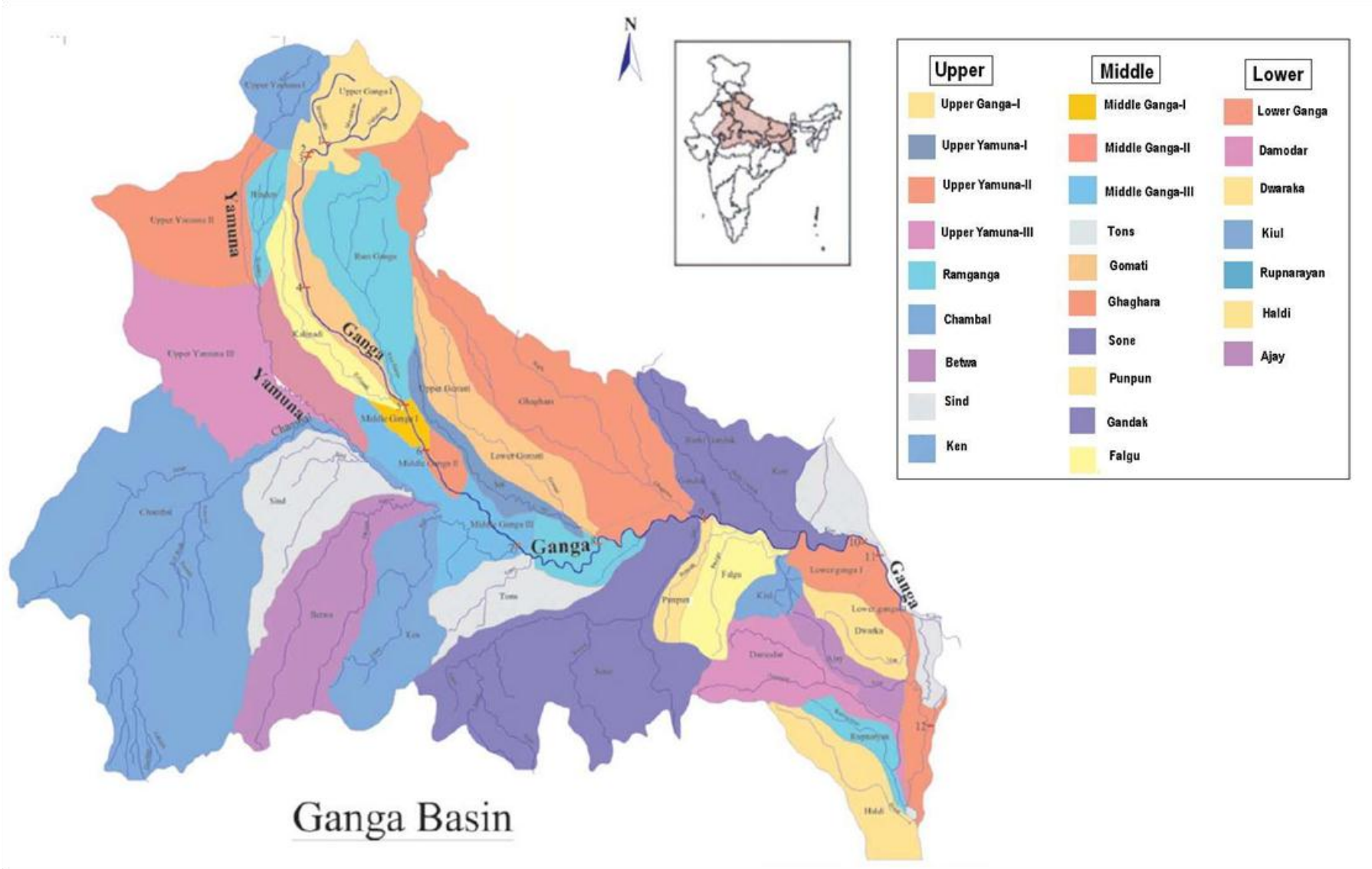


Figure 2.1 The Ganga main stem map
Source: Status paper on river Ganga, NRCD, MoEF, 2009

Table 2.2 State-wise Distribution of the Drainage Area of Ganga Basin in India

S. No.	State	Total Geographical Area (SqKm)	Percent of Total Geographical Area
1	Uttar Pradesh & Uttarakhand	294364	34.2
2	Madhya Pradesh	198962	23.1
3	Bihar & Jharkhand	143961	16.7
4	Rajasthan	112490	13.1
5	West Bengal	71485	8.3
6	Haryana	34341	4.0
7	Himachal Pradesh	4317	0.5
8	Delhi	1484	0.2
	Total Area	**861404**	**100.0**

Source: Status paper on river Ganga, NRCD, MoEF, 2009

2.3 The River

The Ganga rises in the Garhwal Himalaya (30^{o} 55'N, 79^{o} 7'E) as the Bhagirathi. The ice cave of Gaumukh at the snout of the Gangotri glacier, at 3,892 metres above sea level, is recognized as the traditional source of the Ganga. The river cuts through the Himalayas until another head stream, the Alaknanda, joins at Devaprayag as shown in Plate 2.1 (right). It is below this confluence that the united stream of Bhagirathi and Alaknanda becomes known as the River Ganga.

Plate 2.1: The point of origin of the Ganga, known as the Gangotri **(left)** and Devprayag, the point of confluence of the Alaknanda (from right) and Bhagirathi (from left) to form the Ganga **(right)**.

After running some 250 kilometres from its source, the Ganga pierces through the Himalayas at Sukhi (near Rishikesh), before turning southwestwards for another 30 km where it finally descends into the vast Indo-Gangetic plain at Haridwar (elevation 283m). At this point, the river swells into a mighty stream of 750 metres width.

Apart from its sacred significance, water from the Ganga is widely used for domestic and industrial purposes in towns and villages located on its course. The other major use of Ganga water is for irrigation. At Haridwar, where the Ganga opens to the Gangetic Plains, a barrage diverts a large quantity of its waters into the Upper Ganga Canal, to provide water for irrigation. At Bijnore, another barrage diverts water into the Madhya Ganga Canal but only during monsoon months. At Narora, there is further diversion of water into the Lower Ganga Canal. The Ganga does not receive any major tributary until the Ramganga joins at Kannauj adding some 17.79 billion cum/annum of water. At Allahabad (1020 km from the source), the Ganga is joined on the right by the River Yamuna, which actually contributes more water (57.24 billion cum / annum) than the main river itself, augmenting the flow volume of the Ganga significantly.

After Allahabad, the Ganga begins to receive several major tributaries at more frequent intervals, namely, the Tons, Son, Gomati, Ghaghara, Gandak, Burhi Gandak and Kosi. After Rajmahal, the Ganga eventually reaches the head of its delta at Farakka, in the state of Jharkhand, having increased its flow volume at each confluence. In addition to flow volume, water quality and sediment load also fluctuate depending on the composition of the contributing stream.

Below Farakka, the Ganga bifurcates into the Padma and the original channel of the Ganga, known as the Bhagirathi. Therefore, the Bhagirathi is treated as the main Ganga for all purposes in West Bengal. The Padma, carrying the majority of Ganga's flow, eventually turns southeastwards into Bangladesh, while the Bhagirathi (Ganga) winds southwards down the deltaic plain of West Bengal and ultimately empties into the Bay of Bengal under the name of Hugli. Nearly halfway between Farakka and Sagar Island, the hydraulic character of the Bhagirathi (Ganga) suddenly changes upon its entry into the tidal zone of the Gangetic delta. The speed and direction of water in the estuarine streams and creeks are in continual flux due to the ebb and flow of the tides.

Throughout the course of the Ganga, from its source at Gaumukh to its mouth at Sagar Island in Bay of Bengal, it is a common practice for Indians to take daily dips in the holy waters of the Ganga, especially at places of pilgrimage like Rishikesh, Haridwar, Garhmukteshwar, Kannauj, Allahabad, Mirzapur and Varanasi (as seen in Plate 2.2).

Plate 2.2 Images of the Ganga at Haridwar during different times of the year.

Line diagram of the Ganga with major tributaries is shown in Figure 2.2 below.

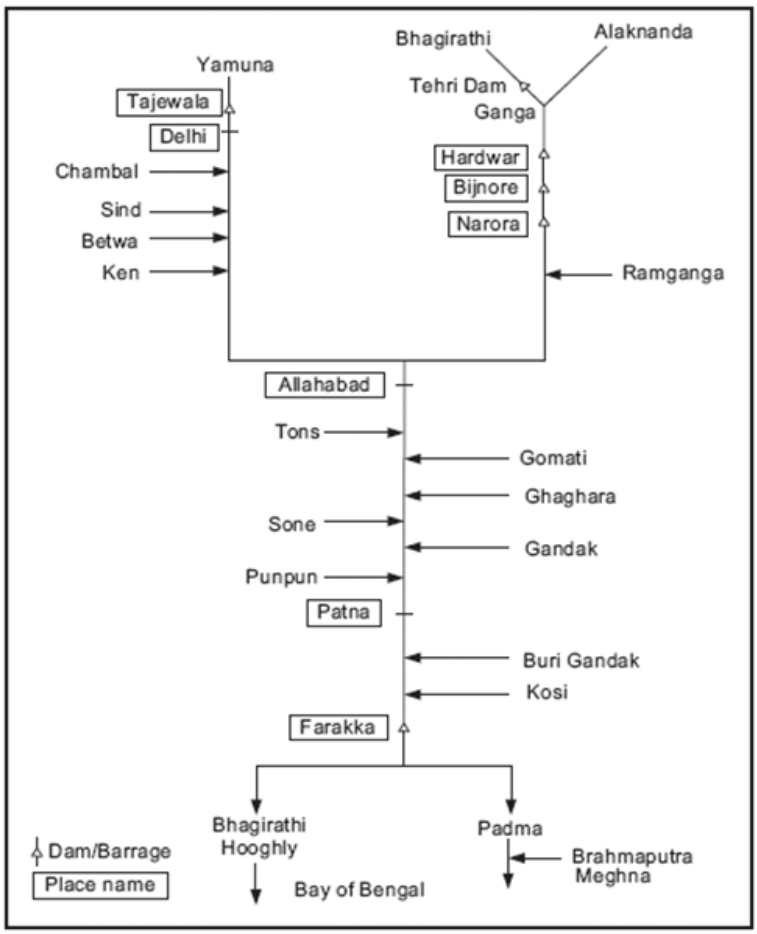


Figure 2.2 Line diagram of the Ganga main stem with tributaries

Source: Status paper on river Ganga, NRCD, MoEF, 2009

2.4 Stream and Flow Characteristics of Ganga

Due to their high gradient and a tremendous velocity, Himalayan rivers including the Ganga have a strong erosive power. The geological fact that the Himalayan rivers run through poorly consolidated sedimentary rocks affected by folds and faults results in high rates of erosion and silt deposition. Landslide debris further adds to the silt load.

Rainfall, subsurface flows and snow melt from galciers are the main sources of water in river Ganga. More than 60 per cent of the water flowing into the Ganga main stem comes from the Himalayan streams joining the Ganga from the north. The Peninsular streams combine to contribute only 40 percent of the water, despite the fact that the catchment area of the Peninsular streams extends well over 60 percent of the entire Ganga main stem.

The tributaries which contribute the largest amount of water per annum are, the Ghaghara including Gomti river (113.5 billion cum), followed by Kodi-Mahananda (81.85 billion cum), the Gandak- burhi Gandak together (58.96 billion cum), Yamuna (57.2 billion cum), Sone-East of sone (44.14 billion cum), the Chambal (32.55 billion cum) and Ramganga (17.79 billion cum). The average annual flow at various gauging stations in river Ganga and tributaries is given in Table 2.3. A lack of water in streams and tributaries (other than major tributaries) increases their susceptibility to water pollution. Therefore, the Ganga's minor tributaries are pollution prone, especially as their flows diminish during the dry season. As the main river's flow rate fluctuates reach to reach, its susceptibility to pollution varies accordingly.

Table 2.3 Mean Annual Flow in Ganga

S. No.	Sub-Basin	Mean Annual Flow (BCM)	Percentage Contribution
1	Ramganga	17.789	3.39
2	Yamuna (excluding Chambal)	57.241	19.9
3	Chambal	32.554	6.2
4	Tons-Kararmnasa	10.609	2.02
5	Gomti-Ghaghra	113.511	21.62
6	Sone-East of Sone	44.144	8.41
7	Gandak-Burhi Gandak	58.967	11.23
8	Kodi-Mahananda	81.848	15.59
	Total (Tributaries)	416.663	79.36
9	Ganga Main Stem	84.98	16.19
10	Evaporation * (attributable to Ground Water)	23.38	4.45
	Total Ganga (Upto Indian Border)	525.023	100

Source: Status paper on river Ganga, NRCD, MoEF, 2009

Based on stream characteristics, the entire 2,525 km course of the Ganga can be divided into the following major five sections: (i) mountainous, (ii) upper plain, (iii) middle plain, (iv) deltaic non-tidal and (v) deltaic tidal plain. The stream characteristics of the river Ganga, from its source to its outfall in the Bay of Bengal, are given in Table 2.4.

Table 2.4 Stream Characteristics along Different Sections of the Ganga

S. No.	Stretch	Section	Length (Km)	Average Slope of Land	Mean Annual Rate of Flow (cum / second)
1	Source to Rishikesh	Mountainous	250	1 in 67	850
2	Rishikesh to Allahabad	Upper plain	770	1 in 4,100	850 - 1,700
3	Allahabad to Farakka	Middle plain	1005	I in 13,800	4,000 -10,200
4	Farakka to Nabadwip	Deltaic non-tidal plain	230	1 in 23,000	1,000 - 1,300
5	Nabadwip to outfall	Deltaic tidal plain	240	1 in 24,000	Variable due to the tides

Source: Central water Commission

The mountainous section stretches from the river's source to Rishikesh. This section has an average bed slope of 1 in 67 and a mean flow rate of 850 cubic metres per second at Rishikesh. The subsequent upper plain section extends from Rishikesh downstream until Allahabad at a slope of 1 in 4,100 and a mean flow rate ranging between 850 and 1,720 cum per second before its confluence with the Yamuna. The third, middle plain section stretches from Allahabad to Farakka, with a slope of 1 in 13,800 and an increase in the mean flow rate to 10,200 cum per second at Azamabad. Following this part lies the upper deltaic non-tidal plain section, with a slope of 1 in 23,000 and a much reduced mean flow rate of 1,300 cum per second near Nabadwip. The final segment is the lower deltaic tidal plain section, with a slope of 1 in 24,000 and varying flows due to influence of the tides.

The large volume and high flow of the Ganga in the middle plain section (1,005 km) between Allahabad and Farakka render this stretch relatively less vulnerable to pollution, compared to the sections on the upstream of Allahabad and downstream of Farakka. However, upstream of Allahabad the mean annual flow is less than 1,700 cum per second and, as a result, the upper plain course of the Ganga is liable to be polluted to some extent if adequate precautionary measures are not taken; this fact is especially true during the lean months. This same

increased susceptibility to pollution also occurs downstream of Farakka, where the mean annual stream flow again falls off drastically to a level of 1,300 cum per second at Nabadwip. Further down, especially in the estuarine section near the outfall, the up-and-down movement of the water periodically causes temporary suspension of the water current, as the tide shifts from ebb to flow and vise versa. As a result of this stagnation, removal of pollutants in the tidal section can expected to be slow and difficult.

2.5 Physiography and Soil Characteristics

Physiographically, India is divided into seven major divisions: (1) Northern Mountains, (2) Great Plains (3) Central Highlands (4) Peninsular Plateaus, (5) East Coast, (6) West Coast and (7) Islands.

The area in Ganga main stem is located entirely in the first three divisions. The peninsular plateau of the Gangetic trough (with an elevation of less than 300 metres) is filled with older (Pleistocene) and recent alluvia, forming nearly 4,000,000 SqKm in the states of Haryana, Rajasthan, Uttar Pradesh and West Bengal, comprising 50% of basin area. The Ganga main stem can be further divided into the following eight physiographic sub-divisions, briefly described below and shown in Figure 2.3.

a) Trans-Yamuna Plain

This sector constitutes the western end of the Ganga main stem, covering the states of Haryana and Rajasthan. The region is characterized by thick, unconsolidated material subtly sloping down from the western watershed towards the Yamuna. On account of the flat topography, water logging and saline efflorescence has been recorded in many areas, especially since the introduction of large-scale and intensive irrigation practices through the Western Yamuna Canal.

b) Ganga-Yamuna Doab

East of Trans-Yamuna plain lies the Ganga-Yamuna interfluvial doab tract, which stands out as a large slab of older alluvial (bangar) terrace sloping towards the south and southeast, falling off from a level of 283 metres at Haridwar to some 95 metres at Allahabad. The twin rivers, Ganga and Yamuna, wind along the low-lying (khadar) flood-plain belts built up by the younger alluvial sediments deposited during periodical inundations. The bangar terraces, on the contrary, are thick deposits of older silts, rising high above the khadar plain – up to 20 metres at times - measured from the present river beds. The bangar surface of the Ganga-Yamuna Doab has a rather variegated topography interspersed by breaks of slope due to terrace formations and sand belts (Bhur), which stand out like transverse sand dunes.

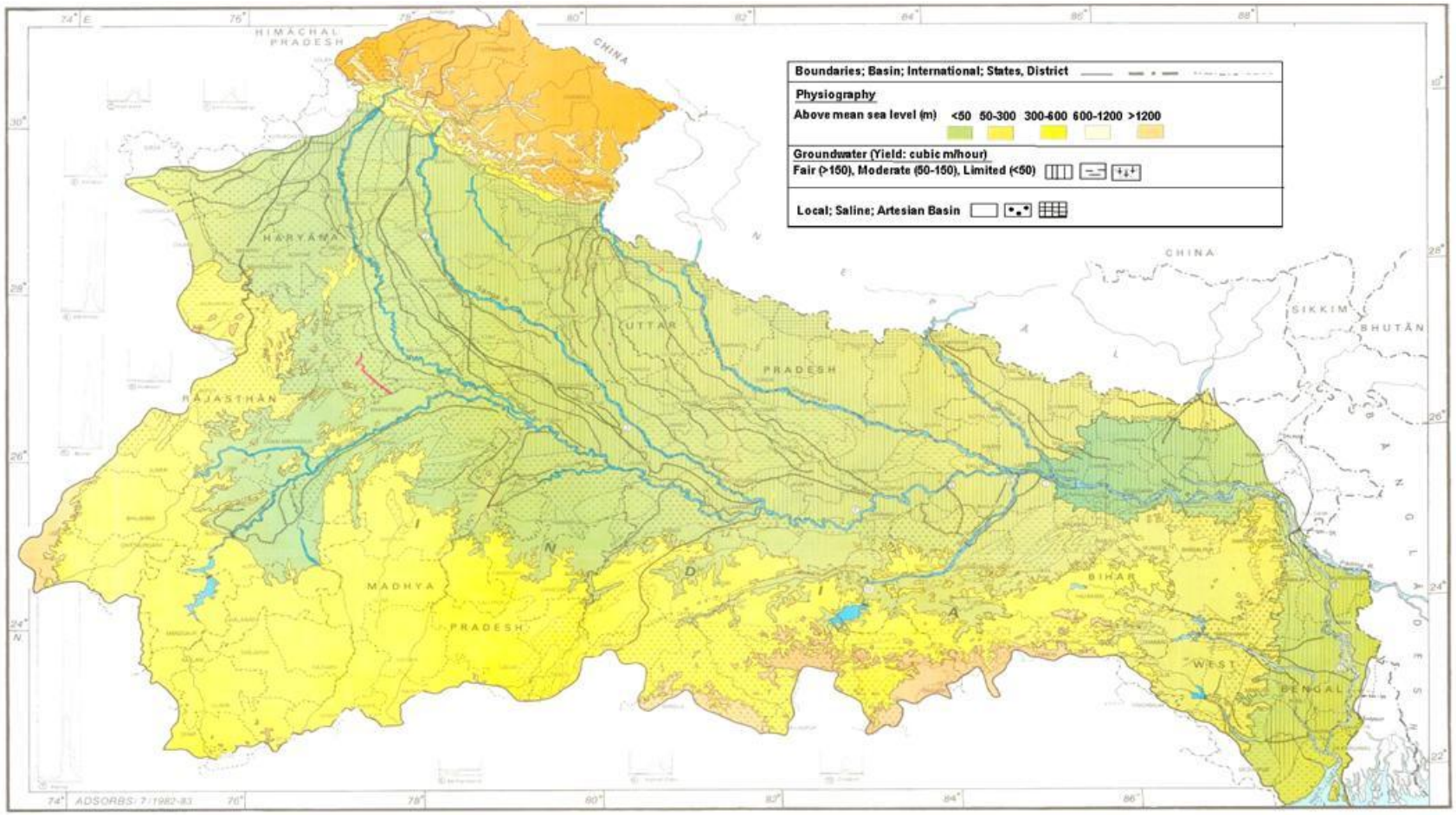


Figure 2.3 Physiography and Groundwater flow of Ganga main stem

(*Source: *Mukherjee and Dasgupta, 1983)*

* Mukherjee, K. N., Dasgupta, S. P., 1983. Center for Study of Man and Environment. Graphic offset press (P) Ltd., Calcutta, India

c) Rohilkhand

To the east of the Ganga-Yamuna doab lies the large plain of Rohilkhand, which extends from the Ganga to near Lucknow, where the land steps down to the lower alluvial plain of Avadh. Rohilkhand comprises a flight of several river terraces separated from each other by step-like breaks of slope. The highest terrace is located at the Himalayan foothills and is built up of bouldery bhabar deposits.

d) Avadh Plain

Further east of Rohilkhand and lying at a lower elevation is the Avadh plain. The Avadh plain comprises the extensive khadar belts of several mighty streams, the chief of which is the Ghaghara.

e) North Bihar Plain

Further east, the great riparian plain of North Bihar appears. The North Bihar plain is riddled with numerous old river beds which have been deserted by the Kosi in the course of its movement from the eastern end of Bihar to its present position as the main channel in the west. In addition to the depressions left by these old river beds, there also lies large marshes and waterlogged areas, known as the chorus, along the Ganga.

f) North Bengal Plain

At the farthest end of the Ganga main stem is the North Bengal plain, which contains Pleistocene deposits of the Barind region, terraces of coarse grained materials and tarai depressions in the piedmont plain below the Darjeeling hills.

g) Bengal Basin

South of the Ganga (Padma), lies the Bengal basin, which comprises much of the Gangetic delta plain's recent alluvium and its western rim. The western rim is made up of Pleistocene alluvial formation (often lateritic), as the land slopes up towards the rocky Chota Nagpur plateau.

2.5.1 Soil Characteristics

The Ganga main stem is characterized by a wide variety of soils. The soils of the high Himalayas in the north are subject to continued erosion and the Gangetic trough provides a huge receptacle into which thousands of metres of thick sediment layers are deposited to form a wide valley plain. The plateau on the south has a mantle of residual soils of varying thickness arising due to the weathering of the ancient rocks of the peninsular shield. Ten classes of soils have developed in the Ganga main stem under different Iithological, climatic and pedogenetic conditions.

Some of the soils within the Ganga main stem are highly susceptible to erosion. Such soils need adequate conservation measures and appropriate land management interventions, with an eye towards preserving the soil resource and keeping the turbidity levels of the surface water within tolerable limits. The susceptibility of each of the soil groups to erosion and the areas covered in the different states within the Ganga main stem are indicated in Table 2.5. The soil classification map of Ganga main stem is given in Figure 2.4.

Among the soil types within Ganga main stem, the alluvial soil covers more than 52 per cent of the basin. The alluvial deposits of the basin not only cover the great Gangetic trough, but also extend over a sizable portion of the peninsular foreland in the form of a layer less than 3 metres thick. The entire alluvial formation is endowed with rich soil nutrients. The alluvial deposits of the Ganga and its tributaries, coming down the Himalaya and the peninsular foreland, have yielded annual harvests of crops for the past thousands of years with little significant deterioration. Besides paddy, this tract produces a wide variety of crops including wheat, jowar, bajra, small millets, pulses of different kinds, maize, cotton, jute and many other food and commercial crops.

If managed properly, the alluvial soils are highly fertile soils, capable of producing the highest possible yields of crops to feed the millions. However, these soils are sensitive to change and prone to rapid degradation and pollution. In certain parts of the basin, the soils are already showing signs of salinity (as in Haryana), alkalinity (as in western U.P.), calcareousness (as in north Bihar) and acidity (as in West Bengal) due to overuse, long occupation and continued application of inputs like excessive irrigation water and toxic agro-chemicals of various types. The land degradation status within Ganga main stem is given in subsequent sections.

Table 2.5 Soil Types in Ganga main stem and their Susceptibility to Erosion (Area in Square Kilometres)

S. No.	State	Mountain Soils	Submontane Soils	Alluvial Soils	Red Soils	Red and Yellow Soils	Mixed Red and Black Soils	Deep Black Soils	Medium Black Soils	Shallow Black Soils	Laterite and Lateritic Soils	Total Area
1	Haryana	-	-	33516	684	-	-	-	-	-	-	34200
2	Uttar Pradesh and Uttarakhand	12428	32586	209491	16457	740	4438	10502	3621	3962	188	294413
3	Bihar and Jharkhand	-	-	91881	32338	19333	-	-	-	-	858	144410
4	West Bengal	-	-	57323	704	7271	-	-	-	-	6712	72010
5	Rajasthan	-	-	40768	12166	16827	9810	9332	9394	9085	-	107382
6	Madhya Pradesh	-	-	17272	39075	5990	11168	14251	79881	33470	598	201705
7	Himachal Pradesh	1296	4280	223	-	-	-	-	-	-	-	5799
8	Delhi	-	-	1225	260	-	-	-	-	-	-	1485
	Ganga Basin	**13724**	**36866**	**451699**	**101684**	**50161**	**25416**	**34085**	**92896**	**46517**	**8356**	861404
	Per cent of Total Area	**1.59**	**4.28**	**52.44**	**11.80**	**5.83**	**2.95**	**3.96**	**10.78**	**5.40**	**0.97**	100
	Susceptibility to Erosion	**Very high**	**Very high**	**Very high**	**High**	**Moderate**	**Moderate**	**Low**	**Low**	**Low**	**Low**	

Source: Central Pollution Control Board, National River Conservation Directorate (MoEF) (2009)

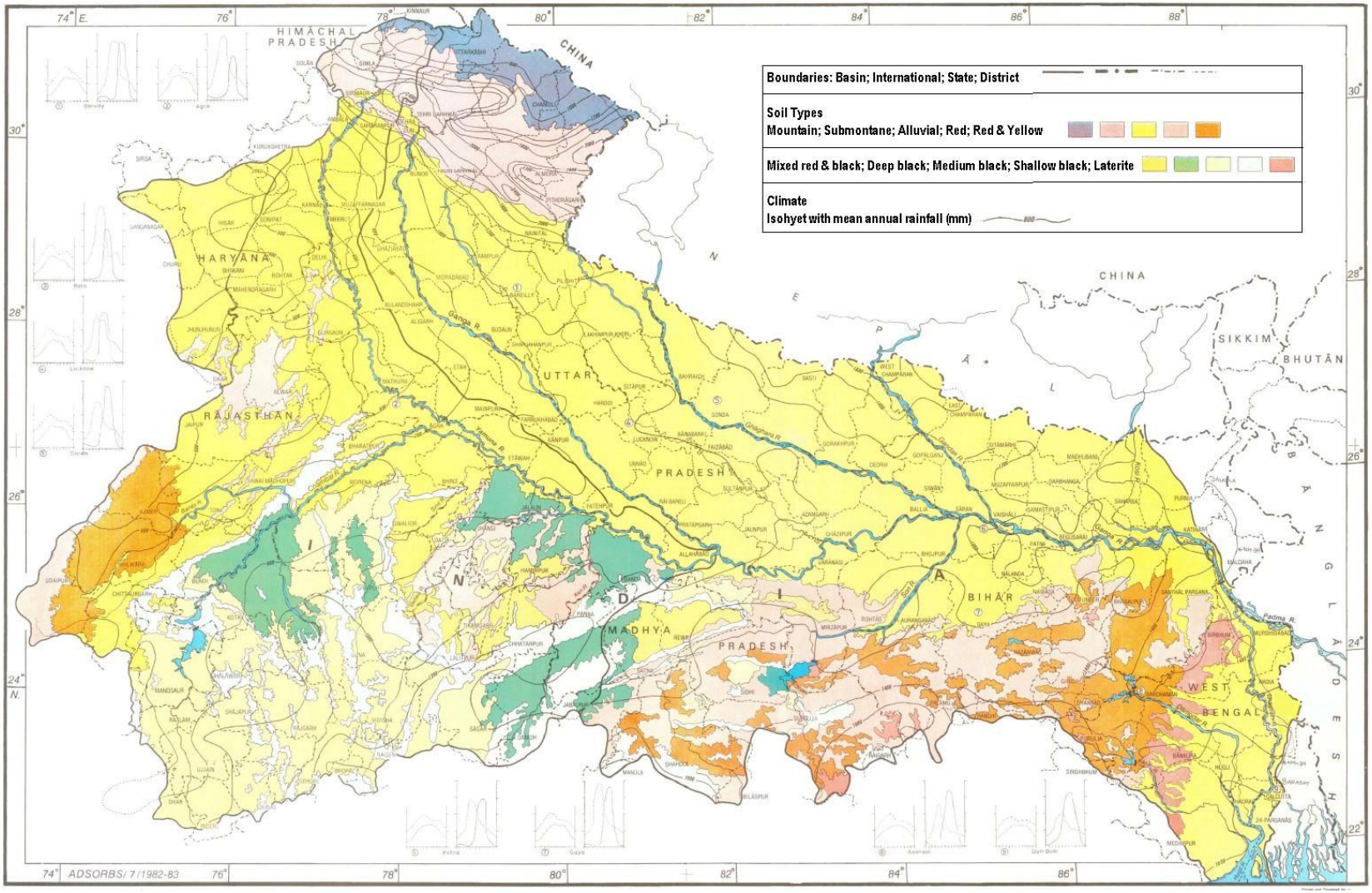


Figure 2.4 Soil and rainfall (isohyetal) map of Ganga main stem

(Source: [*]Mukherjee and Dasgupta, 1983)

[*] Mukherjee, K. N., Dasgupta, S. P., 1983. Center for Study of Man and Environment. Graphic offset press (P) Ltd., Calcutta, India

2.6 Meteorology and Climate

The type of vegetation depends on edaphic, climatic and biotic factors, among which the effect of the climatic factor is most significant. The main climatic factors which control vegetative activity are temperature, sunlight and precipitation. In India, four temperature zones are distinguishable: tropical, sub-tropical, temperate and alpine. Among these, the tropical and subtropical temperature zones are most predominant in the entire Ganga main stem. The climatic details for these temperature zones are given below in Table 2.6**.**

Table 2.6 Temperature Zones of India

Zone	Mean Annual Temp (^{o}C)	Mean Temp Jan. (^{o}C)	Remarks
Tropical	Over 24	Over 18	No frost
Sub-Tropical	17 to 24	10 to 18	Frost is rare

Source: Environmental Atlas of India, CPCB

2.6.1 Temperature

The Ganga basin forms an extensive bowl of warm air, especially during the day-time. The mean maximum daily temperature even in the coldest month (January) does not fall below 21°C, except in the higher hills, whereas the air temperature starts rapidly rising all over Ganga main stem from March onwards, beginning a hot season that prevails from April to June. Usually, May is the hottest month in most part of the basin, except in lower Bengal. Daily mean maximum and mean minimum air temperatures, as recorded at selected stations in the Ganga main stem, are given in Table 2.7.

In the Gangetic plains, westwards of Gaya, the daily mean maximum temperature in May rises to 40°C and above. During May, the mean daily maximum air temperature shoots up as high as 42.3°C in Kota in the Central Indian upland region. The maximum air temperature in other areas are; Allahabad (41.8°C), Agra (41.6°C), Hissar (41.1°), Gaya (40.7°C), Lucknow (40.5°C and Bareilly (40.5°C). Under this high temperature regime, much of the pollutants become suspended in the air and remain aloft for a considerable period of time in the atmosphere. Some of the pollutants are brought down by rain drops where they eventually find their way into surface runoff systems.

Throughout the Ganga main stem, the cold weather period extends from December to February. January is the coldest month, with the temperature often falling below 10°C; this is

especially true in the valley plain west of Gaya, where the daily mean minimum air temperature in January reaches 10.03°C. In January, the daily mean minimum temperature plummets as low as 5.8°C in Hissar, followed by Dehra Dun (5.96°C), Delhi (7.7°C), Agra (7.7°C), Gonda (8.3°C), Bareilly (8.25°C), Lucknow (6.9°C), Allahabad (8.9°C) and Patna (9.2°C). In the lower Gangetic plain the minimum temperature is usually higher: 10.03°C in Gaya and 12.3°C in Kolkata. Low temperatures are often associated with the intrusion of cold air from across the Gangetic plain in the months of December and January. In the cold of the winter months, the heavy cold layers of the atmosphere act as blankets upon the land surface, not allowing the suspended pollutants in the air to escape into the higher atmosphere.

2.6.2 Rainfall

The weather in the Ganga main stem is characterized by a distinct wet season during the period of south west monsoon (June to September). The air temperature starts falling with the onset of the monsoon from June onwards, making the weather more humid and equable. The diurnal range between the daily mean minimum and the daily mean maximum temperature reduces progressively as the monsoon advances. Eventually, the lowest diurnal range of temperature occurs at the peak of the monsoon, which is usually in August, though sometimes in July. As soon as the monsoon is over, the diurnal range of temperature starts increasing rapidly to a maximum attained during the month of November

Due to its proximity to the coast, Kolkata stands as an exception, with its highest diurnal range (13.37°C) occurring during the coldest month (January). On account of high population density and a heavy concentration of industrial units in the Kolkata Metropolitan District, the effect of this temperature is very pronounced, with frequent episodes of smog in the winter evenings followed by mist in the colder morning hours.

The southwest monsoon makes landfall at the mouth of the Ganga around the first week of June and advances upstream. By the end of July the monsoon reaches the western end of the Ganga main stem. In the majority of the basin, the rainy season spreads over three months (July, August and September) and usually 70 to 80 per cent of the total annual rainfall occurs during this period. In the eastern part of the basin, such as in West Bengal and Bihar, the wet season is longer, usually starting in June and continuing until the end of September or early October.

The geographical distribution of the mean annual rainfall in the basin is shown by isohyetal lines on Figure 2.4. The isohyetal lines indicate that the lowest precipitation in the Gangetic plain occurs in Haryana (less than 500 mm per annum), with the rainfall increasing downstream until reaching lower Bengal, where nearly 1,600 mm of rainfall occurs. Heavier rainfall continues in the upper Himalayan region, such as in Dehra Dun, where the rainfall is as high as 2,209 millimeters per annum. The rainfall rates as recorded at selected stations in Ganga main stem is given in Table 2.7.

Table 2.7 Rainfall and Temperature Details at Selected Stations in Ganga Basin

S. No.	Station and Year	Mean Annual Rainfall (mm)	Water Surplus in Wet Months: Jul-Sep (mm)	July to September Rainfall Expressed as Percentage of Annual Rainfall	Mean Temperature in ^{0}C	
					Maximum	Minimum
1	Dehra Dun (1901-2000)	2209.0	1697.4	76.8	27.8	15.4
2	Delhi (Safdarjang) (1901-2000)	716.2	535.2	74.7	31.3	19.0
3	Hissar (1901-2000)	490.8	336.3	68.5	32.6	17.7
4	Agra (1901-2000)	724.8	576.2	79.5	32.5	18.9
5	Allahabad (1901-2000)	962.7	762.0	79.1	32.5	19.6
6	Gaya (1901-2000)	1130.4	847.3	75.0	32.1	20.1
7	Calcutta (Alipore) (1901-2000)	1651.2	950.2	57.5	31.4	22.0
8	Bareilly (1901-2000)	1040.0	784.1	75.4	31.2	18.7
9	Patna (1951-1980)	1003.4	807.1	80.4	31.9	20.8
10	Kota (1951-1980)	843.4	687.4	81.5	32.9	20.5

Source: Monthly mean data of important cities, India Meteorological Department

Within the Ganga main stem, every square kilometre of land surface area receives an average of one million cubic metres of water annually through rainfall. However, less than half of this total is actually available, after accounting for water lost through evapo-transpiration (30 percent) and seepage into the ground (20 percent). Rainfall distribution indicates that the greater part of the basin would be hydrologically dry if the total annual rainfall were distributed evenly over the twelve months of the year. Since the vast majority is concentrated in a three month span in most of the basin, the water available from rainfall usually exceeds what is lost through evaporation during this period, allowing some surplus water to flow down the Ganga river and its tributaries.

2.7 Land Use & Irrigation

2.7.1 Land Use

The states in Ganga main stem are extensively cultivated, constituting approximately about 40 per cent of the total cultivated area of India. About 14 per cent of land is not available for cultivation and is put to various non-agricultural uses. Although the net sown area constitutes 50 per cent of the Ganga main stem states area, the total cropped area and cultivable land constitutes 73 percent and 65 percent of the basin states area, respectively. The cropping intensity is highest in Delhi with 189.7 per cent followed by West Bengal, Haryana, Himachal Pradesh, Uttarakhand and Jharkhand. The landuse pattern and cropping intensity of landuse within the Ganga main stem is given in Table 2.8.

Land not available for cultivation and fallow land in the Ganga main stem states covers a considerable area of 183,640 and 109,450 Sqkm respectively (Table 2.8). This category of land consists of tracts which cannot be put to agricultural or silvicultural uses at an economic level due to their unproductive nature, as well all lands put to various other economic uses, such as mineral exploitation or construction of human settlements, industrial structures, roads, railways, airports and other civil works needed for providing transport, communication and similar infrastructural facilities for human habitation. A large proportion of the non-arable land is also used in urbanization and in construction of homesteads in rural areas all over the thickly populated basin of the Ganga.

The states in Ganga basin have only 16.6% of their land areas covered by forest, as compared to India as a whole which has 21.2% of land under forest cover. In some states, especially Haryana, Delhi, Bihar, Uttar Pradesh, Rajasthan and West Bengal, the forest cover is as low as 0.1 to 13.2 per cent of the geographical area. Most of forest tracts in the Ganga are severely degraded on account of over exploitation. As a result, the forest ecosystem in the basin is under severe stress. Even in the states of Uttarakhand (64.7 per cent), Madhya Pradesh (28.2 per cent) and Himachal Pradesh (19.8 per cent) where the forest cover is higher, the proportion of land actually under dense tree cover within the government forest tracts is very low due to extensive clear felling of trees carried out in recent decades.

Table 2.8 State-wise Land Use Pattern and Cropping Intensity in Ganga States (2007 - 2008)

(Area in Square Kilometres)

S. No	State	Geographi-cal Area	Reporting Area for Land Utilisation Statistics	Forest	Land not Available for Cultivation	Total Fallow land	Net Area Sown	Total Croped Area	Agri.land/ Cultivable Land/ culturable land/Arable Land	Cropping Intensity (%)
1	Bihar	94160	93600	6220	20830	6860	56650	79100	66380	139.6
2	Haryana	44210	43720	40	5610	1120	35940	64580	37460	179.7
3	Himachal Pradesh	55670	45450	11010	11300	750	5430	9710	8130	179
4	Jharkhand	79720	79700	22390	13190	23410	15360	23910	43020	155.7
5	Madhya Pradesh	308250	307560	87030	33920	14330	146870	204160	173100	139
6	Rajasthan	342240	342700	27270	42640	38910	170960	222080	255760	129.9
7	Uttarakhand	53480	56670	34650	4720	1080	7650	12610	15090	164.8
8	Uttar Pradesh	240930	241700	16580	32680	19480	164170	249270	191790	151.8
9	West Bengal	88750	86840	11740	17830	3310	52960	97520	57210	184.1
10	Delhi	1480	1470	10	920	200	230	440	540	189.7
	Ganga states	**1308890**	**1299410**	**216940**	**183640**	**109450**	**656220**	**963380**	**848480**	**146.8**
	India	**3287260**	**3056740**	**696260**	**432180**	**251480**	**1408610**	**1958350**	**1824420**	**139**

Source: Directorate of Economics and Statistics, Department of Agriculture and Cooperation, 2008; indiastat.com

2.7.2 Irrigation

The Gangetic plain is one of the most extensively irrigated basins in the world. As of 2008, the net irrigated area in the basin states was about 361,100 square kilometres, constituting more than 57 per cent of the net irrigated area of India as a whole. The net and gross irrigated areas are highest in Uttar Pradesh & Uttarakhand, which also share major drainage area of the basin. Throughout much of the basin, the fields are repeatedly irrigated for raising crops more than once within a year. When considering all these multiple irrigated areas together, the gross irrigated area in all the basin states is estimated to be of the order of 484,240 Sq.km. The intensity of irrigation in Ganga basin is presented in Table 2.9.

Table .9 State-wise Intensity of Irrigation in the Ganga Basin (1999-2008)

S.No.	State	Net area Irrigated from all Sources (SqKm)	Gross Area Irrigated from all the Sources (SqKm)	Net Area Sown (SqKm)	Net irrigated to Net Sown (Percent)
1	Haryana	30250	53110	35940	84%
2	Uttar Pradesh & Uttarakhand	134260	196960	171820	78%
3	Bihar & Jharkhand	36460	48820	70920	51%
4	West Bengal	31360	36610	52960	59%
5	Rajasthan	62450	80880	170960	36%
6	Madhya Pradesh	65060	65670	146870	44%
7	Himachal Pradesh	1040	1870	5430	19%
8	Delhi	220	320	230	95%
	Ganga states	361100	484240	655130	55%
	India as a whole	630990	764430	1408610	44%

Source: [*] Ministry of Agriculture, 2008

As per the data compiled by department of Agriculture and Cooperation (2001), nearly 309,530 Sq Km. of land area is irrigated from all available water sources. The most extensively used water sources are the groundwater wells that irrigated nearly 205,090 Sq Km of land area during the year 2000-01 (Table 2.10). A large proportion of the water used eventually trickles into the subsoil layers through the cultivated fields, recharging groundwater supplies. The entire quantity of water used comes from the net balance of

[*] "Land Use Statistics at a Glance- State-wise" 2008, Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India

rainwater received each year, after deducting losses through evaporation and transpiration. On average, each square kilometer of the Ganga main stem receives a million cubic meters of water as rainfall. Thirty per cent of this is lost as evaporation, while the remainder eventually exits the land surface as run off and/or seeps down into the subsoil as groundwater recharge, a portion of which often oozes out at lower levels into streams. In the course of the water's movement either overland or below the surface, various chemical compounds gets dissolved in it. Some of these extraneous chemical constituents are derived from the residues of pesticides and chemical fertilizers, which are added to the soil every year for better yield of crops.

Table 2.10 State / Source-wise net area irrigated (2000-2001) in the Ganga Basin

Sl. No.	Name of the State / UT	Canals (SqKm)	Tank (SqKm)	Wells (SqKm)	Other Sources (SqKm)	Total Area (All Sources) (SqKm)
1	Bihar	11360	1550	20930	2410	36250
2	Haryana	14760	10	14670	140	29580
3	Himachal Pradesh	30	(a)	140	1070	1240
4	Madhya Pradesh	8080	850	26510	5910	41350
5	Rajasthan	13540	380	34730	420	49070
6	Uttar Pradesh	30910	820	93840	2590	128160
7	West Bengal	2610	1730	13970	5230	23540
8	Delhi	20	-	300	20	340
	Ganga states	81310	5340	205090	17790	309530
	India as a whole	159890	25240	332770	28920	546820

Source: Water Data- Complete Book, Central Water Commission, GoI, 2005
Note: (a): Below 5000 Sq.Km Total may not tally due to rounding off.

The net irrigated area in the Ganga basin constitutes nearly 56.6 percent of India's 546, 820 SqKm of net irrigated area. About 41.4 per cent of the basin's irrigated area lies in Uttar Pradesh alone. In fact, the three Gangetic States – Uttar Pradesh, Bihar and West Bengal – have between them 60.7 per cent of the basin's total area irrigated.

2.8 Major/ Medium Water Resources projects in the Basin

2.8.1 Irrigation Projects

In the Ganga main stem, there are several major systems of canals. The upper Gangetic main canal, taking off from Haridwar, is 230 km long and carries a discharge of about 300 cubic metres per second. Further down, the lower Gangetic canal has a discharge of more than 150

cubic metres per second. The total number of medium or major irrigation projects in the Basin (644 as of the latest published survey in 2009) benefits a command area of about 36.12% of the basin, or about 472,226 Sqkm. Nearly half of this command area falls in Uttar Pradesh which, at 97.13% coverage, is almost entirely blanketed by irrigation projects. Haryana achieves the second highest percentage of command area coverage with 87.5%, but its 38,683 Sqkm is bested by Bihar's 59,392 Sqkm. Madhya Pradesh, despite having the most number of projects (144), has third highest total command area of about 48,628 Sqkm and mere 15.78% coverage. This is due to the fact that most of its projects are of a medium size. On the low end, a mere 0.64% of Himachal Pradesh's total geographic area is covered by irrigation. Information on the number of major/medium irrigation projects and their respective command areas as a percentage of total area in the Ganga main stem states is given in Table 2.11.

Table 2.11 Information on Major/Medum Irrigation projects and Catchment Area in Ganga Basin (2009)

States	Total Geographical Area (Sqkm)	Total Command Area (Sqkm)	% of Geographical Area	Number of Irrigation Commands		
				Major	Medium	Total
Bihar	94163	59392.55	63.07	22	110	132
Haryana	44212	38683.56	87.5	9	0	9
Himachal Pradesh	55673	358.3	0.64	1	6	7
Jharkhand	79714	3994.77	5.01	2	72	74
Madhya Pradesh	308245	48628.88	15.78	30	114	144
Rajasthan	342239	50518.9	14.76	23	68	91
Uttarakhand	53483	2517.1	4.71	0	12	12
Uttar Pradesh	240928	234007.63	97.13	62	78	140
Delhi	Not available	NA	NA	NA	NA	NA
West Bengal	88752	34124.93	38.45	5	30	35
Ganga states	**1307409**	**472226.62**	**36.12**	**154**	**490**	**644**

Source: Central Water Comission, Regional Remote Sensing Services Centre, GoI

These irrigation projects derive their water from a variety of sources. Canals cater to some 28 per cent of the net irrigated area. Wells, however, provide the nearly twice that amount, especially in Uttar Pradesh and Uttarakhand (73%), West Bengal (59%), Madhya Pradesh (64%), Delhi (88%) and Rajasthan (71%), with net irrigated area served by wells given in parentheses. The sources of water for irrigation in percentage of net irrigated area within Ganga main stem is given in Table 2.12.

Table 2.12 Sources of Water for Irrigation within Ganga Basin (2000-2001)

S.No.	State	Canals	Tanks	Wells	Other sources
1	Haryana	50%	0%	50%	0%
2	Uttar Pradesh & Uttarakhand	24%	1%	73%	2%
3	Bihar & Jharkhand	39%	5%	49%	7%
4	West Bengal	11%	7%	59%	22%
5	Rajasthan	28%	1%	71%	1%
6	Madhya Pradesh	20%	2%	64%	14%
7	Himachal Pradesh	2%	-	11%	86%
8	Delhi	6%	-	88%	6%
	Ganga states	28%	2%	65%	6%
	India as a whole	29%	5%	61%	5%

Note: All figures indicate % of net irrigated area
Source: Central Water Commission

2.8.2 Projects for consumptive use

All of the major projects function as conduits for irrigation water; they also provide a means of flood control by diverting or storing excess water during the monsoon season. In all, there are 12 major diversion/storage projects in the Ganga main stem for consumptive uses, representing a total of between 2556.6 to 2581.8 m^3/s water diverted and 6797 MCM stored annually. The name, location, capacity and additional information on these projects are presented in Table 2.13.

As evident from the table, many of these storage projects are very and only 3 new projects were developed since early 1990s. The most recent project being, the Sharda Sahayak Canal – represents by far the largest project in terms of water diverted and area irrigated. Renovation of older projects, as well as the construction of newer ones will likely be necessary for the Ganga main stem to meet its future agricultural demands.

Table 2.13 Diversion /Storage Projects for Consumptive Use located in Ganga

Year of Completion/ Commissioning	Name and Location	Diversion/ Storage	Discharge(m^3/s)/ Storage in (MCM)	Purpose
1854	Upper Ganga Canal, Haridwar	Diversion	297 m^3/s	Irrigation (0.924 million Ha)
1874	Agra Canal, Okhla Barrage, Delhi	Diversion	30.8 m^3/s during Non-monsoon and 56 m^3/s during monsoon	Irrigation
1880	Lower Ganga Canal, Narora	Diversion	157 m^3/s	Irrigation (0.5 million ha)
1960	Gandhisagar Dam/ M.P.	Storage	6797 MCM Live Storage	Irrigation over 0.757 million ha. 115 MW
1990-91	East Ganga Canal Bhimgoda Haridwar	Diversion	237 m^3/s	Irrigation during Kharif 0.233 million ha
In between 1719-1748 AD during Mughal Dynasty	Eastern Yamuna Canal	Diversion	85 m^3/s	Irrigation
1355 AD During Ferozshah Tuglaq rule	Western Yamuna Canal	Diversion	190 m^3/s	Irrigation
2000	Sharda Sahayak Canal, Lakhimpur Kheri	Diversion	650 m^3/s	Irrigation (1.674 million ha)
1985	Gandak Canal	Diversion	147 m^3/s	Irrigation 0.96 million ha)
1963	Kosi Canal	Diversion	425 m^3/s	Irrigation (0.44 million ha)
1960	Kota Barrage	Diversion	230 m^3/s	Irrigation (0.5 million ha)
1994	Madhya Ganga Canal, Bijnor	Diversion	234 m^3/s	Irrigations 0.306 million ha)

Source Status Paper on Ganga River, NRCD, MOEF 2009

2.8.3 Hydroelectric Storage Projects in the Ganga main stem

With extensive monotonous regions and a multitude of tributaries, the Ganga is rich in hydroelectric potential. The 8 existing projects and 3 additional projects in construction are a testament to the regions importance to India's overall hydroelectricity portfolio. The fact that almost half of the existing projects have been completed in the past decade and 3 more projects are currently under construction suggests that India will continue to look to the basin to meet the growing energy demands of its rapidly developing economy. The list of hydroelectric storage projects in the Ganga basin is provided in Table 2.14.

Table 2.14 Storage Projects for Hydroelectricity Generation located in Ganga

Year of Completion/ Commissioning	Name and Location	Storage	Storage (MCM)	Purpose
1962	Rihand Dam/ Sonbhadra, UP	Storage	8900 MCM Live Storage	Hydro Electricity 300 MW + Water Supply to Thermal Plants
1970-71	Obra Dam Sonbhadra, UP	Storage	211 MCM Gross Storage	Hydro Electricity 99 MW
1973	Chambal Valley Project (Excluding Kota Barrage)	Storage	10500 MCM Live Storage	370 MW Hydro Electricity
1974	Ramganga Multipurpose Project at Kalagarh in Bijnor	Storage	2190 MCM-Gross Storage	Hydroelectric (198 MW) and Irrigation (.575 million Ha Flood Control
1991	Tons I at Bansagar	Diversion	Barrage	Hydro Electricity
2001-02	Tons II & III at Bansagar	Storage	5410 MCM Live Storage	Hydro Electricity 90MW
2006	Tehri Dam on Bhagirathi	Storage	2615 MCM Live	2400 MW of Hydropower and Irrigation to 0.27 million ha Land. Drinking water supply to Delhi @ 10 m^3/s
2006	Dhauliganga Pithoragarh	Storage	-	Hydro Electricity 280 MW

Year of Completion/ Commissioning	Name and Location	Storage	Storage (MCM)	Purpose
Under construction	Tapovan Vishnugarh Project, Joshimath (Chamoli)	Run of the River	Dhauliganga	Hydro Electricity 520 MW
Under construction	Lakhwar Phase I and Phase II on River Yamuna	Storage	333 MCM Live Storage	Installed Capacity 420 MW
Under construction	Jamrani Multipurpose Dam near Kathgodam	Storage	144 MCM Live Storage	Irrigation (0.15 Million Ha) + 30 MW Hydro + drinking

Source Status Paper on Ganga River, NRCD, MOEF 2009

2.9 Groundwater

2.9.1 Groundwater Potential and Use

The Ganga main stem has a vast reservoir of groundwater, replenished every year at a very high rate. The conjunctive use of groundwater for irrigation, even within the canal command areas, not only ensures steady supply to the cultivated fields on time but also helps reduce water logging and salinization due to consequent downward movement of subsurface moisture.

The groundwater usage for irrigation in the states falling under Ganga basin exceeded 104.7 billion cum per year as of 2008 and accounted for nearly 50 per cent of the groundwater irrigated area of the entire country. The net annual groundwater availability for irrigation, domestic and industrial usage in the states of the Ganga main stem has been assessed at 187.4 billion cum per year. Some 60 per cent of this potential has already been utilized. The groundwater usage pattern in the basin states is given in Table 2.15**.** The extent of groundwater utilization for irrigation is highest in Uttar Pradesh (45.36 BCM per year), followed by Madhya Pradesh (16.08 BCM per year), West Bengal (10.84 BCM per year) and Rajasthan (11.6 BCM per year).

Table 2.15 State-wise Groundwater Usage Pattern in the Ganga Basin

S. No.	State	Annual Groundwater Draft (BCM per year)			Net annual Groundwater availability (BCM/year)	Projected Demand for Domestic and Industrial uses upto 2025 (BCM per Year)
		Irrigation	Domestic and Industrial uses	Total		
1	Haryana	9.1	0.35	9.45	8.63	0.60
2	Uttar Pradesh	45.36	3.42	48.78	70.18	5.30
3	Uttarakhand	1.34	0.05	1.39	2.1	0.08
4	Bihar	9.39	1.37	10.77	27.42	2.14
5	Jharkhand	0.7	0.38	1.06	5.25	0.56
6	West Bengal	10.84	0.81	11.65	27.46	1.24
7	Rajasthan	11.6	1.39	12.99	10.38	2.72
8	Madhya Pradesh	16.08	1.04	17.12	35.33	1.74
9	Himachal Pradesh	0.09	0.03	0.12	0.39	0.04
10	Delhi	0.2	0.28	0.48	0.28	0.57
	Ganga states	**104.7**	**9.12**	**113.81**	**187.42**	**14.99**
	India as a whole	**212.37**	**18.05**	**230.41**	**398.7**	**29.14**

Source: Central Groundwater Board, 2008 and Central water commission 2008

Apart from irrigation, groundwater resources are also being heavily tapped for industrial and domestic uses majoring both urban and rural areas. Throughout the alluvial area of the Ganga main stem, the major urban water supply schemes are dependant upon groundwater resources. Similarly, a large number of industries also withdraw significant amounts of groundwater, especially from the easily accessible aquifers in the alluvial zone. The demand for domestic and industrial uses are expected to increase to 14.99 BCM per year in the Ganga main stem states by the year 2025, as shown in Table 2.15.

The mean annual replenishable groundwater in India as a whole has been assessed at 433 billion cumec per year, of which about 202.5 billion cumec per year (46.8%) lies in the states of the Ganga main stem. The annual replenishable groundwater levels, annual groundwater draft and balance of groundwater available for further exploitation for each state within the Ganga main stem is given in Table 2.16.

Table 2.16 State-wise Ground Water Resources Availability, Utilisation and Stage of Development in Ganga Basin

S. No.	State	Annual Replenishable Groundwater (BCM per Year)	Annual Groundwater Draft (BCM per Year)	Balance available (BCM per year)	Stage of Groundwater Development (%)
1	Haryana	9.31	9.45	-0.14	109
2	Uttar Pradesh	76.35	48.78	27.57	70
3	Uttarakhand	2.27	1.39	0.88	66
4	Bihar	29.19	10.77	18.42	39
5	Jharkhand	5.58	1.06	4.52	20
6	West Bengal	30.36	11.65	18.71	42
7	Rajasthan	11.56	12.99	-1.43	125
8	Madhya Pradesh	37.19	17.12	20.07	48
9	Himachal Pradesh	0.43	0.12	0.31	30
10	Delhi	0.3	0.48	-0.18	170
	Ganga Basin	**202.54**	**113.81**	**88.73**	
	India as a whole	**433.03**	**230.59**		

Source: Central Water Commission, Govt. of India, 2008

Among the various states within the Ganga main stem, Uttar Pradesh has the largest replenishable groundwater potential, with 76.35 billion cumec per year of usable groundwater; of this total, about 48.78 billlion cumec per year is currently in use primarily for irrigation, although a large share is consumed in the major cities for domestic and industrial purposes. Madhya Pradesh has the second highest replenishable potential in the basin at around 37.19 billion cum per annum here. The stage of groundwater development is highest in Delhi with 170 per cent followed by Rajasthan with 125 per cent and then Haryana with 109 per cent, followed by Uttar Pradesh, Uttarakhand, West Bengal and Bihar.

The vast Gangetic alluvial trough is characterized by not only one of the most prolific aquifers in quantitative terms, but also by the relatively high quality of the available water, though the quality deteriorates as one proceeds down the river to the outfall. Along the Himalayan foothills (bhabar and tarai belts), the water is of high quality, as these belts are under continuous recharge from the Himalayan streams. In certain localized areas of the Ganga plain, the fluoride & arcenic content in the groundwater is high enough to cause fluorosis and skin diseases when regularly consumed for long periods of time. In the central

alluvial trough, the groundwater has low mineral contents. The mineral content increases near the southern fringe of the alluvial formation, especially in certain parts of Agra, Aligarh, Mathura, Mainpuri and Ballia districts of Uttar Pradesh,. Near the delta area in West Bengal, the water in certain aquifers turns saline due to incursion of sea water.

2.9.2 Groundwater Quality

Ground water quality of the states falling under Ganga main stem is given in Appendix 2.1. The groundwater quality is monitored by the Central Ground Water Board once a year (April/May) through a network of observation wells located all over the country. The hot spots for groundwater in districts coming under basin states are identified on the basis of six main parameters: salinity (EC>3000 micro simen/cm), chloride, fluoride (>1.5 mg/l), iron (>1.0 mg/l), arsenic (>0.05 mg/l) and nitrate (>45 mg/l). The states of Bihar, Uttar Pradesh and West Bengal is affected by arsenic (where the concentration is greater than the permissible limit of 0.05 mg/l as per IS: 10500), fluoride, iron & nitrate. Salinity and chloride have been identified in Haryana, Delhi, Himachal Pradesh, West Bengal, Uttar Pradesh, Rajasthan and Madhya Pradesh.

2.10 Water Logging and Salinity Problems

The total irrigation command area of major and medium projects in the Ganga basins is estimated to be about 472,226 Sqkm, or 36.1% of the 1,307,409 Sqkm of area (both figures exclude Delhi). Of that irrigated area, 1.75%, or 8,268.6Sqkm is waterlogged. The situation is clearly most dire in Bihar, where over 10.5% of its irrigated area is waterlogged. Yet percentage figures do not tell the whole story, as Uttar Pradesh, despite having a relatively low percentage of its irrigated areas waterlogged, has lost nearly 1,266.8 sqkm to waterlogging – far more than the other states of the Ganga main stem (excluding Bihar) combined. Quite surprisingly, Jharkhand seems to have avoided any waterlogging issues despite its proximity to Bihar, although the extent of irrigation in this region is relatively low.

The breakdown in terms of perennial versus seasonal waterlogging also provides relevant insight into the problems of the Ganga basin states. Perennial waterlogging refers to the average amount of waterlogging year-round, excluding the monsoon season, whereas seasonal refers to the additional waterlogging brought about by the monsoon. In the basin, seasonal waterlogging far outweighs perennial waterlogging by a count of 7,476 Sqkm to

792.6 sqkm, respectively. This fact is true for all states in the basin except for Madhya Pradesh which receives no additional waterlogging as a result of the monsoon. Once more, Bihar leads the way in seasonal waterlogging, accounting for more seasonal waterlogging than all the other states combined. The vast increases seen here and throughout the basin suggest that waterlogging prevention efforts must focus on controlling the monsoon rainwaters and/or adequately protecting cropland from complete inundation. The extent and variation of waterlogging in major/medium irrigation command areas on a state-wise basis is given below in table 2.17.

Table 2.17 State-wise Magnitude and Seasonal Variation of Water Logging in Irrigatation Command Areas of Ganga Basin

States	Total Geographic Area	Total Command Area (Major/Medium Projects)	Breakdown of Waterlogging in Command Areas		Total Waterlogged Area	
			Perennial	Seasonal	Total Area	% of Command
Bihar	94163.0	59392.6	616.7	5662.2	6278.9	10.6
Haryana	44212.0	38683.6	32.9	131.7	164.6	0.4
Himachal Pradesh	55673.0	358.3	0.1	2.6	2.6	0.7
Jharkhand	79714.0	3994.8	0.0	0.0	0.0	0.0
Madhya Pradesh	308245.0	48628.9	5.4	0.0	5.4	0.0
Rajasthan	342239.0	50518.9	7.2	76.9	84.1	0.2
Uttarakhand	53483.0	2517.1	0.8	1.5	2.2	0.1
Uttar Pradesh	240928.0	234007.6	113.0	1153.9	1266.8	0.5
Delhi	Not available	NA	NA	NA	NA	NA
West Bengal	88752.0	34124.9	16.8	447.2	464.0	1.4
Ganga states	**1307409.0**	**472226.6**	**792.6**	**7476.0**	**8268.6**	**1.8**

Source: Central Water Comission, Regional Remote Sensing Service Centre, GoI, 2009

Salinity also represents a significant problem for the Ganga basin states, with 1% of its major/medium irrigated command areas affected by excess salt levels. Once again, Bihar and Uttar Pradesh suffer the most salt degradation, with 2.64% and 1.21% of irrigation command areas affected, respectively; however, UP's total salt affected area exceeds that of Bihar's by a count of 2,831.4 Sqkm to 1,568.8 sqkm, respectively. Once more, Jharkand manages to avoid any adverse affects. Himachal Pradesh has also avoided any salinity problems, explained both by its altitude and the fact that it has the smallest irrigation command area in

the basin states (excluding Delhi). The magnitude of salt affected areas in the Ganga main stem states' major/medium irrigation command areas is given below in Table 2.18.

Continued irrigation over the years has contributed to building up of the salt and alkali levels in the cultivated soils. In the entire irrigation command area, especially in areas where the drainage is poor, the salinity level and alkali status in the soils rise to an appreciable degree not necessarily captured in state-level numbers. In certain concentrated areas, the soils have been rendered infertile (usar) and alkali-affected (reh), such as pockets of Haryana and Western Uttar Pradesh. From these areas there is constant subsurface seepage and the flow of wastewater here is charged with salts and alkalis, which eventually find their way to the river waters in the Ganga main stem.

Table 2.18 State wise extent of Salt Affected Areas in Irrigatation Command Areas of Ganga Basin

States	Total Geographic Area	Total Command Area (Major/Medium Projects)	Total Salt Affected Area (Major/ Medium Projects)	
			Area	% of Command
Bihar	94163	59392.55	1568.87	2.64
Haryana	44212	38683.56	193.93	0.50
Himachal Pradesh	55673	358.30	0.00	0.00
Jharkhand	79714	3994.77	0.00	0.00
Madhya Pradesh	308245	48628.88	44.10	0.09
Rajasthan	342239	50518.90	20.53	0.04
Uttarakhand	53483	2517.10	0.13	0.01
Uttar Pradesh	240928	234007.63	2831.46	1.21
Delhi	NA	Not available	NA	NA
West Bengal	88752	34124.93	64.70	0.19
Ganga states	**1307409**	**472226.62**	**4723.72**	**1.00**

Source: Central Water Commission, Regional Remote Sensing Service Centre, GoI. 2009

2.11 Land Degradation: Ganga main stem

The term land degradation refers to the decline in the productivity and quality of land resulting from natural calamities as well as human actions. Land degradation and associated loss of soil productivity is the subject of environmental concern.

Within Ganga main basin states, the total land area which faces conditions of degradation is about 1,468,200 Sqkm, or 44.68% of the total geographical area. The primary causes of land degradation with corresponding afflicted areas are, in order, water erosion (almost 936,800

Sqkm), soil acidity (about 160,330 Sqkm) and water logging (almost 142,990 Sqkm), though these problems vary greatly by state. For example, despite being near the bottom in % of degraded area, Rajasthan leads all states in the Ganga main stem in salinity/alkalinity with about 14,180 Sqkm afflicted, with Uttar Pradesh/Uttarakhand taking a close second at 13700 Sqkm affected. The leading states in terms of % degraded area are Himachal Pradesh (75%), Madhya Pradesh/Chhattisgarh (59.1%), Delhi (52%) and Uttar Pradesh/Uttarakhand (52%). Himachal leads because of its extensive water erosion and waterlogging problems, while water erosion alone represents by far the largest source of degradation for Madhya Pradesh/Chhattisgarh and Uttar Pradesh/Uttarakhand; Delhi's % numbers are inflated by its significantly smaller land area versus the other states, however water erosion is the most significant contributor there as well. The extent of land degradation problems within Ganga main stem is given in Table 2.19.

Table 2.19 State-wise Extent of Various Kinds of Land Degradation in Ganga main stem states (2007)

States	Water Erosion (Sqkm)	Wind Erosion (Sqkm)	Water Logging (Sqkm)	Salinity/ Alkalinity (Sqkm)	Soil Acidity (Sqkm)	Complex Problem (Sqkm)	Degraded Area (Sqkm)	Geogra-graphi-cal area (Sqkm)	Degraded Area (%)
Bihar + Jharkhand	30240	0	20010	2290	10290	0	62830	173870	36.1
Haryana	3150	5360	1460	2560	0	2140	14670	44210	33.2
Himachal Pradesh	27180	0	13030	0	1570	0	41780	55670	75
Madhya Pradesh + Chhattisgarh	178830	0	3590	460	67960	11260	262100	443450	59.1
Rajasthan	31370	66500	530	14180	0	1100	113680	342240	33.2
Uttar Pradesh + Uttarakhand	113920	2120	23500	13700	0	0	153240	294410	52
West Bengal	11970	0	7100	1700	5560	1190	27520	88750	31
Delhi	550	0	60	100	0	110	820	1480	55.4
Ganga Basin states	**936800**	**94830**	**142990**	**59460**	**160330**	**73810**	**1468200**	**3286020**	**44.68%**

Source *National Bureau of Soil Survey, Land Use Planning Indian Council*

2.12 Vegetation and Forests

The vegetation type of the Ganga main stem is largely comprised of tropical moist and dry deciduous types, but also includes a few additional varaties. The vegetation type of Ganga main stem are described below and illustrated in Figure 2.5.

i. **Tropical Moist Deciduous Vegetation-** This vegetation type thrives in areas having moderate rainfall of 1500-2000mm, a mean annual temperature of 26^{o}C to 27^{o}C and an average relative humidity of 60 to 80 per cent. It is also known as the monsoon forest as the trees shed their leaves during dry season. It is found on the Western Ghats, eastern coastal plain, eastern plateau, Himalayan foothills and in some parts of Sutlej-Ganga plains. Common trees are sal, teak, sandal wood, arjun, jarul, ebony mulberry, kusum siris, palas, mahua, simul and dhup.

ii. **Tropical Dry Deciduous Vegetation-** The dry deciduous vegetation type grows in areas where rainfall is less than 150mm and the dry period is relatively long. Trees grow shorter than in tropical moist deciduous category and the undergrowth is shrubby and grassy. During the hot, dry phase (March to May months), the trees shed their leaves. This type is found in eastern Rajasthan, Kathiawar, rainshadow area of the Deccan plateau, central India and Punjab. Common plants are teak, sal, bijasal, laurel, palas, khair and kendu.

iii. **Sub-Tropical Coniferous Vegetation-** This type is a pure association of chir pine without underwood and a few shrubs. It is found throughout the whole length of the northwest Himalaya between elevation of 1000-1800m.

iv. **Himalayan Dry Temperature Vegetation-** This type is found in the inner dry ranges of the Western Himalaya where precipitation is below 1000mm, and is predominantly a coniferous forest with xerophytic shrubs. Epiphytes and climbers are rare. Important species are chilgoza, deodar, oak, maple, ash, celtis, parrotia, olive, etc.

v. Himalayan Moist Temperate Vegetation- In the western Himalaya, between 1500m and 3000m elevation, forests of deodar, spruce, maple, walnut, poplar, cedar, chestnut, birch, oak etc. occur. These are 30 to 50m high. Undergrowth is mostly evergreen. Mosses and ferns grow freely on trees.

The extent of forest cover among the various states within Ganga main stem is given in Table 2.20.

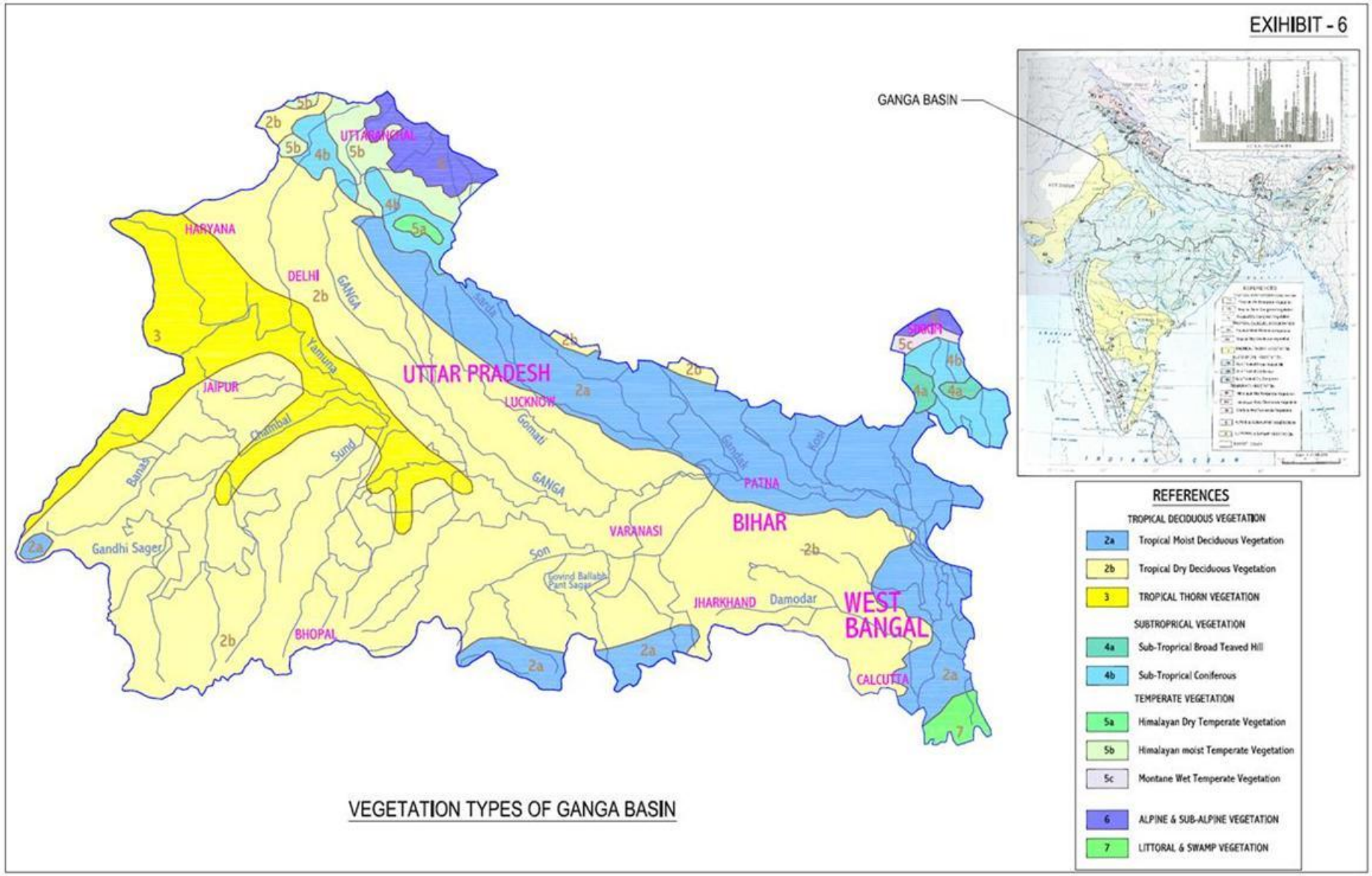


Figure 2.5 Vegetation Types of Ganga main stem

Table 2.20 State-wise Forest Cover in Ganga Basin States

State	Geographical Area (Sqkm)	Forest Cover				% of Geographical Area	Change in Forest Cover v. 2005
		Very Dense Forest (Sqkm)	Moderatly Dense Forest Cover (Sqkm)	Open Forest (Sqkm)	Total (Sqkm)		
Bihar	94,163	231	3,248	3,325	6,804	7.23	-3
Delhi	1,483	7	50	120	177	11.94	0
Haryana	44,212	27	463	1,104	1,594	3.61	-10
Himachal Pradesh	55,673	3,224	6,383	5,061	14,668	26.35	2
Jharkhand	79,714	2,590	9,899	10,405	22,894	28.72	172
Madhya Pradesh	308,245	6,647	35,007	36,046	77,700	25.21	-39
Rajasthan	342,239	72	4,450	11,514	16,036	4.69	24
Uttar Pradesh	240,928	1,626	4,563	8,152	14,341	5.95	-5
Uttarakhand	53,483	4,762	14,165	5,568	24,495	45.80	2
West Bengal	88,752	2,987	4,644	5,363	12,994	14.64	24
Ganga Basin states	**1,308,892**	**22,173**	**82,872**	**86,658**	**191,703**	**14.65**	**167**
India	**3,287,263**	**83,510**	**319,012**	**288,377**	**690,899**	**21.02**	**728**

Source: Forest Survey of India, 2007

The Ganga basin has gained significant forest cover in between the 2007 and 2005 surveys. This increase was fueled almost entirely by the incredible surge in Jharkhand, suggesting the success of reforestation and conservation efforts there. However, Madhya Pradesh has lost more forest cover than the rest of the basin combined, and renewed conservation efforts must take hold there to protect the state's 25.21 per cent of land area that is forested. The decline in forests in Haryana is also alarming, given that the state has the lowest level of forest cover in the Ganga main stem, excluding the largely urban area of Delhi.

2.12.1 Macrophytic, Marginal and Riparian Vegetation of the Ganga*

The Macrophytes constitute the marginal vegetation growing on the bank of rivers in or near water where it is found emergent, submergent, or floating. It provides shelter for breeding animals and fishes. Some of the soil binder plants which are found throughout the stretch of the Ganga river include Saccharum spontaneum, Ipomoea carnea, Lantana camara, Imperata

* Krishna Murti, C.R., Bilgrami, K. S., Das, T.M, Mathur, R. P., 1991. The Ganga, A Scientific Study. The Ganga Project Directorate, Northern Book Centre, New Delhi.

cylindrical, Cynodon dactylon and Dichanthium annulatum. The macrophyte vegetation changes continously in response to floods and associated changes in water level. Some macrophytes are ecologically and economically very important. The riparian vegetation acts as a significant conserver of water, nutrient, and soil, while minimizing the adverse effects of pollutants that run through the slope of the river bank. Thus, these plants help prevent river pollution, siltation, and upwelling of river beds. They also minimize the adverse effects of floods to a considerable extent. A list of the plants constituting macrophyte, marginal and riparian vegetation is given in Appendix 2.2. Industrial wastewater effluents tend to decrease the rate seed germination of macrophytes as well as the rate of survival after germination, thus significantly impacting the diversity of macrophytic vegetation on the river banks. Therefore, those plants which exhibit resistance to contamination must be employed as tools in bio-control of pollution. Furthermore, the advantages of microphytes can be exploited by testing the suitability of different tree species for the cultivation in flood prone areas.

2.13 Biological Profile of the Ganga*

2.13.1 Phytoplankton

Phytoplanktons are heterotrophic autotrophic organisms, individually too small to be seen by the naked eye but when present in large cluster may appear green due to the presence of chlorophyll. They form the foundation of the food web for most aquatic life and are responsible for half of the photosynthetic activity on earth, making them important to both local and global ecosystems. In the Ganga river, the phytoplankton density varies both spatially and temporally along the different stretches of the river. Phytoplankton population is generally very high in the middle stretches of river Ganga (Mirzapur to Farakka) relative to upper (Gangotri to Garhmukteshwar) and lower stretches (Berhampur to Bally). The densities increase with the water temperature during the first half of the year (January to May). The monsoons, on the other hand, lead to an increase in the turbidity of water, leading to less solar penetration and hence less phytoplankton. The plankton population is adversely effected by human activities like pilgrims' bathing, waste water discharges from domestic and industrial activities resulting in decreases of the common plankton population and increases in highly pollutant tolerant forms which further degrade the water quality.

- Common Algae:Oscillatoria princps, Aulosira fertillisima, Spirogyra subsalsa, Pinnularia nobilis, Navicula viridis

- Pollution Sensitive Algae: Lyngbya magnifica, Nodularia Spumigena, Merismopedia elegans, Cosmarium tenue.

2.13.2 Zooplankton

Zooplankton are organisms drifting in the water column of oceans, seas, and bodies of freshwater. They generally feed upon other plankton, including phytoplankton, along with bacteria and various types of particulate plant matter. Both zooplankton and phytoplankton not only play a vital role in the stability of the marine ecosystem but also act as an indicator of water health as they are affected by slight changes in the environment. Changes in temperature, acidity or nutrient levels from farm runoff and pollution can all have dramatic effects on plankton. Similar to phytoplankton, the zooplankton population is greatest during summer and lowest during winter at various stretches of the river Ganga. Pollution tolerant zooplanktons were reported to be numerous in the pollution zones of wastewater discharge points from industries and domestic sectors. Changes in plankton can act as early warning signs of a problem in the environment. Some of the common zooplantons in the Ganga river include:

- Rotifer: Brachionus caudatus, B. forficula, B. calyciflorus, B.quadridentata, Filinia opoliensis
- Copepoda: Pseudodiaptomus annandalei, Mesocyclops hyalinus, Nauplii of Cyclopoids
- Cladocera: Moina micrura, Bosmina meriodionalis

2.13.3 Fish*

The river Ganga supports fisheries and contributes significant economic benefits to the riparian communities and the national economy. Out of the total fish landings in river Ganga, 29.8% of fishing is from a riverine source. The fisheries in the upper stretch of the river comprise only fresh water species whereas the lower stretch comprises both freshwater and estuarine species. The list of most common fishes found in various stretches of river Ganga is given in Appendix 2.3. Several species are not native to the Ganga system but isntead come from the hills and other rivers during monsoon floods. These species include Danio dangila, D. devario, Botia Dario and B. lohachata. Juvenile fishing in the post-flood period is very

* - Krishna Murti, C.R., Bilgrami, K. S., Das, T.M, Mathur, R. P., 1991. The Ganga, A Scientific Study. The Ganga Project Directorate, Northern Book Centre, New Delhi.
- The Central Inland Fisheries Research Institute (CIFRI), www.cifri.ernet.in/152.pdf

common which results in the destruction of millions of fingerlings of major carps. This practice causes incalculable loss to good quality fish like Catla, Rohu and Mrigal. Breeding for most of the Ganga fish begins at the onset of monsoon. Although there is not any marked variation in different seasons in general, the varietal diversity is greatest during winter and the post monsoon period.

Ganga water affected by waste discharge from domestic, agriculture and industrial sectors becomes hazardous for the growing carp, affecting the normal food chain in the river eco-system and creating imbalances. Laboratory experiments and partially controlled field investigations conducted by Bhagalpur University* with various types of pure detergents reveal that most commonly used detergents are highly toxic to fish and fish seed, reducing growth, increasing mortality and hampering reproductive ability. Furthermore, there has been a noticeable shift in species composition in catches and even total fish catch is declining day by day due to human activities such as increased water abstraction, river course modification, and reservoirs. Hilsa, Tenualosa ilisha, which constituted a major fishery in Ganga until the 1960s, is now disappearing while exotic fishes like tilapia and common carp have started appearing in the 2000s. The systematic list of fish found in Ganga basin in given in Appendix 2.3.

Along with the above mentioned species, the following species of prawns were also recorded: Macrobrachium lamarrei, M. birmanicum choprai, M. malcolmsonii, Parapenaeopsis sculptilis, P. stylifera, Metapenaeus brevicornis, M. monoceros, Penaeus mondon, P. indicus, P. semisulcatus, Expalaemon stylifera, E. tenuipes and Leptocarpus fluminicola.

2.13.4 Vertebrate Biota of the River Ganga

The Ganga is a natural repositary of a different range of fauna. The vertebrates found in the river Ganga (given in Appendix 2.4) include the amphibia, reptilia, mammalia and aves (birds) classes. Killing of some birds and mammals has been observed in this region. Furthermore, pollution of the river adversely affects the general living conditions of the fauna at times causing migration to other areas.

- Amphibia: Rana is widely distributed in the river Ganga. R. limnocharis, R. tigrina and R. cyanophlyctes are also found in the middle and lower stretch of Ganga. Tadpole larvae are quite common during the breeding season.

- Reptilia: Some of the important reptiles found in the Ganga river include Trionyx gangeticus, Kachuga Kachuga, Lissemys punctata, Gavialis gangeticus (Gharial) and Natrix piscator (Grass snake).
- Birds: The Ganga basin is a sanctuary for a large number of birds including migratory ones. A large number of migratory birds visit Gangetic belts during the onset of winter. The birds found in the Ganga river are listed in Appendix 2.4.
- Mammals: Gangetic dolphins (Platanista gangetica) know as Susa, Sons or Swis in various parts of the basin represent the lone member of this class in the Ganga river. These mammals are found between Kalakankar to Phaphamau. The indiscriminate killing of this aquatic mammal is threatening its very existence in the river region.

2.14 Sensitive Environmantal Habitats

Environmentally sensitive areas in the Ganga basin comprise Biosphere Reserves, Wildlife Sanctuaries, National Parks and Tiger Reserves among others (rare and endangered species). These areas are are ecologically fragile zones and need to be protected from pollution and abatement of flow rates in various sections of the river. At present about 31 per cent of the National parks in India are located in Ganga basin along with 15 per cent of wild life sanctuaries protecting some of the endangered species like Bengal Tigers, Ganga Dolphins and Vultures. Mangroves which are more resilient and very unique ecosystems on the planet are also located in the basin at Sundarbans (West Bengal). The environmentally sensitive areas within the Ganga main stem are briefly summarized hereunder.

2.14.1 Protected Areas

2.14.1.1 Biosphere Reserves

The Government of India has established 15 Biosphere Reserves of India, (categories correspond to IUCN Category V protected areas), which protect larger areas of natural habitat (more than a National Park or Animal Sanctuary) and often include one or more National Park and / or Reserves, along buffer zones that are open to some economic uses. Protection is granted not only to the flora and fauna of the protected region, but also to the human communities which inhabit these regions and their ways of life.

The Ganga basin has two Biosphere reserves, namely the Nanda Devi Biosphere Reserve and the Sundarbans National Park, which are also a part of the World Network of Biosphere

reserves. The location of Biosphere reserves within the Ganga main stem are shown in Appendix 2.5.

Table 2.21 Biosphere Reserves located within the Ganga main stem

S. No.	Name	Location	State	Tributary	Type	Area (SqKm)
1	Sunderbans	North and South 24-Paraganas	West Bengal	Ganga	Gangetic Delta	9630
2	Nanda Devi	Pithoragarh	Uttarakhand	Ramganga	West Himalayas	5860.69

Source: Forest and Wildlife Statistics, India, 2004, MoEF

i. Nanda Devi National Park - Nanda Devi National Park is one of the most spectacular wilderness areas in the Himalayas and is located in Pithorgarh District of Uttrakhand state. It is dominated by the 7,800m peak of Nanda Devi, India's second highest mountain which is approached through the Rishi Ganga gorge, one of the deepest in the world. No humans live in the park, which has remained more or less intact because of its rugged inaccessibility. It has very diverse flora and is the habitat of several endangered mammals, among them the snow leopard, serow, Himalayan musk deer and bharal. The Nanda Devi National Park (NDNP) is one of the very few wilderness areas in India that has remained naturally protected. The Nanda Devi basin was declared as Nanda Devi Sanctuary in 1939. An area of 630 sq. Km. was added as Nanda Devi National Park in the year 1982 which is now a part and core zone of Nanda Devi Biosphere Reserve. The Park became a world heritage site in the year 1988. Some of the important peaks encircling the National Park are Dunagiri (7066mt), Changband (6864mt), Kalnka (6931mt) Rishi pahar (6992 mt) Mangraon (6765mt), Nanda Khat (6631 mt), Maiktoli (6803 mt), Mrigthuni (6655mt), Trishul-1 (7120mt), Trishul-II (6319mt), Bethartoli Himal (6352mt) and Nandadevi East (7434 mt.). Nanda Devi National Park is an outstanding mountain wilderness area with few if any parallels elsewhere in the Himalayas on account of its concentration of high peaks and glaciers lying within range of near-pristine habitats. It lies within a bio-geographical transition zone between the Western and Eastern Himalayas and supports a variety of threatened and uncommon species of large mammals.

ii. Sunderbans National Park - The Sundarbans lies across the outer deltas of the Ganges, Brahmaputra and Meghna rivers. The park is located in North and Sourth 24-Paragnas Districts in the state of West Bengal. At 10,000 sq.km, it forms the largest mangrove forest in the world, with 40% falling in India, and 60% in Bangladesh. The forest

is composed of small forested islands and mud flats intersected by a complex network of tidal waterways, and exemplify the ecological processes of monsoon rain flooding, delta formation, tidal influence and plant colonisation. The area has a wide range of rare fauna, including the Bengal tiger, estuarine crocodile, Indian python and many reptiles and birds. As part of the Man and Biosphere Programme (MAB), accepted in the general conference of the UNESCO in 1970, the Ministry of Environment of Forests, Govt. of India adopted the National MAB programme and declared the entire 9630 sq. km. of Sundarban as the Sundarban Biosphere Reserve in 1989. The Sundarban Biosphere Reserve has also been included in the World Network of Biospheres by UNESCO in November, 2001. The extent of mangrove Reserved Forest in Indian Sundarban is around 4260 sq. km., which is administratively divided into the Sunderban Tiger Reserve (2600 sq. km.) and Forest Divn. (1660 sq. km.). Out of this total recorded forest area, 55% is under vegetation cover and balance 45% is under water body/ char land.

2.14.1.2 National Parks and Wildlife Sanctuaries

a) National Park

A National Park is a reserve of natural or semi-natural land, declared or owned by the Government of India and set aside for human recreation and enjoyment, as well as animal and environmental protection and is restricted from most development. The International Union for Conservation of Nature (IUCN) and its World Commission on Protected Areas has classified National Parks under its Category II type of protected areas. At present India has 94 National Parks, spread all across the country, out of which 27 National Parks are within the Ganga basin (apart from the two biosphere reserves mentioned in the previous section). The total area cover of National Parks including biosphere reserves in the Ganga basin is about 21,197 Sqkm, with about 50% of them are located in the state of Uttarakhand. A list of 27 national parks in Ganga Basin including district, adjacent tributary and settlement information is presented in Table 2.22. It however needs mention that, the Ganga basin boundaries are not exact and hence national parks within 30 km of a Ganga tributary, have been considered to be located in the basin.

b) Wildlife Sanctuaries

India has 502 animal sanctuaries, commonly referred to as Wildlife Sanctuaries (IUCN Category IV protected area). Out of this 502, about 75 are located in the Ganga basin. The total area set aside for these sanctuaries is 14,086 Sqkm. An exhaustive list of wildlife

sanctuaries within the Ganga main basin by state is given Appendix 2.6 and locations are shown in Appendix 2.5. It however, needs mention that the sanctuaries have been identified based on their location in the Ganga basin districts and their actual location could vary based on exact boundary of the basin / sanctuary.

c) Tiger Reserves

Project Tiger, a wildlife conservation program initiated by Government of India in 1972 to protect the Bengal Tigers, governs these reserves, which are meant to be representative of various regions throughout India. The programme strives to maintain a viable population of this conservation-reliant species in their natural environment. The Bengal Tiger faces extinction due largely to the threat of poaching for their pelts. Out of the 28 designated tiger reserves, 10 are located in the Ganga Basin, and comprise a total "core area" of over 8838 Sqkm; core area refers to the primary protected area of the reserve, in contrast to the so-called "buffer area" in which some development activities are allowed. The list of tiger reserves in Ganga basin, with associated district and adjacent tributary information, are given in Table 2.23. Since, the Ganga basin boundaries are not exact, the tiger reserves within 30 km of a Ganga tributary, have been considered to be located in the basin.

Table 2.22 National Parks and Wildlife Sanctuaries located in Ganga Basin

Name	State	Location (District)	Adjacent Tributary*	Adjacent Settlement*	Area, SqKm
Valmiki National Park	Bihar	West Champaran	Koshi	Narkatigang Bagha	335.65
Kalesar National Park	Haryana	Yamunanagar	Yamuna	Jagadhri Yamunanagar	46.82
Sultanpur National Park	Haryana	Gurgaon	Yamuna	Gurgaon	1.43
Betla National Park	Jharkhand	Palamau	Koel	Daltongani	231.67
Sanjay National Park	Madhya Pradesh	Sidhi/Sarguja	Son	Sidhi	1938.00
Kanha National Park	Madhya Pradesh	Mandla	Narmada	Baihar	940.00
Satpura National Park	Madhya Pradesh	Hoshangabad	Narmada	Hosangabad	585.17
Panna National Park	Madhya Pradesh	Panna, Chatarpur	Son	Satna	543.00
Bandhavgarh National Park	Madhya Pradesh	Shandol	Son	Katni	105.40
Madhav National Park	Madhya Pradesh	Shivpuri	Chambal	Shivpuri	337.00
Van Vihar National Park	Madhya Pradesh	Bhopal	Narmada	Bhopal	4.45
Fossil National Park	Madhya Pradesh	Mandla	Son	Katni	0.27
Desert National Park	Rajasthan	Jaisalmer	Banas	Jaisalmer	3162.00
Ranthambore National Park	Rajasthan	Swai Madhopur	Chambal	Sawai Madhopur	392.00
Mount Abu Wildlife Sanctuary	Rajasthan	Sirohi	Banas	Pali	288.00
Sariska National Park	Rajasthan	Alwar	Banas	Alwar	273.80
Keoladeo National Park	Rajasthan	Bharatpur	Yamuna	Agra	28.73
Dudhwa National Park	Uttar Pradesh	Lakhimpur-Kheri	Ganga, Sarda	Dhangadhi	490.29
Gangotri National Park	Uttarakhand	Uttarkashi	Ganga	Gangi	1552.73
Rajaji National Park	Uttarakhand	Haridwar, Dehradun, and Pauri Garhwal	Ganga	Rishikesh	820.42
Corbett National Park	Uttarakhand	Nainital and Pauri Garhwal	Yamuna	Yamunanagar	521.00
Govind Pashu Vihar	Uttarakhand	Uttarkashi	Bhagirathi	Uttarkashi	957.97
Valley of Flowers National Park	Uttarakhand	Pithoragrh	Ramganga	Joshimath	87.50

Name	State	Location (District)	Adjacent Tributary*	Adjacent Settlement*	Area, SqKm
Buxa National Park	West Bengal	Jalpaiguri	Torsa, Bramhaputra	Alipurduar	117.10
Neora Valley National Park	West Bengal	Darjeeling	Bramhaputra	Kalimpong	88.00
Gorumara National Park	West Bengal	Jalpaiguri	Tista	Jalpaiguri	79.45
Hiral National Park	West Bengal	Darjeeling	Tista, Torsa	Darjeeling	78.60
Ganga main stem Total	**27 Parks**				**14006.45**

**Note: TERI used GIS maps to estimate adjacent tributaries and settlements within 30km of a given National Park*

Source: Forest Statistics India 2000, Indian Council of Forestry Research and Education, Respective State Forest Department Websites, Respective National Park Official Website

Table 2.23 Tiger Reserves located in Ganga main stem

Name	State	Location (Distrct)	Adjacent Tributary*	Adjacent Settlement*	Core Area (SqKm)
Valmiki	Bihar	West Champaran	Koshi	Narkatigang Bagha	880.76
Bandhavgarh	Madhya Pradesh	Shahdol and Jabalpur	Johilla and Son	Katni	716.90
Kanha	Madhya Pradesh	Mandla	Narmada	Baihar	940.00
Panna	Madhya Pradesh	Ken	Panna and Chhatarpur	Son	576.13
Ranthambhore	Rajasthan	Sawai Madhopur and Karauli	Chambal	Sawai Madhopur	1113.36
Sariska	Rajasthan	Alwar	Chambal	Alwar	681.11
Dudhwa-Katerniaghat	Uttar Pradesh	Lakhimpur-Kheri	Ganga, Sarda	Dhangadhi	648.00
Corbett	Uttarakhand	Nainital and Pauri Garhwal	Yamuna	Yamunanagar	821.99
Buxa	West Bengal	Jalpaiguri	Torsa, Bramhaputra	Alipurduar	760.00
Sunderbans	West Bengal	North and South 24-Paraganas	Ganga	Haldia	1699.92
Ganga main stem Total	**10 Reserves**				8838.18

**Note: TERI used GIS maps to estimate adjacent tributaries and settlements within 30km of a given National Park*

Source: Project Tiger Task Forest Reports (2004, 2010), Project Tiger Website

A brief description of some of the major national parks and tiger reserve within the Ganga main stem is outlined below, based on the information available from the respective State Forest Departments.

i. **Valmiki National Park and Tiger Reserve**: Valmiki National Park is located in the northern-most part of the West Champaran district of the Indian state of Bihar. The tract is broken and undulating, often showing highly fragile geological formations. As a result, there are steep ravines, knife-edge ridges and precipitous walls formed by land slips and soil erosion. Valmiki is the 18th Tiger Reserve of the country and the second in Bihar. The core area of the Reserve was declared as a National Park in 1989. The Government of Bihar had notified 464.60 sq. km. area as Valmiki Wildlife Sanctuary in 1978. Later, in 1990, an area of 419.18 sq. km. was added to the Sanctuary. Thus, the Valmiki Wildlife Sanctuary embraces a total area of 880.78 sq. km.

ii. **Kalesar National Park -** Kalesar National Park is situated in the foot hills of Shiwalik ranges of mighty Himalays. It falls under Yamunanagar district of Haryana and shares a boundary with three states: Himachal Pradesh, Uttrakhand and Uttar Pradesh. The Yamuna river forms the eastern boundary with Uttar Pradesh, while the main shiwalik ridge serves as the state boundary between Haryana, Himachal Pradesh and Uttarakhand in the north. The park was declared a National Park on 8th December 2003 with an area of 11570 acres. Just adjacent to the National Park is the Kalesar Wildlife Sanctuary, which received thi designation on 13th December 1996 with an area of 13209 acres. Kalesar National Park is named after the Kaleshar (shiva) temple located in protected area. The whole area is full of bio-diversity, including dense Sal forest, Khair forest and patches of grass lands, which supports an amazing variety of plants and animal species.

iii. **Sultanpur National Park -** Sultanpur National Park, located at about 50 Kms from Delhi and 15 Km from Gurgaon on Gurgaon Farukhnagar road is a bird paradise, both for local as well as migratory aves, particularly in the winter months. The National Park has an area of 359 acres, out of which about 180 acres is pondage area and the rest provides habitat for terrestrial birds. Of the recorded 250 bird species, 150 are residents or local-migratory, while others come form faraway northern regions like Siberia, Europe and Afghanistan. The

common resident species are Little egret, Painted stork, White ibis, Little brown dove, Indian crested lark, Myna, Red vented bulbul, Magpie robin, Weaver bird, among others. Every year about 90 species of migratory birds arrive here in search of feeding grounds and to pass the winter. In winter, the sanctuary provides a picturesque panorama of migratory birds such as Rosy pelican, Spotted sand piper, starling, Blue throat, among others. In summer, 11 species of birds such as Koel and Cuckoos can be recognised by their melodious songs.

iv. **Betla National Park and Palamau Tiger Reserve** Palamau Wildlife Sanctuary in the state of Jharkhand was initially created over a forest area of 979.97 Sq. Km. and since then an area of 231 Sq. Km. of this sanctuary has been designated as Betla National Park. Both the areas have been included in the Palamau Tiger Reserve created under Project Tiger. The area is drained by the North Koel and its tributary, the Burha river. Forests here are of Dry and Moist Deciduous types with bamboo brakes. Besides diverse herbs, shrubs and grasses, the important tree species are Sal, Asan, Sidha, Semal, Karam, Chilbil, Kusum, Bherhul, Dhaura, Khair, Salai etc. The sanctuary is rich in flora and fauna with 47 species of mammals, 174 species of birds, 970 species of flora including 25 species of climbers, 46 species of shrubs in addition to herbs, grasses etc. Tiger, Leopard, Elephant, Gaur, Sambhar, Cheetal, Barking Deer, Sloth Bear, Nilgai, Wild Dog, Wolf, Hyaena etc and varieties of reptiles and beautiful birds can be seen here without much effort.

v. **Sanjay National Park –** The National Park, was established in 1983-84 and is situated in Sidhi District in the state of Madhya Pardesh. The total area of the national park is 1471 Sq.Km. The principal fauna of the Park are Tiger, Panther, Sambhar, Blue Bull, Chousingha, Cheetal, Gour, Bear, and many species of birds. The principal flora is Sal, Saja, Tendu, Dhawda, Haldu etc.

vi. **Kanha National Park and Tiger Reserve:** Located in the "Maikal" ranges of the Satpuras, and falling in the Mandla and Balaghat districts of Madhya Pradesh, Kanha Tiger Reserve is internationally renowned for its typical Central Indian flora and fauna. Apart from supporting a viable population of tigers, the National Park has also distinguished itself in saving the highly endangered hard ground barasingha (*Cervus duvauceli branderi*) from extinction, and has the unique distinction of harbouring the last world population of this deer species.

The Tiger Reserve, with an area of 1949 sq. km., is comprised of two divisions, namely the Core Zone (National Park) with 940 sq. km. and the Buffer Zone (Multiple Use Area) of 1009 sq. km. Besides, there is also Phen Wildlife Sanctuary (110 sq. km.), a Satellitic Micro Core under the unified control of the Field Director, Kanha Tiger Reserve. The Tiger Reserve harbours flat-hill tops, varying degree of slopes, and rolling meadows in the valleys, which offer unique settings for diverse types of wildlife habitat and form ideal niches for various species of plants and animals. Apart from the over 600 species of flowering plants, there are around 300 species of birds and 43 species of mammals. Besides, several species of reptile, arthropod and termite are also found in the Reserve. The diversity of habitats influences the local distribution of mammals. The presence of the mosaics of meadows within the woodland, and large expanses of herbage availability, also have a bearing on the aggregations of herbivores. The central meadows of Kanha, locally known as "maidans", are rich in ungulates and other fauna. This high prey density area is encompassed on three sides by the ridges of the Deccan trap, leaving a gap only in the North towards Sonf. This topographical peculiarity poses a physical barrier to animal movement from the central meadows. Likewise, the ridges extending along the eastern boundary of the reserve impede animal movement between the eastern and western portions of the park. Such topographical attributes foster pockets of high and low prey density areas within the Protected Area, resulting in an unequal concentration of tigers and co-predators in different portions of the habitat.

vii. **Satpuda National Park –** This park was established in the year 1981 and is located in Hoshangabad district of Madhya Pradesh. The Tiger Reserve encompasses the Bori Wildlife Sanctuary and the Pachmarhi Wildlife Sanctuary. Bori is the oldest forest reserve in India and Panchmari is the only hill station of central India. Panchmari has numerous panoramic view points and water falls and has long been a pilgrimage centre for Worshippers of Shiva, especially for people from Vidharbha region of Maharasta. The scenic splendour of the Pachmarhi hill is unmatched by any formation far and wide. The forest department of Madhya Pradesh was essentially born here when the soldier turned forester Captain James Forsyth constructed the Bison lodge in 1862. His book 'The Highlands of Central India' details his journey from Jabalpur to

Panchmari. Pachmarhi has unique floral formation in that sal occurs as an isolated patch, in a sea of teak forest, far away from its main distribution. Forest Department and M.P. Ecotourism Development Board are now promoting it as major trekking destinations. Principal Fauna found in the park are: Tiger, Panther, Sambhar, Chital, Bhedki, Blue Bull, Four-hornedantelope, Chinkara, Bision (Gour),Wild Boar, Wild Dog,Bear, Black buck, Fox, Porcupine, Flying squirrel, Mouse deer, Indian giant squirrel etc. and various species Birds may also be seen there. While the flora mainly consists of Sal,Teak, Tendu, Aonla, Mahua, Bel, Bamboo etc.

viii. **Panna National Park and Tiger Reserve** – It is situated in the central Indian state of Madhya Pradesh, at a distance of around 25 km from Khajuraho. The region, famous for its diamond industry, is also home to some of the best wildlife species in India and is one of the most famous Tiger Reserves in the country. This National park was established in the year 1981. The principal fauna consists of Tiger, Panther, Blue bull, Sambhar, Chinkara, Spotted deer, Bear, Wild dog, Wolf, Jackal, Monkey, Crocodiles etc. Additionally, birds of various species may also be seen here. The principal flora comprises of Dhawda, Tendu, Saja, Achar, Seja, Salai, Kullu, Aonla, Mahua, Bel etc.

ix. **Bandhavgarh National Park and Tiger Reserve**: Bandhavgarh was declared a national park in 1968. Cradled between the Vindhyan ranges and the eastern flanks of Satpura ranges of Central Indian Highlands, Bandhavgarh Tiger Reserve lies mostly in Umaria and partly in Katni districts of Madhya Pradesh. It is best known as the "tiger land" of India, for the highest density of tigers, as compared to rest of the country. The diverse mix of habitats here, consisting of rocky hills covered with dense forests as well as low-lying swampy plains, supports a corresponding plentitude of fauna. Its luxuriantly rich eco-systems provide amply for every living being – from tiny insects to the majestic tigers. The Bandhavgarh hill is flat-topped with gentle northerly slope. Its vertical cliffs are the ideal nesting site of now highly endangered long-billed vultures and other rare birds of prey like the Shaheen Falcon. The forest of Bandhavgarh is classified as Tropical Moist Deciduous Type and is dominated by Sal trees. Lofty Saja and Arjun *(Terminalia spp.)*, Lendia *(Lagerstroemia spp.)*, Salai *(Boswelia spp.)*, Bija *(Pterocarpus spp.)*, Mahua *(Madhuca spp.)* and the like contribute to the floral diversity. Bamboos are found throughout the tract. Sal

and Bamboo patches form an excellent habitat for the famous Bandhavgarh tigers. The open marshy grasslands or *bahs* have abundance of many species of grasses which support a rich herbivore population and, as a result, carnivores frequent these areas. It is believed that these swamps were once the home of swamp deer which gradually got eliminated owing to environmental changes. Woody climbers such as *Butea superba* and *Bauhinia vahlii* and lianas such as Gulheri *(Spatholobus roxburghii)* are found picturesquely twining through the stately Sal. There are patches of scrub-like vegetation – home to a large diversity of bird life. The Bandhavgarh Tiger Reserve (1161.471 sq. km.) comprises of Bandhavgarh National Park (448.842 sq. km.), Panpatha Wildlife Sanctuary (245.842 sq. km.) and a Buffer Zone (466.787 sq. km.) surrounding both the Park and the Sanctuary.

x. **Madhav National Park** - The Madhav National Park is situated on the northern fringe of the Central Highlands of India. It is a part of the upper Vindhyan hills, forming plateaus, and having small and big nallas. The slopes are generally gentle, rarely steep. Spreading over an area of almost 355 sq.kms., the Madhav National Park is fascinating mix of natural splendors of history and architectural wonders. The park, one of the oldest, is situated in the northern part of Madhya Pradesh, near the town of Shivpuri. Madhav got the status of a National Park in 1958. The park is unique in that it has both lake and forest ecosystems. Sakhya and Madhav Sagar are the two lakes in the park, which are important biodiversity support systems. These lakes not only add to the natural beauty of the area, but also provide a permanent source of water to the wildlife, and a fine wetland habitat to the aquatic fauna including thousands of migratory waterfowls. Marsh Crocodiles are in abundance in Sakhya sagar lake, creating a special attraction for tourists. The park represents the Northern Tropical dry deciduous mixed forest type, as well as dry thorn forest, typical of North-Western Madhya Pradesh. The forests here are home to antelopes like Nilgai, Chinkara and Chowsinga and Deer including Chital, Sambar and Barking Deer. One can see animals like the Leopard, Wolf, Jackal, Fox, Wild dog, Wild pig, Porcupine, Marsh Crocodile and the Python. With a varied terrain of wooded hills, dry, mixed deciduous forests, and flat grasslands around the lakes, the park offers abundant opportunities of sighting a variety of wildlife.

xi. **Vanvihar National Park -** The Van Vihar National Park is situated in the heart of Bhopal City in Madhya Pradesh. 445.21 hectare degraded hillock along with private Village land was initiated in 1980 and finally notified as a National Park in 1983. Funding from Central Zoo Authority (CZA) has started in 1993-94 and also granted Van Vihar as a medium-sized zoo on the same year. With the dedicated efforts of the park management, this area has now been transformed into an oasis of greenery. The area today serves as the green lung for Bhopal City. Although it has the status of a National Park, the Van Vihar is developed and managed as a modern Zoological Park, following the guidelines of the Central Zoo Authority. The animals are kept in their near natural habitat. Most of the animals are either orphans brought from various parts of the state or are exchanged from other zoos. Contrary to popular belief, not a single animal is deliberately captured from the forest.

xii. **Fossil National Park –** It was established in the year 1983 in Mandla District of Madhya Pradesh. Fossils of various trees are found here. Eucalyptus and Tinsa are among the fossilised trees.

xiii. **Desert National Park:** Situated in Jaisalmer City of Rajasthan, the Desert National Park is an excellent example of the ecosystem of the Thar Desert and its rich fauna. The Sudashri forest post is the most ideal place for observing wildlife in the Desert National Park. Sand dunes form less than 20 percent of the park, which consists of craggy rocks, pavements and compact salt lake bottoms, intermedial areas and fixed dunes. Its inhabitants include the Blackbuck, Chinkara, Wolf, Indian fox, Desert fox, Hare and Desert cat. Flights of sandfrouse start coming to waterholes from sunrise onwards. One also hears the morning call of the Grey partridge, Blue and Green tailed bee-eaters, Drongos, common and bush quail and Indian rollers are some of the birds which are commonly found around waterholes. The park is also home to the great Indian Bustard which is peril of extinction.

xiv. Ranthambore National Park and Tiger Reserve - Ranthambhore Tiger Reserve, once a princely game reserve is the place where the celebrated Indian Tiger is best seen. Ranthambhore Tiger Reserve lies on the junction of Aravali and Vindhyas just 14 Kms from Sawai Madhopur in Eastern Rajasthan. It sprawls over a varying and undulating landscape. The scenery changes

dramatically from gentle and steep slopes of the Vindhyas and sharp and conical hills of the Aravali. A tenth century fort also blends amicably with the background. Pure sands of Dhok (Anogeissus pendula) interspersed with grasslands at the plateaus, meadows in valleys and luxuriant foliage around the canals make the jungle. Three big lakes – Padam Talab (meaning Lake), Malik Talab and Raj Bagh – are similar turquoises studded in the vast forest that abounds with aquatic vegetation including duckweeds, lilies and lotus. The rugged park terrain alternates between dry deciduous forest and open grassy meadow, and is dotted by several lakes and rivers that are only made passable by rough roads built and maintained by the Forest Service. The tiger is not the only attraction at Ranthambhore although it is the park resident that people most often come to see. A variety of birds including Owlets, the ubiquitous Langur (monkey), Leopard, Caracal, Hyena, Jackal, Jungle Cat, marsh Crocodiles, Wild Boar, Bears and various species of Deer are the other attractions.

xv. **Mount Abu Wildlife Sanctuary -** The sanctuary situated in Rajasthan stes, comprises the oldest mountain ranges - The Aravali. It was declared a Wildlife Sanctuary in 1960. Apart from having several sightseeing places this sanctuary is a draw for nature lovers as it has great potential for Eco-tourism. This sanctuary is long and narrow in shape but the top spreads out into a picturesque plateau which is about 19 km. in length and 5-8 km. in breadth. Altitudinally it varies from 300m at the foot in Mil to 1722m at Gurashikhar, the highest peak of the Aravali Ranges. The rocks are igneous and, due to the weathering effect of wind and water, large cavities are common. This feature is typical of Aravali and particularly of Mount Abu. Toad Rock in Mount Abu provides one such example of such these cavaties.

xvi. **Sariska National Park and Tiger Reserve**: Sariska Tiger Reserve is situated only 200 km from Delhi and 107 kms from Jaipur. Although larger than Ranthambor, it is less commercialised and has less tigers but a similar topography. It covers an area of 800 sq km in total, with a core area of approximately 500 sq km. The Northern Aravali Hills dominate the skyline with their mixture of sharp cliffs and long narrow valleys. The area was declared a sanctuary in 1955 and became a National Park in 1979. The landscape of Sariska consists of the hills and narrow valleys of the Aravali hill range. The topography of Sariska supports scrub-thorn arid forests, dry deciduous forests, rocks and

grasses. The broad range of wildlife here is a wonderful example of ecological adaption and resistance, as the climate here is fairly erratic. The park is home to numerous carnivores including Leopard, Wild Dog, Jungle Cat, Civets Hyena, Jackal, and Tiger. These feed on species such as Sambar, Chital, Nilgai, Chausingha, Wild Boar and Langur. Sariska is also well known for its large population of Rhesus Monkeys, which are found around Talvriksh. The avian world is also well represented with Peafowl, Grey Partridge, Bush Quail, Sand Grouse, Tree Pie, Golden backed Woodpecker, crested Serpent Eagle and The Great Indian horned Owl.

xvii. **Keolada Ghana National Park** - This magnificent bird haven came into being paradoxically as a duck shooting preserve for Maharaja Suraj Mull of Bharatpur. He transformed the shallow depression formed by the confluence of River Gambhir and River Banganga into a reservoir by damming the rainwater in monsoons. Flood waters created shallow wetland ecosystems, forming a perfect habitat for an astounding variety of birds. The park that continued to be a hunting preserve for the Maharaja and the British until 1964, after which hunting was banned.

xviii. **Dudhwa National Park**[*] **-** Situated on the Indo-Nepal border in District Lakhimpur-Kheri of Uttar Pradesh, the Dudhwa Tiger Reserve with an area of 614 sq. Km is one of the nation's finest, serving as one of the few remaining examples of the exceedingly diverse and productive tarai eco-systems. The northern edge of the reserve lies along the Indo-Nepal border and the southern boundary is marked by the river Suheli. It is home to a large number of rare and endangered species which includes Tiger, Leopard, Swamp deer, Hispid hare, Bengal Florican, etc. From mosaic grasslands and dense sal forests to swampy marshes, the terrain of Dudhwa National Park is as diverse as the wildlife population it harbors. While the northern edge of the Park lies along the Indo-Nepal border, the River Suheli marks the southern boundary. A Tiger Reserve since 1879, Dudhwa became a National Park in 1977 and adopted the Project Tiger in 1988. Although the Tigers at the Park are numerous, sightings are rare due to the thick forest cover of the area. Besides Tigers, Leopards, Hispid Hares, Swamp Deer (Barasingha) and Rhinos thrive amidst the vegetation. Apart from

[*] Uttar Pradesh tourism, Govt. of UP, <http://www.up-tourism.com/destination/dudhwa/intro.htm>

the swamp deer, there are at least 37 species of mammals and 16 species of reptiles. Dudhwa Wildlife Sanctuary is said to have 101 tigers and four leopards. Recently, the hispid hare has also been spotted in the area. It was here in 1984 that a major rhinoceros rehabilitation project was started since these forests had been the habitat of the rhinoceros 150 years ago. Five rhinos were relocated from Assam but two of the females died due to the strain of transportation. These were replaced in 1985 by four more females from Nepal. Dudhwa's birds, in particular, are a delight for any avid bird watcher. The marshlands are especially inviting for about 400 species of resident and migratory birds including the Swamp Partridge, Great Slaty Woodpecker, Bengal Florican, plenty of painted storks, sarus cranes, owls, barbets, woodpeckers, minivets and many more. Much of the park's avian fauna is aquatic in nature, and is found around Dudhwa's lakes- especially Banke Tal. The major vegetation types in this region are Tropical Semi-evergreen forest, Tropical Moist Deciduous forest, Riparian and Swamp forest and Dry Deciduous forest. The dominant tree species are Shorea robusta, Terminalis tomentosa, Adina cordifolia, Terminalia belerica, Eugenia jambolana, Dalbergia sissoo, and Bombax malabaricum. The various types of forests throughout the park are interrupted by wide stretches of mesophyllous grasslands locally called the phantasm.

xix. **Gangotri National Park** - The Park is situated in Uttarkashi District over a vast area of 2390.02sq.km. . Gangotri, after which the park is named, is one of the four *dhamas* (pilgrim sites) of Uttarakhand. The park located within the upper catchment area of the Bhagirathi river offers a panoramic view of several waterfalls. It also forms a vital link in the green corridor that extends between the Govind National Park and Kedarnath Wildlife Sanctuary. It provides the majestic beauty of coniferous forests and the grandeur of vast glaciers, as well as lush green meadows. The forests are Himalayan Moist Temperate type. Vegetation consists of Chirpine Deodar, Fir, Spruce, Oak and Rhododendrons. The fauna includes Snow leopard, Brown bear, Black bear, Himalayan thar, Serow, Musk deer, Cheer pheasants, Partridges, Monal, Himalayan snow cock etc.

xx. **Rajaji National Park -** Rajaji National Park is situated along the hills and foothills of Shivalik ranges in the Himalayan foothills and represents the Shivalik eco-system. Spread over an area of 820.42 sq km, Rajaji is a

magnificent ecosystem nestled in the Shivalik ranges and the beginning of the vast Indo–Gangetic plains, thus representing vegetation of several distinct zones and forest types like sal forests, riverine forests, board–leaved mixed forests, scrubland and grassy. On the map it is located between Haridwar and Dehradun and Chillawali. Three sancturies in the Uttarakhand Shivaliks - Rajaji, Motichur and Chila – were amalgamated into a large protected area and named Rajaji National Park in the year 1983 after the famous freedom fighter Late Sri C. Rajgopalachari, popularly known as "Rajaji". It possesses as many as 23 species of mammals and 315 bird species. The abundance of nature's bounty heaped in and around this park compels a large number of wildlife conservationists and nature lovers to visit this most breathtaking wilderness area. The uniqueness of the Parks stands in that it is the northern most limits of the Tiger, Asian elephants, King Cobra and certain bird species.

xxi. **Corbett National Park and Tiger Reserve –** The first wildlife reserve of India, Corbett National Park was established in 1936, as the Hailey National Park. Later it changed to Ramganga and finally Corbett National Park in the honor of legendary hunter-turned-conservationist, best known for hunting man-eating tigers and leopards in the Kumaon and lower Garhwal. Corbett National Park is known for its varied wildlife, as well as the launch site of Project Tiger. Corbett National Park was one of the nine tiger reserves created at the launch of the Project Tiger in 1973. The area of the Corbett National Park is 520.84 sq. km. In 1991, an area of 797.72 sq km was added as buffer area of the Corbett Tiger Reserve. Wildlife found in the Corbett National Park include the Tiger, Elephant, Chital, Sambar, Nilgai, Gharial, King cobra, Wild boar, Hedgehog, common Musk shrew, Flying fox, Indian pangolin, and nearly 600 species of birds.

xxii. Govind Pashu Vihar (Govind Wildlife Sanctuary and National Park) – The Park is spread over an area of 472sq.km.and sanctuary in 485.89sq km. in Uttarkashi District of Uttarakhand. The forest of the park consists of Chirpine, scrub tropical Euphorbia scrub and oak species. In the Eighth Five-year plan, the Government of India set up the "Snow Leopard Project" to ensure the long-term conservation of the elusive and endangered Snow Leopard. In 1990, a team of experts chose the Govind Wildlife Sanctuary as one of the implementation sites

of the project and, subsequently, 472 sq. km within the upper reaches of the sanctuary (the Snow leopard's preferred habitat) were designated as the Govind National Park. It lies between Longitude: 78.05ºE and Latitude: 31.00 to 31.25ºN. The wild life species found in the park are Snow leopard, Leopard cat, the brown and the black Himalayan bear, fishing Cat, Musk deer, Serow, Thar, Goral, Sambar, Wild boar, etc. The birds found are Monal, Snow pigeon, and Green pigeon. The altitude within the park ranges from 1400m to 6323m above sea level and magnificent, jaggered snow-capped peaks mesmerize all visitors.

xxiii. **Valley of Flowers National Park -** The Valley of Flowers National Park is the second core zone of the Nanda Devi Biosphere Reserve. The credit for the discovery of the Valley of Flowers goes to the British mountaineers Franks S. Smythe and R.L. Holdsworth who incidentally reached this valley after a successful expedition of Mount Kamet in 1931. Fascinated by its beauty and grandeur Frank S. Smythe revisited this area in 1937 and published a book named "Valley of Flowers" (1938). However, there is no doubt that Frank S. Smythe's writing made this valley world famous. The valley of Flowers lies in the main valley of Alaknanda and Laxman Ganga in the Garhwal Himalayas in Chamoli district of Uttarakhand. The Pushpawati river flows through this valley from its source in the Tipra Glacier, which extends upto Ghori Parbat Peak. It is a flat valley 5km. long and 2km. wide. Its altitudinal range varies from 3200 to 6675m. The Park is surrounded by Gauri Parbat (6590m) and Rataban (6126m) in the east, Kunthal (4430m) in the west, in the west, Saptsring (5030m) in the south and Nilgiri Parvat (6479m) in the north. Valley of Flowers is a trek of about 16km from Govindghat which is 25km from Joshimath. From Govindghat one has to trek 13km to reach Ghangaria. After crossing the Alaknanda river at Govindghat, an ascending bridle path along Bhyundar Ganga leads to Ghangharia. From here the valley is situated at a distance of 3km. Almost 300 species of wild flowers bloom here in natural way. Wherein some of the species are Anemone, Geranium, March marigold. Primula, Potentilla, Geum. Asters Lilium, Himalayam Blue poppy, Aconitum, Delphinium, Ranunculus, Rhododendrons and numerous others. Most of the flowers have medicinal values too. The abundance of Asmanda fern in this valley is a rare sight than in other Himalayan valleys. Apart from the flowers some species of Butterfly, Musk deer. Blue sheep (Bharal), Himalayan birds & Snow leopard are also

found in the park. One fully equipped interpretation centre at Ghangaria is available. At this interpretation centre regular slide shows on Valley of Flowers and wildlife is held in the evening hours through out the season.

xxiv. **Buxa National Park and Tiger Reserve** – It is situated in the Jalpaiguri district of West Bengal and covers and area of 117.10 square km. It was established in the year 1992.

xxv. **Neora Valley National Park** – This national park is situated in the Darjeeling district of West Bengal with an area of 88 square km. It was established in the year 1986.

xxvi. **Gorumara National Park** – Lying in the Jalpaiguri district of West Bengal, this national park covers an area of 79.45 square km. It was established in the year 1994.

2.14.2 Endangered species in Ganga main stem

The names, species names and location of the various endangered species of the Ganga main stem are given below in Table 2.24.

Table 2.24 Endangered Species of Ganga main stem

Name	Species	Location
Vultures	Gyps Bengalensis, Gyps Tenuirostris and Gyps Indicus	Basin-wide
Ganga Dolphin	Platanista Gangetica	Ganga River
Bengal Florican	Houbaropis Bengalensis	Uttar Pradesh
Bengal Tiger	Panthera Tigris Thirs	Madhya Pradesh, Uttarakhand, Rajasthan and West Bengal
Gharial (Crocidile)	Gavialis Gangeticus	Ganga River (specifically Uttar Pradesh, Rajasthan and Madhya Pradesh)

Source: MoEF Endangered Species Brochure, 2009

Among these, the Ganga Dolphins warrant additional focus. Ganga Dolphins are one of only four varieties of exclusively freshwater dolphins in the world, with the others residing in China, Pakistan and in the Amazon river basin, which spans multiple countries in Latin America. However, a combination of pollution and poaching for their oil has threatened their survival. As such, they are recognized by Schedule I of the Wildlife Protection Act (1972) as a "highly endangered" species and indeed, only an estimated 2,000 or so remain. The Ministry of Environment and Forests has

recently declared the Ganga Dolphin as India's "National Aquatic Animal" – a clear sign of the importance of this rare species.

Gharial face similar threats as the Ganga dolphins, as they mostly share the same habitat. Bengal Floricans are threatened by the continuous conversion of their grassland habitats to agricultural purposes. The various vulture species throughout India face extinction due to a number of reasons, the most significant of which is the use of diclofenac as a pain-killer for animals. The vultures absorb the diclofenac by consuming the carcasses of dead animals. The vultures are then unable to metabolize the drug, which causes a gout-like illness and eventually, death. The threats and conditions of the Bengal Tigers have been detailed above.

2.14.3 Mangrove forests and the Sunderbans

Mangrove forests consist of salt-tolerant plant species and occur along the inter-tidal zones of rivers and seas. The plants form narrow strips or extensive patches in the estuarine habitats and/or river deltas of tropical and sub-tropical climates. Due to the fact that mangroves must survive the tidal fluctuations and storms surges associated with the harsh environment between land and sea, they display distinctive morphological and physiological adaptations that make them at once one of the more resilient and more unique ecosystems on the planet. These extensive adaptations allow for mangrove forests to become perhaps the most productive and diverse kind of wetland area in the world. However, mangroves provide more than just a habitat for a diverse array of species and wildlife; their ecosystem also serves as a plentiful source of firewood, timber, fodder, fruits, medicines, etc. for neighboring human settlements while providing a critical buffer zone against cyclones, sea-level rise and other natural threats.

Mangroves are classified by the density of their canopy cover. The categories are "very dense" (canopy cover of more than 70%), "moderately dense" (canopy cover of between 40-70%), and "open" (canopy cover between 10-40%).

Among the states within Ganga main stem, only West Bengal has mangrove forests cover, due to the fact that part of the Sunderbans mangrove forest falls within its

boundaries. All told, the Sunerbans is 10,000 km^2, however only 40% falls in India, with the rest residing in Bangladesh. Like most mangroves, the Sunderbans consist of a number of small, forested islands floating amidst tidal streams. It is also home to a number of rare fauna, most notably, the Bengal Tiger.

Table 2.25 West Bengal Mangrove Cover Data

State	Very Dense Mangrove	Moderately Dense Mangrove	Open Mangrove	Total	Change since 2005
West Bengal	1,038	881	233	2,152	16
India	1,405	1,659	1,575	4,639	58

Source: Forest Survey of India, 2007

As presented in table 2.25, about 43% percent of the total mangroves are found in West Bengal. The state provides nearly 74% of India's very dense mangrove cover, and over half (53%) of India's moderately dense mangroves. It provides a much smaller share of India's open mangroves, as this type of cover is far less prevalent in this stretch of the Sunderbans mangrove forest.

2.14 Summary

The Ganga Basin, as presented in the earlier sections of presents diverse environmental characters. With the basin spread over an area of about 861,404 km^2 India, the river traverses through 2500 km in 11 states of India and houses a population of over 300 million. The mean annual flow in the river is estimated to be over 525 billion m^3, with about 60 percent contributed from Himalayan Glaciers and 40 percent contribution from peninsular streams / tributaries. The three district physiographic divisions (Norethern Mountains, Great Plains and Central Highlands), present a wide variety of soils, over 52 percent of which is Alluvial Soil. Owing to the alluvial soils and availability of water, the Ganga Basin is extensively cultivated, with a good network of irrigation canals.

In terms of environmental features, about 15% of the Basin is covered with forests, about 11 percent which is a dense forest, including the Mangrove rich forests of Sundarbans. These forests house a rich variety of flora and fauna and comprises number of sensitive environmental habitats including 2 biosphere reserves, 27 national parks, 75 wild life sanctuaries, 10 tiger reserves in all the elven basin states. While many of them are not exactly situatied along the river banks, the two biosphere

reserves (Nanda Devi in Uttara Khand and Sundarbans in West Bengal), 12 national parks, 18 wild life sanctuaries and 5 tiger reserves are located in the five main stem states (Uttrakhand, Uttar Pradeshm, Bihar, Jharkhand and West Bengal) of NGRBP. The important endangered species in these habitats include, the Ganga Dolphin, Royal Bengal Tiger, Gavialis Gangeticus (Crocodile) and number of vultures.

Presence of these environmental sensivities further substantiates the need for improving the water quality in Ganga and also improving the environmental quality of the Basin. This however also warrants careful planning of sub-projects, that ensures protection and also avoids impacts on these sensitive habitats.

Chapter 3

Social Analysis

"The Ganga, especially, is the river of India, beloved of her people, round which are intertwined her 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 yet ever the same Ganga."

- Jawaharlal Nehru, First Prime Minister of India.

3.1 Socio-economic profile of Ganga main stem

Ganges mainly flows though five Indian states namely, Uttarakhand, Uttar Pradesh, Bihar, Jharkhand, and West Bengal. Each of the state has distinct socio-economic profile. But Jharkhand and Bihar are the worst in terms of socio-economic development.

The Ganga main stem is one of the most densely populated and fertile river basins in the world. The basin supports about 300 million people over an area of approximately 800, 00 sq. km of which some 100 million are directly dependent on the river and its tributaries. The Ganges basin supports one of the world's highest densities of humans.

The state of the river Ganga is significantly affected by the population living within the basin. The Ganga main stem has 1949 cities and towns, with an estimated population of 125 million. Average population density in the Ganga main stem is 520 persons per square km as compared to 312 for India (2001 census).

3.1.1 Uttarakhand

Uttarakhand was formed on the 9th November, 2000 as the 27th State of India, when it was carved out of northern Uttar Pradesh. Located at the foothills of the Himalayan mountain ranges, it is largely a hilly State, having international boundaries with China (Tibet) in the north and Nepal in the east. On its north-west lies Himachal Pradesh, while on the south is Uttar Pradesh. It is rich in natural resources especially water and

forests with many glaciers, rivers, dense forests and snow-clad mountain peaks. Char-dhams, the four most sacred and revered Hindu temples of Badrinath, Kedarnath, Gangotri and Yamunotri are nestled in the mighty mountains. It's truly God's Land (Dev Bhoomi). Dehradun is the Capital of Uttarakhand. It is one of the most beautiful resort in the submountain tracts of India, known for its scenic surroundings. The town lies in the Dun Valley, on the watershed of the Ganga and Yamuna rivers.

It is blessed with a rare bio-diversity, inter-alia, 175 rare species of aromatic & medicinal plants are found in the State. It has almost all major climatic zones, making it amenable to a variety of commercial opportunities in horticulture, floriculture and agriculture. It has a vast tourism potential in adventure, leisure, and eco-tourism. With levels of literacy higher than the national average, the State has abundant availability of quality human resources. Within a short span of its existence, Uttarakhand has emerged as a significant destination for investments in manufacturing industry, tourism and infrastructure. Emphasis is on stimulating all three sectors of its economy (agriculture, industry and services), to their fullest potential in tandem with the geographic profile of the state. The Government of Uttarakhand has undertaken several policy measures and incentives in order to encourage inflow of investment into the various sectors of its economy[2].

The State of Uttarakhand has three districts which fall in the main-stem of Ganga: Haridwar, Tehri Garhwal and Uttarkashi (Figure 3.1). These districts have a total population of 2,346,947. Of that total number, only 383,779 reside in some of Uttarakhand's major towns which lie in the Ganga main stem. The largest of these towns are Hardwar (MB), Tehri (MB), Uttarkashi (MB) and Dhaluwala (CT). Only 6,515 scheduled tribal people reside in Uttarakhand's share of the Ganga main stem, comprising about 0.002 per cent of Uttarakhand's Ganga main stem population. Uttarakhand and Uttar Pradesh in total have 702 towns and cities, with 54 Class I cities and 47 Class II cities. Some of the Class I cities are Hardwar, Roorkee, and Class II like Rishikesh. Refer Appendix 3.1 for more detail on population in the cities.

[2] Government of Uttarakhand <http://ua.nic.in/uk.gov.in/pages/display/115-about-us>

Figure 3.1 Districts of Uttarakhand State Located in Ganga Main Stem

Source: http://www.mohfw.nic.in/NRHM/State%20Files/uttranchal.htm as per Census 2011

3.1.2 Uttar Pradesh

Uttar Pradesh is the rainbow land where the multi-hued Indian Culture has blossomed from times immemorial. Blessed with a variety of geographical land and many cultural diversities, Uttar Pradesh, has been the area of activity of historical heroes like - Rama, Krishna, Buddha, Mahavira, Ashoka, Harsha, Akbar and Mahatma Gandhi. Rich and tranquil expanses of meadows, perennial rivers, and dense forests and fertile soil of Uttar Pradesh have contributed numerous golden chapters to the annals of Indian History. Dotted with various holy shrines and pilgrim places, it plays an important role in the politics, education, culture, industry, agriculture and tourism of India.The two pious rivers of Indian mythology, Ganga and Yamuna flow through this state. Uttar Pradesh is surrounded by Bihar in the East, Madhya Pradesh in the

South, Rajasthan, Delhi, Himachal Pradesh and Haryana in the west and Uttaranchal in the north and Nepal touch the northern borders of Uttar Pradesh, it assumes strategic importance for Indian defence. Its area of 2,36,286 sq kms. lies between latitude 24 deg to 31 deg and longitude 77 deg to 84 deg East. Area wise it is the fourth largest State of India. In sheer magnitude it is half of the area of France, three times of Portugal, four times of Ireland, seven times of Switzerland, ten times of Belgium and a little bigger than England[3].

The state of Uttar Pradesh (UP) has 17 districts in the Ganga main stem, namely: Ballia, Allahabad, Bulandshahar, Azamgarh, Fatehpur, Varanasi, Farrukhabad, Sant Ravidas Nagar Bhadohi, Saharanpur, Rae Bareli, Mirzapur, Kanpur Nagar, Kanpur Dehat, Kannauj, Jyotiba Phule Nagar, Ghazipur and Bijnor. These districts have an enormous combined population, totaling 45,595,698 in number. Some of the larger towns in UP's share of the Ganga main stem include Allahabad (M Corp), Saharanpur (MB), Fatehpur (MB), Varanasi (M Corp), Farrukhabad-cum-Fatehgarh (MB), Kanpur (M Corp) and Mirzapur-cum-Vindhyachal (MB), with the total large town population of UP in the Ganga main stem reaching 8,078,852. UP's tribal population in the Ganga main stem numbers only 16,621, accounting for an insignificant per cent of the total number. Some of the Class I cities in the state are Kanpur, Allahabad, Lucknow, Agra, Varanasi, Aligarh, Jhansi and some of the Class II cities in the state are, Tanda, Faridpur, Bijnor. For population details for class I and II cities refer to Appendix 3.1

[3] http://upgov.nic.in/

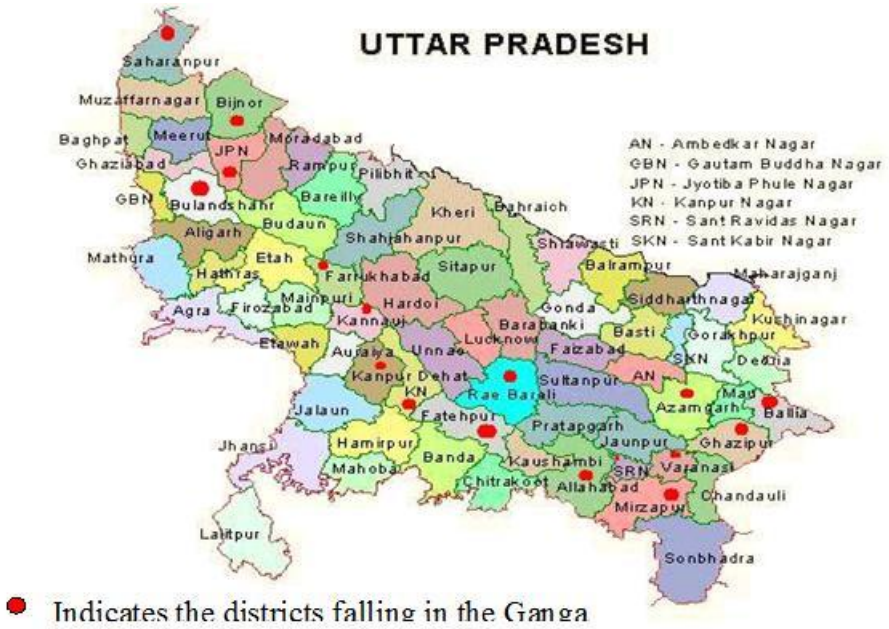


Figure 3.2 Districts of Uttar Pradesh State Located in Ganga Main Stem
Source: http://www.mohfw.nic.in/NRHM/State%20Files/up.htm as per Census 2011

3.1.3 Bihar

Bihar is located in the eastern part of the country (between 83°-30' to 88°-00' longitude). It is an entirely land–locked state, although the outlet to the sea through the port of Kolkata is not far away. Bihar lies mid-way between the humid West Bengal in the east and the sub humid Uttar Pradesh in the west which provides it with a transitional position in respect of climate, economy and culture. It is bounded by Nepal in the north and by Jharkhand in the south. The Bihar plain is divided into two unequal halves by the river Ganga which flows through the middle from west to east[4].

In Bihar, there are 12 districts which fall within the Ganga's main-stem namely, Begusarai, Buxar, Katihar, Khagaria, Lakhisarai, Munger, Patna, Purnia, Saran, Sheikhpura, and Vaishali with a population of about 25,543,106 (Figure 3.3). Some of the main towns which fall in the Bihar region of the basin are Patna, Begusarai, Bhagalpur, Chapra, Munger, Katihar, Hajipur and so on with a population of about 3539970 which accounts for nearly 14 per cent of the total population in the region. The scheduled tribes account for about 1.4 per cent of the people who inhabit the basin. Bihar and Jharkhand has in total 215 towns and cities. Bihar has 29 Class I cities and 24 Class II cities. Some of the class I cities are, Patna, Gaya, Bhagalpur,

[4] Government of Bihar ,<http://www.gov.bih.nic.in/Profile/default.html >

Begusarai, Darbhanga, etc. and class II cities like Buxar, Sitamarhi, Mokameh, etc. For more details on the class I and II cities' population refer to appendix 3.1

● Indicates the districts falling in the Ganga main

Figure 3.3 Districts of Bihar State Located in Ganga Main Stem

Source: http://mohfw.nic.in/NRHM/State%20Files/bihar.htm#hp as per Census 2011

3.1.4 Jharkhand

The 28th state of the Indian Union was brought into existence by the Bihar reorganization Act on November 15,2000- the birth anniversary of the legendary Bhagwan Birsa Munda. Jharkhand is famous for its rich mineral resources like Uranium, Mica, Bauxite, Granite, Gold, Silver, Graphite, Magnetite, Dolomite, Fireclay, Quartz, Fieldspar, Coal (32% of India), Iron, Copper (25%of India) etc. Forests and woodlands occupy more than 29% of the state which is amongst the highest in India[5].

[5] Government of Jharkhand <http://jharkhand.gov.in/AboutState_fr.html>

The State of Jharkhand has only one district, known as Sahibganj, which falls in the Ganga main stem (Figure 3.4). The district of Sahibganj has a population of 927,770. The two major towns of this district are Sahibganj and Rajmahal, which have a combined population of only 98,131. In sharp contrast to most other districts in the Ganga main stem, Sahibganj's tribal population of 270,423 greatly exceeds the amount of people living in its major towns and comprises 29 per cent of Jharkhand's Ganga main stem population. Some of the Class I cities of the state are, Jamshedpur, Ranchi, Dhanbad, and class II like Katras, Tisra. For demographic details for the cities refer to Appendix 3.1

● Indicates the districts falling in the Ganga main stem

Figure 3.4 Districts of Jharkhand State Located in Ganga Main Stem

Source: http://www.mohfw.nic.in/NRHM/State%20Files/jharkhand.htm as per Census 2011

3.1.5 West Bengal

The seven districts of West Bengal which is part of the Ganga main stem are 24 Pargana South, 24 Pargana North, Hoogli, Howrah, Kolkota, Maldah, Medinipur (Figure 3.5). In all, around 42,630,182 people reside in the West Bengal region of the Ganga main stem, with about 9,293,861 people residing in major towns like

Maheshtala, Rajpur Sonarpur, Serampore, Hugli-Chinsurah, Chandannagar, Haora, Kolkota, Bhatpara, South Dum Dum and so on. Around four per cent of the population in the basin belongs to the scheduled tribe class. . Bengal has 160 towns and cities, out of which 27 are class I and 27 are class II cities. Some of the Class I cities are, Kolkatta, Haora, Siliguri, South Dumdum and some of class II cities are, Ranaghat, Bolpur, etc. Refer to Appendix 3.1 for city wise population statistics.

● Indicates the districts falling in the Ganga main stem

Figure 3.5 Districts of West Bengal State Located in Ganga Main Stem

Source: http://www.mohfw.nic.in/NRHM/State%20Files/wb.htm as per Census 2011

3.1.6 Demographic profile of Ganga main stem

Basic demographic characteristics of the states are described in the table below.

Table 3.1(a) Distribution of Population by Location and Caste

	Uttarakhand	Uttar Pradesh	Bihar	Jharkhand	West Bengal	India
Total Population	8,489,349	166,197,921	82,998,509	26,945,829	80,176,197	1,028,610,328
% urban population	25.67	20.78	10.46	22.24	27.97	27.82
% rural population	74.33	79.21	89.54	77.76	72.03	72.18
Number of households	2,566,282	34,301,455	16,316,527	5,838,522	20,140,157	193,579,954
Household size	5.3	6.5	6.1	5.6	5.1	5.3
% SC Population	17.87	21.15	15.72	11.84	23.02	16.2
% ST Population	3.02	0.01	0.91	26.30	5.50	8.2
% Population below poverty line	NA	31.15	42.6	NA	27.02	

Source: Census of India 2001

Majority of the population in all the five states falls in rural category (72 %-89 %). Out of the five states, Jharkhand has the maximum population of Scheduled Tribes, the indigenous people. In all the states, tribes are present in all the districts along the river Ganga except for two districts in Uttar Pradesh, though the spatial distribution varies from state to state.

Table 3.1(b) Distribution of Population by Class of Cities

State		Number of cities	Total Population
Uttarakhand	Class I	5	1,141,150
	Class II	1	69,460
Uttar Pradesh	Class I	60	25,205,180
	Class II	46	3,382,520
Bihar	Class I	23	5,783,554
	Class II	14	1,113,800
Jharkhand	Class I	14	4,964,171
	Class II	10	826,300
West Bengal	Class I	59	19,699,751
	Class II	27	2,004,440

(Source: Central Pollution Control Board, 2008

The major proportion of the population in all the five states reside in Class I cities. Uttar Pradesh has the highest number of Class I (60) and Class II (46) cities, while Uttarakhand has the least number of Class I (5) and Class II (6) cities, amongst the five states.

Table 3.2 Distribution of Population by Sex

	Uttarakhand	Uttar Pradesh	Bihar	Jharkhand	West Bengal	India
Total Population	8,489,349	166,197,921	82,998,509	26,945,829	80,176,197	1,028,610,328
% male	50.95	52.68	52.10	51.52	51.71	51.73
% female	49.04	47.31	47.89	48.47	48.28	48.26
Sex Ratio (Number of females per 1000 males)	964	898	921	941	934	933
Sex ratio (0-6 years)	908	916	942	965	960	927

Source: Census of India 2001

All the five states have comparable sex ratio. Though the average number of females per 1000 males is less, and Uttar Pradesh is the worst state in terms of the sex ratio. The state of Uttarakhand is the best amongst the five states in sex ratio and even better than the national average of 933 females per 1000 males. While in sex ratio categorization for the age group of 0-6 years, state of Jharkhand fares well and has sex ratio even more than national average.

Table 3.3 Distribution of Population by Age Group

	Uttarakhand	Uttar Pradesh	Bihar	Jharkhand	West Bengal	India
0-9 years	1,993,446	45,612,898	23,810,374	7,173,741	17,106,869	238,763,954
%	23.53	27.57	28.75	26.66	21.37	23.27
10-14 years	1,093,530	22,310,434	11,063,777	3,534,953	9,538,536	124,846,858
%	12.91	13.48	13.36	13.13	11.91	12.17
15-59 years	4,730,247	85,888,210	42,445,259	14,625,165	47,718,976	585,638,723
%	55.84	51.91	51.25	54.34	59.60	57.09
60 years and above	654,356	11,649,478	5,501,274	1,578,662	5,700,099	76,622,321
%	7.72	7.04	6.64	5.87	7.12	7.47

Source: Census of India 2001

All the states witness the maximum number of population (55%-60%) in the age group ranging from 15-59 years. In the age group of 0-9 years, maximum population is present in Bihar and the minimum is in West Bengal. In the age group of 60 years and above the same trend is seen that is maximum population in Uttarakhand and minimum in Jharkhand. Uttar Pradesh is the most populous state.

Table 3.4 Educational Level

	Uttarakhand	Uttar Pradesh	Bihar	Jhar-khand	West Bengal	India
Literacy Rate	72.28	57.36	47.53	54.13	69.22	64.8
% male	83.28	68.82	59.68	63.83	77.02	75.26
% Female	59.63	42.22	33.12	38.87	59.61	53.67
Education Level among literates						
Informal	NA	NA	NA	NA	NA	NA
Below primary	41,107	10,922	53,108	714,953	790,284	12,503,832
Primary	39,240	7,433	47,909	668,489	386,445	8,566,717
Middle	25,963	4,737	24,540	414,740	225,054	4,561,035
Secondary and Sr. Secondary	11,550	1,954	20,315	282,720	85,454	2,891,825
Graduate and above	5,779	830	6,463	81,619	20,566	761,179

Source: Census of India 2001

Uttarakhand state shows highest literacy rate while Bihar shows the lowest literacy rate amongst the five states in terms of both male and female literacy rate. Literacy rate of Bihar is (47.53 %) less than National literacy rate while literacy rate of Uttarakhand is much better than the national literacy rate of 64.8%. Literacy rate is an indicator of development and the level of awareness about the cleanliness, hygiene and healthy lifestyle amongst the natives. Women in all the five states have lesser rate of literacy as compared to males, reflecting the poor importance given to the education of women.

3.1.7 Gender Analysis

For the successful implementation of any project, it is important that both men and women are made equal partners in all stages of the project. This section examines the status of women in the five project states of Uttarakhand, Bihar, Jharkhand, Uttar

Pradesh and West Bengal using selected demographic, educational, socio-cultural, health-related and economic indicators. There are two demographic variables that include sex ratio and child sex ratio pertaining to the 0-6 years age group. Effective female literacy, that is, number of female literates in the population above six years and gender gap in literacy rates are the two educational indicators used in this section. The four health-related educational indicators used in this section. The four health-related variables are the female infant and child mortality rates, along with gender differences in the two rates. The socio-cultural variables are mean age at marriage among females and the total fertility rates. Female work participation rates along with the gender gap in participation levels are the twin economic variables considered in this analysis.

The indicators used here include both attainment levels as well as gaps between men and women in selected spheres. For any planned development to be effective and for replication of successful experiments, there is a need for more specific details that can be provided by gender related development indicators. However, the variables and indicators for women's status need to be simple and disaggregated. The gender development indicators can generate specific sets of information that can be usefully utilized for identification of and intervention for the amelioration of the status of women. Individual, disaggregated indicators provide statistical data in a format that is amenable to the identification of problem areas as well as for intervention, thereby making it a better tool in comparison to any composite index.

The projects undertaken over the past few decades have suggested a strong positive link between a focus on gender and women's participation, on the one hand, and the degree of project success, sustainability, on the other. The lesson learned from these projects suggests that though women are the primary users and managers of domestic as well as community-based activities, they and their views are not systematically represented in decision-making bodies. Focusing on gender leads to benefits that go beyond good project performance as manifested in such aspects as better procurement, O & M, cost recovery, and hygiene awareness. Focus on gender has multiplier effects and Gender should be addressed through an approach that is participatory and responsive to the needs of the poor. The participation of beneficiaries and focus on poverty reduction are two other key determinants of the

effectiveness and sustainability of the project. Based on the latest information available from secondary sources, indicators have been selected to reflect the levels of women's status.

3.1.7.1 The Status of Women

Women work both for the labour market and for the household. Some of this work is recognized and remunerated, while most of it is not enumerated and remains unpaid. Women's contribution to the household, economy and society goes unrecognized since most of the activities females are involved in do not enter the sphere of the market and remain non-monetized. Most of the work undertaken by women is often interspersed with other household chores, making it difficult to separate the various tasks performed. The perpetuation of gender stereotypes and the social division of labour that typecasts women mainly as workers in the domestic sphere has been the chief barrier to the recognition of women's economic work participation. Non-recognition of women's participation in economic activities is not only an outcome of (a) their work being intertwined with household activities; and (b) being unpaid, making it difficult for enumerators to identify women as workers, but also stems from flawed definitions and the limited scope of economic activity.

The role played by women in the care sector, predominantly their reproductive work (bearing, rearing, nurturing children and household maintenance), falls outside the national accounting systems. Many of the tasks non-working women are involved in would be considered work if performed by a person hired for the purpose or unrelated to the household. Because women perform roles, which are not statistically counted as economic and hence not monetarily valued, women's roles and their contribution are assigned a lower status. The role fulfilled by women in household maintenance and care activities is often trivialized. Assigning monetary value to all the tasks undertaken by them, however, is not very easy. Some efforts have been made to study the manner in which time is spent by women in the course of the day through time use surveys (Government of India, 2000).

3.1.7.2 Female Work Participation Rate and the Gender Gap in Work

The female work participation rate (FWPR) is measured by calculating the proportion of female main plus marginal workers among the female population. Standard definitions of economic activity indicate low rates of FWPR. At the all-India level, only 30 per cent of women are defined as workers, main or marginal. Among the states along the river Ganga, Uttar Pradesh, West Bengal and Bihar are the states where the female work participation rate is lower than the national figure and the gender gap in work is higher. In female work participation rate, Uttar Pradesh is ranked 2 in the entire country with a participation rate of 31.9 and West Bengal is ranked first with a gender gap of 41.8 in work.

Table 3.5 Female Work Participation Rate and Gender Gap in Work

State	Female work participation rate	Rank	Gender gap in work	Rank
Bihar	23.5	5	35.7	6
Jharkhand	32.2	14	26.3	15
West Bengal	21	3	41.8	1
Uttarakhand	31.9	12	23.5	18
Uttar Pradesh	20	2	37.8	4
India	**30.3**		**31**	

Source: Rustagi Preet 2004) Notes: Work participation rates are calculated as the proportion of total workers (main + marginal) among respective populations above six years.

On the other hand, female work participation rate is high in tribal state of Jharkhand and hilly state of Uttarakhand. These are also the states where there are low gender disparities in terms of work participation. Higher FWPR can be partially explained by the fact that community-based organization of subsistence production requires a high level of women's labour participation.

On the whole, FWPR is low, partly as a result of the poor coverage given to women's work, especially in the unorganized sector and partly due to heavy domestic responsibilities that inhibit women's economic activities. Nearly 50 % of women who are principally involved in home-making reported that there was no other household member to undertake these responsibilities.

3.1.7.3 Gender Disparity in Sex

Sex Ratio

Table 3.6 Sex Ratio

States	Sex Ratio	
	1991	**2001**
Bihar	895	916
Jharkhand	NA	941
West Bengal	907	929
Uttarakhand	NA	964
Uttar Pradesh	872	898
India	923	934

Source: Census of India, 1991 and 2001

The gender composition in the population, that is, the sex ratio defined as the number of women per 1000 men, though has increased as compared to 1991 is not favourable to women in any of the five states. However, the ratio is higher than the national figure in Uttarakhand and Jharkhand. Uttar Pradesh has the lowest sex ratio followed by Bihar and West Bengal. Till 1981, undivided Bihar had the sex ratio higher than the all India gender balance, but its sex ratio declined to 911 in 1991. This drastic fall from a ratio of 946 in 1981 reflects the deteriorating situation of women in the state. In addition to the worsening mortality conditions, some of the reasons for this decline lie in increasing economic pressure for survival and sex selective migration. On the other hand, Uttar Pradesh and West Bengal have always recorded sex ratios below the all-India levels. Male migration from these states is part of the explanation.

Child Sex Ratio

Table 3.7 Child Sex Ratio

State	Sex Ratio of Children in the Age Group of 0-6 Years	
	1991	**2001**
Bihar	953	938
Jharkhand	NA	965
West Bengal	967	963
Uttarakhand	NA	908
Uttar Pradesh	878	916
India	945	927

Source: Census of India, 1991 and 2001

The scenario in the next decade ending in 2001 reflects a worsening gender balance among children. Child sex ratios dropped by 18 points for the country as a whole, and

as were in the states of Bihar and West Bengal. However, the figures are much higher than the national figure of 927 in Bihar, Jharkhand and West Bengal. Though there has been an increase in Uttar Pradesh, the figures in Uttarakhand and Uttar Pradesh is much lower than the national figure.

3.1.8 Education

3.1.8.1 Female Literacy Rate

Will improvement in female literacy ensure greater gender equality can be stated with a certain degree of certainty that improving the education of women will lead to gender development; it is difficult to affirm that improvements reflected through this variable of female literacy alone will be sufficient to bring about women's equality. Use of this or other education-related indicators reflects attainment/achievement levels and highlights the gap or extent of parity between men and women. Existing levels of discrimination and biases are an outcome of socio-cultural factors and patriarchal structures which are not easily overcome by introduction of literacy alone. Nevertheless, the benefits of education cannot be trivialized as these would have a long-term impact upon the empowerment of women.

Table 3.8 Female Literacy and Gender Gap in Literacy

State	Female Literacy in %	Rank	Gap in Literacy in %	Rank
Bihar	33.57	1	26.75	4
Jharkhand	39.38	2	28.56	2
Uttar Pradesh	42.98	4	27.25	3
Uttarakhand	60.26	17	23.75	9
West Bengal	60.22	16	17.3	19
India	54.16		21.69	

Source: Census of India, 2001

As the table 3.8 above shows, female literacy is extremely poor in Bihar, Jharkhand and Uttar Pradesh and all the three states are ranked among the top 5 worst states in terms of women's literacy. These are also the states with higher gender gap in literacy. This could be because of low enrolment of girl child in primary schools coupled with high dropout rate (Rustagi, 2004). In Uttarakhand, though women literacy rate is higher than the national female literacy rate, the gender gap is more than the national figure. West Bengal is the only state among the five, where literacy

rate is higher than the national literacy rate and even the gender gap is lower than the national figure.

3.1.9 Women's Health

In the government's approach to the issue of women's health there is an excessive focus on reproductive health[6]. Women are viewed mainly as the means of reproduction, often at the cost of their own personal, individual identity. Even now, despite some efforts to widen women's health concerns to include the issues of nutrition, sexuality and control over their bodies, state policies and programmes still emphasize and concentrate on family welfare and reproductive health. A major share of the budgetary allocations is under these heads[7].

3.1.9.1 Mean age of Marriage among Women

The NFHS-III (2005-2006) states that 47 per cent of married women surveyed between the ages of 20 to 24 years were married before the age of 18 and 32 percent of married men surveyed between the ages of 25 to 29 were married before the age of 21. Despite the legally stipulated minimum age of 18 years at marriage, majority of the girls still get married before attaining this age in all the states except Uttarakhand (Table 3.9). Early marriage often accompanies early pregnancy, with young unprepared mothers being saddled with responsibilities beyond their capacities. Pregnancies at young ages are more likely to result in underweight babies, stillbirths or abortions, especially where mothers suffer from poor health and deficiencies.

Table 3.9 Mean Age of Marriage among Women

State	% Women in the Age Group of 20 to 24 Years who got Married by the Age of 18 Years	% Men in the Age Group of 25 to 21 Years who got Married by the Age of 21 Years
Uttarakhand	23	21
Jharkhand	63	47
Bihar	69	43
West Bengal	54	27
Uttar Pradesh	58.6	51
India	47	32

Source: NFHS- III 2005-2006

[6] Datta, Anindita. (2003):Articulation of an Integrated Women's Health Policy Using the Life Cycle Approach; Indian Journal of Gender Studies, pp. 25-43;10(1)

[7] Rastogi P. (2004): Significance of Gender-related Development Indicators: An Analysis of Indian States; Indian Journal of Gender Studies, pp. 291-343; 11(3)

3.1.9.2 Total Fertility Rate and Anemia among Women

The fertility rate as per the NFHS-II and III is an average of three babies per woman for the country as a whole, which is little less than the average of 3.4 in NFHS –I. The number of childbirths among women from the states of Uttar Pradesh, Bihar and Jharkhand is even higher (Table 3.10). Frequent childbearing, often an offshoot of the predominant preference for a son in our society, takes a heavy toll on women. Among resource poor households, it is distressing to note that women breastfeed more than one child simultaneously due to lack of money to feed the older child with an alternative or supplementary diet. During childbirth, several serious complications are commonly reported, such as hemorrhage, excessive bleeding, anemia, toxicity, premature babies and associated problems and among these, anemia is a prominent cause leading to maternal deaths, apart from resulting in physically weak children.

Table 3.10 Total Fertility Rate and Incidence of Anemia among Men and Women

State	Number of Children per Woman	% Reported Anemic in the Age Group of 15 to 49 Years	
		Women	Men
Uttarakhand	2.6	54.7	30.5
Jharkhand	3.3	70.6	37.8
Bihar	4	68.3	32.6
West Bengal	2.3	63.8	33.1
Uttar Pradesh	3.8	50.9	24.7
India	2.7	56.2	24.3

Source: NFHS-III-2005-2006

Every second woman in India suffers from some degree of anemia according to NFHS-III. The majority of ever married women in the age group of 15 to 49 years in all the five states along the river are anemic as compared to one third of the men in the same age group (Table 3.10). Iron deficiency is particularly pronounced among women inhabiting the eastern states (Bihar, Jharkhand and West Bengal) as compare to the northern state of Uttar Pradesh and Uttarakhand.

3.1.9.3 Median age of first birth for women

Table 3.11 Median Age of First Birth of Women

States	Median Age of First Birth for Women	% Women Already Mother / Pregnant In The Age Group Of 15 – 19 Years
Uttar Pradesh	19.4	14.3
Uttarakhand	20.5	6.2
Bihar	18.7	25
Jharkhand	18.9	27.5
West Bengal	19	25.3
India	19.8	16

Source: NFHS-III

As per NHFS –III, the percentage of women giving birth to a child even before the age of 18 years is quite high in the states of Jharkhand, Bihar and West Bengal as compared to national figure of 16 percent (Table 3.11). The median age of first child birth for a woman is about 20 years that again show that in most of the cases, a girl gets married even before attaining the age of 18 years. Among the states, Uttarakhand is slightly better off where the median age is above 20 years and little over 6 percent of women in the age group of 15 to 19 have already become mother.

3.1.9.4 Couple Protection Rate

Table 3.12 Sterilization among Men and Women

States	Percent of Men and Women those who have Undergone Sterilization for Family Planning	
	Women	Men
Uttar Pradesh	17.5	0.2
Uttarakhand	32.1	1.8
Bihar	23.8	0.6
Jharkhand	23.4	0.4
West Bengal	32.2	0.7
India	37.3	1.0

Source: NFHS – III, 2005-2006

Women apart from being anemic and bearing the strain of maternity and childcare, the additional burden of contraception also falls overwhelmingly on women. The adoption of contraceptive measures among the women is higher. Male contraception is still poor, with very few men agreeing to vasectomy. It is as if to emphasize that since women conceive and bear children, it is their sole responsibility to control or

protect themselves against further reproduction[8]. As the table 3.12 above shows, over one third of the women have undergone sterilizations as compared to just 1 percent of men. In the states, apart from Uttarakhand where men sterilization is close to 2 percent, in all other states men sterilization is less than a percent.

3.1.9.5 Awareness about HIV/AIDS

Table 3.13 Awareness about HIV/AIDS among Men and Women

States	% aware of HIV/AIDS in the Age Group of 15 to 49	
	Men	Women
Uttarakhand	91	64
Uttar Pradesh	74	40
Bihar	70	35
West Bengal	74	50
Jharkhand	53	29
India	80	57

Source: NFHS-III, 2005-2006

Barring Jharkhand where awareness is low among both men and women, more than 70 percent men are aware of HIV/AIDS. However percentage of women being aware is less than 50 percent except in Uttarakhand where the figures are better than the national figures (table 3.13).

3.1.9.6 Spousal Violence

Table 3.14 Percentage of Women who ever Experienced Spousal Violence

States	% Women who ever experienced Spousal Violence
Uttarakhand	28
Uttar Pradesh	42
Bihar	59
West Bengal	40
Jharkhand	37
India	**37.2**

Source: NFHS-III, 2005-2006

Women often face violence at the hands of their protectors. Among crimes against women, cruelty by the husband and his relatives as defined by Section 498A of the

[8] Adapted from Rastogi P. (2004): Significance of Gender-related Development Indicators: An Analysis of Indian States; Indian Journal *of Gender* Studies, pp. 291-343; 11(3)

Indian Penal Code (IPC) consistently tops the list. The NFHS –III data shows that over one third of the ever married women in India have experienced spousal violence. Among the states, the situation is worse in Bihar where nearly three fifths of the total surveyed women have reportedly faced spousal violence followed by Uttar Pradesh (42%) and West Bengal (40%). The spousal violence in Bihar has drastically increased since 1999 when Bihar was ranked 22nd after Uttar Pradesh (14) and West Bengal (17) in the country wide ranking of states[9].

3.1.9.7 Women's Participation in Decision-making

Since women are located in different households, castes, communities and regions and are bound by distinct rituals, practices and structures of power, they rarely view themselves as a group with similar demands and needs. They are often governed by decisions that others take on their behalf which are unquestioningly followed. Little over one third of the married women in India participate in decision making at the household level. The percentage however is higher in Jharkhand, probably because of largely matriarchal society.

Table 3.15 Percentage of Married Women who Participate in Decision Making at Household Level

States	% Married Women who Participate in Decision Making at Household Level
Uttarakhand	36.0
Uttar Pradesh	33.7
Bihar	32.7
West Bengal	23.9
Jharkhand	41.8
India	36.7

Source: NFHS-III, 2005-2006

As the analysis above indicates that women though play an important role in the society, yet they have a very low status in the society coupled with little control over household resources; considerable health hazard; and poverty. It has been recognized

[9] Adapted from Rastogi P. (2004): Significance of Gender-related Development Indicators: An Analysis of Indian States; Indian Journal *of Gender* Studies, pp. 291-343; 11(3)

therefore that any sub project developed as part of the NGRBA programme should address and integrate such gender issues and inequalities.

Mainstreaming gender equity and empowerment is already a focus area in the NGRBA programme preparation. Based on identified gender issues through socio-economic survey of every sub project activities will be integrated under each proposed investment to address women's needs.

3.1.10 Poverty Analysis

The project will support several activities of the recently constituted NGRBA through this project. These will cover a range of interventions: i) building the institutional capacity of the NGRBA, participating entities, and regulators such Pollution Control Boards at the Centre and State levels, ii) a selection of activities that will help accomplish its Mission Clean Ganga, which aims to prevent any untreated waste going into the over 2500 km long river by year 2020. Therefore, the selection of interventions would primarily focus on characteristics of the candidate discharges / location – quantum of generation, concentration of pollution, etc. While the overall impact of these activities would be broadly positive, especially as these improvements would improve quality of the ambient environment in the basin as a whole, some of the activities / interventions could potentially adversely impact some poor people dependent on the current status of the river, its surrounding areas, and the settlements that are located along/very close to the River.

The Gangetic plain covering about 287,000 km^2 of area across 5 states – Uttarakhand, Uttar Pradesh, Bihar, Jharkhand, and West Bengal, is a monotonous plain formed by the fine grained soil carried down by the Ganga over millennia. It is one of the most fertile areas in the country. Physiographically, the 2250 km reach in the plains is divided into 3 parts – Upper Gangetic Plains (about 770km) in Uttarakhand and UP; Middle Gangetic Plain (1005 km) in UP, Bihar, with a sliver in Jharkhand; and Lower/Deltaic plain (470 km) almost entirely in West Bengal. Uttarakhand, Uttar Pradesh, Bihar, and Jharkhand have been part of a group of states lagging persistently in terms of overall growth and development as measured across a variety of indicators. While West Bengal has not been traditionally identified with this group, its recent decelerating performance is a cause of a rising concern.

This annex provides an overview of some historical as well as recent estimates on income poverty for the 5 project states. As will be described later, high levels of rural poverty are a particular concern in the Middle Gangetic Plain where despite access to highly fertile soil and abundance of water, people are not able to quickly and permanently move out of poverty. Starting with a comparison of these with the country-wide poverty / income scenario, this annex then briefly describes the current poverty situation in the districts along the River Ganga vis-à-vis that within the respective states. Additional information in the last section has been included to provide anecdotal evidence of some of the key issues that would be further explored as part of the Poverty and Social Impact Assessments (PSIAs) to be taken up during project implementation.

3.1.10.1 Historical Trends

The project states have had a disproportionately high incidence of income poverty for decades. As can be seen from Table 3.16, their efforts to increase the income their residents have shown mixed results. In most cases, they have lagged the average for the country as a whole. These numbers can be put into perspective by noting that India's population rose from 528 million in 1971 to 1027 million in 2001. In the same period, total population of the project states increased from 189 million to just over 329 million. Slightly under half (~45%) of all poor people in India lived in these states at the beginning of the current millennium. Though the proportion of poor people continued to decline in these states, the rate of reduction had not been able to keep pace with the overall rate for India, except for West Bengal, where again it seemed to have slowed down towards the end of 1990s. Another significant feature of income poverty that period, not reflected in Table 3.16, pointed out in Mehta and Shah (2003), is that its incidence in the low income states(then 5[10] – Bihar, MP, Orissa, Rajasthan, and UP), which include 4 project states except West Bengal was over 50% higher than poverty in other large states.

[10] In end-2000 Uttarakhand was created out of UP, Jharkhand out of Bihar, and Chhattisgarh out of MP.

Table 3.16 Historical Incidence & Concentration of Poverty: Project States and India11

State	Percentage of India's Population		Percentage of poor population in the State		
	Total Population	Poor			
	2001	1999-2000	1973-74	1993-94	1999-2000
Bihar (Bihar + Jharkhand)	10.69	16.36	61.91	54.96	42.6
UP (Uttar Pradesh + Uttarakhand)	17.00	20.36	57.07	40.85	31.15
West Bengal	7.81	8.20	63.43	35.66	27.02
INDIA	100	100	54.88	35.97	26.1

3.1.10.2 Recent Estimates of Income and Poverty

The last decade has seen a sustained increase in the growth rate for the entire country in which the 8% threshold has been crossed in almost half the years. This unparalleled increase in incomes of the states has resulted in increased income for the average person in each state. Since the creation of the smaller states – Jharkhand and Uttarakhand, there has been some improvement with their average rate of growth of per capita income being higher than the India has a whole for the period 2001-2008. However, the larger ones Bihar and Uttar Pradesh – continue to lag behind India, as well as their newest off-shoots. As can be seen from Table 3.17, Bihar also followed a very volatile growth pattern with 2 years of negative growth. West Bengal seems to be losing the early advantage it had gained in terms of per capita income until 2003 and lately it seems to have slowed down substantially compared to national rate.

Table 3.17 Statewise Per Capita Income and Growth Rates at Constant Prices (New Series 1999-2000)

Year	Bihar		Jharkhand		Uttar Pradesh		Uttarakhand		West Bengal		INDIA	
	Income (`)	GR (%)	Income (`)	GR (%)	Income (`)	GR (%)	Income (`)	GR (%)	Income (`)	GR (%)	Income (`)	GR (%)
2000-01	6554		9980		9721		14932		16244		16172	
2001-02	5994	-8.5	10451	4.7	9672	-0.5	15364	2.9	17225	6.0	16764	3.7
2002-	6658	11.1	10563	1.1	9806	1.4	16530	7.6	17567	2.0	17101	2.0

[11]Adapted from Mehta A. and A Shah (2003): Chronic Poverty in India: Incidence, Causes and Policies; World Development pp491-511; doi: 10.1016/S0305-750X(02)00212-7; Elsevier Science Limited

Year	Bihar		Jharkhand		Uttar Pradesh		Uttarakhand		West Bengal		INDIA	
	Income (`)	GR (%)	Income (`)	GR (%)	Income (`)	GR (%)	Income (`)	GR (%)	Income (`)	GR (%)	Income (`)	GR (%)
03												
2003-04	6117	-8.1	11173	5.8	10120	3.2	17542	6.1	18374	4.6	18301	7.0
2004-05	6772	10.7	12869	15.2	10421	3.0	19524	11.3	19367	5.4	19331	5.6
2005-06	6719	-0.8	12950	0.6	10758	3.2	20355	4.3	20212	4.4	20868	8.0
2006-07	8167	21.6	14252	10.1	11334	5.4	22178	9.0	21753	7.6	22580	8.2
2007-08	8703	6.6	15303	7.4	11939	5.3	23477	5.9	23229	6.0	24295	7.6
Mean Growth		4.6		6.4		3.0		6.7		5.3		6.0

Source: http://planningcommission.nic.in/data/datatable/Data0910/tab%2061.pdf + TT calculations

This increased income has translated into the reduction in poverty at the aggregate level. The latest figures available for the entire country are from the 61st Round of NSSO survey of Consumer Expenditure carried out in 2004-05. The Planning Commission has used this survey and calculated the percentage of poor people and their numbers for the project states as reproduced in Table 3.18. While not strictly comparable, as the new states were created only in 2000, it indicates that the incidence of poverty has fallen in Bihar, Jharkhand, and West Bengal. In this period, project states' share of poor people of India has increased from just less than 45% (see Table 3.18) to slightly more than 54%. The sharply increased rate of poverty in Uttarakhand, where the rate of increase of per capita income has been faster than India as a whole, and in Uttar Pradesh, due to its size, are disconcerting developments for the states and India.

Table 3.18 Nos. and % of Population below Poverty Line 2004-05 (Based on URP-Consumption)

State	Rural		Urban		Combined	
	% of Population	No. of persons (00,000)	% of Population	No. of persons (00,000)	% of Population	No. of persons (00,000)
Bihar	42.1	336.72	34.6	32.42	41.4	369.15
Jharkhand	46.3	103.19	20.2	13.2	40.3	116.39
Uttar Pradesh	33.4	473	30.6	117.03	32.8	590.03
Uttarakhand	40.8	27.11	36.5	8.85	39.6	353.96

State	Rural		Urban		Combined	
	% of Population	No. of persons (00,000)	% of Population	No. of persons (00,000)	% of Population	No. of persons (00,000)
West Bengal	28.6	173.22	14.8	35.14	24.7	208.36
India	28.3	2209.24	25.7	807.96	27.5	3017.2

Source: Table 2 of Poverty Estimates for 2004-05 - Press Note dated March 2007, Press Information Bureau, GoI

One possible explanation for the increase level of poverty can be from the definition of the poverty line. As can be seen from Table 3.19, the poverty line for rural areas Uttarakhand is about 34% higher than weighted average for India; and in urban areas, the corresponding number is about 18% higher. For other states, for rural areas, the notional all-India poverty line is higher but difference is less than 10%. In case of the urban areas, all 4 states have defined their poverty lines 10-20% below the implicit level for India.

Table 3.19 State-Specific Poverty Lines in 2004-05 (Per Capita per Month)

State	Rural	Urban
Bihar	354.36	435.00
Jharkhand	366.56	451.24
Uttar Pradesh	365.84	483.26
Uttarakhand	478.02	637.67
West Bengal	382.82	449.32
India	356.30	538.60

**The poverty line (implicit) for all-India level is worked out from the expenditure class-wise distribution of persons (based on URP consumption, that is, consumption data collected from 30-day recall period for all items) and the poverty ratio at all-India level. The poverty ratio at all-India level is obtained as the weighted average of the state-wise poverty ratio.*
Source: Table 1in PIB, GoI ibid.

3.1.10.3 Poverty at the State Level

This section delves into the differences among the states – rural and urban to present the latest available situation analysis for the project states. It has been compiled from the 61st round of NSSO survey mentioned above and draws heavily on Chaudhari and Gupta (2009)[12]. Other sources of information used for the analysis include the Census of India, 2001. The following additional indicators of poverty have been identified

[12] Chaudhari S. and N. Gupta (2009): Levels of Living and Poverty Patterns: A District-wise Analysis for India, Economic and Political Weekly Vol. XLIV No. 9 pp94-110.

from the state-level profiles: i) % of households with no assets; ii) % of households cooking in the open; iii) % of households with drinking water source outside premises; iv) % of households using crop residue/firewood as fuel; v) of households having no drainage in the house; and vi) % of households with no latrine within the house.

As can be seen from Table 3.20, the lowest average Monthly Per Capita Expenditure (MPCE) in the rural areas is for Bihar while the highest is in Uttarakhand. However, Uttarakhand is also the most unequal and Bihar emerges with the lowest Lorenz ratio highlighting a more equitable society, at least in terms of expenses incurred. In urban areas, West Bengal has the highest MPCE and highest inequality as measured by the Lorenz Ratio (LR), however, though Bihar has the lowest MPCE, Uttar Pradesh has the most equitable distribution among the project states. It is also striking that the average MPCE in rural Bihar is only over 17% of the poverty line in Table 3.19, while in West Bengal the corresponding average MPCE is more than 45% higher than its own poverty line even though each is home to a similar proportion of India's rural population.

Table 3.20 State Level Estimates of Average MPCE, Head Count Ratio, and Lorenz Ratio in 2004-05

State	Rural					Urban				
	% of All-India Population	Average MPCE (`)	RSE of MPCE	% Poor	Lorenz Ratio	% of All-India Population	Average MPCE (`)	RSE of MPCE	% Poor	Lorenz Ratio
Bihar	9.1	417	0.95	42.6	0.2054	2.7	696	5.76	36.1	0.3289
Jharkhand	2.8	425	1.61	46.2	0.2247	1.6	985	5.58	20.3	0.351
Uttar Pradesh	18.1	533	1.23	33.3	0.2807	13	857	4.96	30.1	0.323
Uttarakhand	0.9	647	4.49	40.7	0.2859	0.8	978	6.00	36.5	0.364
West Bengal	8.1	562	2.02	28.4	0.2696	7.8	1124	3.10	13.5	0.3786
India	100	559	0.54	28.3		100	1052	1.14	25.6	

Source: Table 4 in Chaudhari and Gupta ibid.

Table 3.21 provides a snapshot of performance of the project states on the key indicators that may be pointers to poverty. In terms of the material possessions, Bihar has the least with about 50% of all households owning none of the specified assets. On this count, rural areas of Uttar Pradesh and urban areas of Uttarakhand are the best performers in each setting. While one would expect open cooking to be less in the hill

areas of Uttarakhand, the low numbers is Jharkhand are slightly unexpected and may warrant further inquiry. While sourcing drinking water from outside premises is a reality for uniformly large proportion in urban and rural population of Jharkhand, it is a situation that is also faced by over 75% of rural households in West Bengal. The use of biomass based fuel for cooking may indicate limited access to clean fuel and therefore moving away to kerosene or gas may be a clear signal of reduced poverty. In Jharkhand's case, low figures can be easily traced to coal use, especially in the urban areas. Together with the low numbers of cooking in the open, this points to a potential risk of damage due to indoor air pollution that can adversely affect the health, especially among the women in Jharkhand. The most surprising data pertains to drainage as one would have expected that with the flat slopes in the plain regions, drainage would be a very important feature of the area's dwellings. However, almost 70% of all households in West Bengal and almost 85% of rural households do not have drainage for carrying away wasted water, the risks of water-related illnesses may always be lurking. On the provision of latrine within the house, Uttarakhand is the best performer, followed by West Bengal, and Bihar is worst overall with over 80% of houses not having such a facility. Among the rural areas, Jharkhand is the worst performing state, with only 10% of houses with a latrine within the house. Improved provision of drainage from houses and household latrines can have beneficial impacts for the households and also help to achieving the project goal of reduction/elimination of untreated waste going into the river.

Table 3.21 Selected State Level Non-income Indicators of Poverty (as of 2001)

State		% owning none of the 'specified' assets	% cooking in the open	% with drinking water source outside premises	% using crop residue / firewood / cow dung as fuel	% with no drainage in the house	% with no latrine within the house	Out of Million Households
Bihar	Total	49.5	21.6	61.4	91.1	62	80.8	13.983
	Rural	51.3	22.5	63.7	96.0	65.1	86.1	12.660
	Urban	32.2	13.8	29.5	43.8	31.4	30.3	1.323
Jharkhand	Total	39.6	8.4	80.0	69.1	70.4	80.3	1.282
	Rural	44.3	8.8	90.3	84.6	82.3	93.4	0.895
	Urban	22.6	7.0	42.8	14.2	27.6	33.3	0.387
Uttar Pradesh	Total	20.3	16.8	54.0	85.3	29.5	68.6	25.761
	Rural	21.4	18.4	61.8	96.3	35.0	80.8	20.590
	Urban	15.7	10.6	23.0	41.8	7.6	20.0	5.171

State		% owning none of the 'specified' assets	% cooking in the open	% with drinking water source outside premises	% using crop residue / firewood / cow dung as fuel	% with no drainage in the house	% with no latrine within the house	Out of Million Households
Uttarakhand	Total	25.7	6.9	54.7	60.7	51.9	54.8	1.586
	Rural	30.1	7.7	67.3	74.7	65.0	68.4	1.196
	Urban	12.0	4.3	17.9	17.4	11.8	13.1	0.390
West Bengal	Total	30.1	14.6	67.9	64.6	69.2	56.3	15.716
	Rural	34.0	17.1	76.5	84.2	84.1	73.1	11.162
	Urban	20.4	8.3	46.6	16.6	32.9	15.2	4.554

Source: Housing Profile from Census of India 2001

3.1.10.4 Poverty within project states

Since the 61st round of the NSSO used districts as the units of reporting, it is possible to compare the distribution of poor people within the state across districts. Since the Ganga flows through some of the districts in each state, in Jharkhand only 1 district – Sahibganj, a comparison is presented below of the incidence of poverty in districts that line the Ganga vis-à-vis those that do not share any part of their land with the flowing main stem of the mighty river in each state. During subsequent stages of the project, the detailed PSIAs could focus on the variables listed in Table 3.21 in addition to the classical poverty indicators that are being compared in the following portion of this analysis. This would help in better targeting of interventions in line with project objectives.

Bihar

In Bihar, the Ganga flows through around 1/3rd of the state's districts. As can be seen from Table 3.22, there is little difference between the MPCE and incidence of poverty in rural areas between the 12 districts that line the Ganga and the 25 districts that do not. However, in urban areas, the situation is markedly different. The percentage of urban poor is far less (> 50% less) in the districts where the Ganga flows. It also compares favorably with the overall 34.6% poverty ratio for the entire state. The MPCE is also more than `217 higher in urban areas of these districts compared to urban areas of other districts in Bihar. This would mean that urban areas in non-Ganga districts would need to increase MPCE by about 45% to match the performance of the districts bordering the river.

Table 3.22 Comparison of Districts within Bihar on Income Poverty Parameters (2004-05)

	Number of Districts	RURAL				URBAN			
		Proportional population	MPCE (`)	% Poor	Median LR	Proportional population	MPCE (`)	% Poor	Median LR
Ganga Bank	12	30	418.38	42.23	0.19	53.7	796.55	28.0	0.251
Non-Ganga	25	70	416.06	42.8	0.179	46.3	579.24	45.56	0.24

Source: Chaudhari and Gupta ibid + TT calculations

Jharkhand

In Jharkhand, Ganga flows along a 50km stretch lining just Sahibganj district. The district is home to about 3.6% of rural population and about 1% of urban population of the state. It is worse off than the rest of the state on MPCE – in both rural and urban areas. The incidence of poverty is also higher than the state as a whole (63.7% in rural areas compared to 46.2% for Jharkhand; 29.95 for urban areas in Sahibganj compared to 20.3% for the entire state). Its economy is built around the coal business and river seems to be playing little part in its economy.

Uttar Pradesh

Out of UP's 70 districts, 17 are physically connected to the Ganga. As can be seen from Table 3.23, while there is little (~0.2%) in the MPCE values for rural areas in the two groups of districts, in urban areas the MPCE in Ganga districts is higher by slightly over 5%. This contrasts with the situation in Bihar (Table 3.22) where even after an increase of about 25% only a small change in the Lorenz ratio is anticipated. Another contrast with Bihar appears in the incidence of poverty in urban areas. As groups, difference is very small between Ganga and Non-Ganga districts only about 4.3%.

Table 3.23 Comparison of Districts in Uttar Pradesh on income poverty parameters (2004-05)

	Number of Districts	RURAL				URBAN			
		Proportional population	MPCE (`)	% Poor	Median LR	Proportional population	MPCE (`)	% Poor	Median LR
Ganga Bank	17	26.7	523.52	31.82	0.239	28.5	895.96	27.511	0.304
Non-Ganga	53	73.1	536.30	33.82	0.251	71.8	842.08	31.85	0.283

Source: Chaudhari and Gupta ibid + TT calculations

Uttarakhand

In Uttarakhand, the rural MPCE for districts where the Ganga flows is about 6% lower than in rural areas of other districts of the state. However, the situation is quite different in urban areas as can be surmised from Table 3.24. In urban areas, MPCE increases over 85% and the incidence of poverty is reduced by more than 10%. It should be noted that the difference between the incidences of poverty in two groups of districts is the largest in Uttarakhand.

Table 3.24 Comparison of Districts in Uttarakhand on Income Poverty Parameters (2004-05)

	Number of Districts	RURAL				URBAN			
		Proportional population	MPCE (`)	% Poor	Median LR	Proportional population	MPCE (`)	% Poor	Median LR
Ganga Bank	3	29.4	604.37	28.19	0.251	27.2	1136.82	17.7	0.234
Non-Ganga	10	70.4	643.63	38.83	0.231	72.7	918.45	43.6	0.261

Source: Chaudhari and Gupta ibid + TT calculations

West Bengal

West Bengal has the highest concentration of urban population of all the project states. The urban areas in 7 districts along the Ganga have distinction of having the least % of poor people in all project states. Along the river, moving from rural to urban area would more than double MPCE, and the % of poor persons would be reduced by 50% whereas for the non-Ganga districts, this would result in a 50% increase as shown in Table 3.25. The increase in the Lorenz ratio is also comparatively larger for the increase in MPCE.

Table 3.25 Comparison of Districts in West Bengal on Income Poverty Parameters (2004-05)

	Number of Districts	RURAL				URBAN			
		Proportional Population	MPCE (`)	% Poor	Median LR	Proportional Population	MPCE (`)	% Poor	Median LR
Ganga Bank	7	46.9	610.75	23.38	0.256	68	1269.38	9.07	0.365
Non-Ganga	11	53.1	518.95	32.85	0.233	31.9	813.64	25.59	0.309

Source: Chaudhari and Gupta ibid + TT calculations

3.1.10.5 Specific Activities and Impacts on Poverty/Livelihoods

In the preceding data and its brief analysis, several dimensions of poverty of the population within project states at the district level have been described. Under the project, in context of the presence of vulnerable/poor people, three distinct situations (and many in the continuum that connects these), each requiring a different approach to handle the potential impacts can be: a) where the objectives of project activity also yield direct benefits to the poor and/or vulnerable people in the project area; b) some adjustment in the design of the project activity would lead to direct benefit/ positive impact for the vulnerable section; and c) where the project activities, if implemented without any regard for the local / present vulnerability, could result in negative impacts and would therefore require planning for specific mitigation measures in advance. In the following paragraphs, each of the three situations is briefly presented and analyzed. It should provide the basis for developing consistent approaches for handling such situations as the program evolves and more site-specific information regarding the nature and extent of poverty and other vulnerabilities becomes clearer.

a) Enhancing Farm produce and Farmers' benefits in Urban/Fringe Areas

Peri-urban agriculture is crucial for the supply of fresh produce to Indian cities, and for local livelihoods and the economy. However, there is little understanding or support for the particular opportunities and threats associated with farming these areas, especially when untreated/partially treated wastewater is used for irrigation. As part of an India-wide evaluation for IWMI[13], wastewater irrigation and its impacts on livelihoods in Kanpur were assessed. The study noted the

[13] Winrock International (2006):Urban Wastewater: Livelihoods, Health and Environmental Impacts in India; submitted to International Water Management Institute, Colombo.

perceived advantage of added income (about doubling of income from same sized plot using fresh water) as a key driver of this practice.

The study covered 2770 farmers with average holding for lessees and land owning farmers are 1.25 ha and 0.81 ha, respectively in the Jajmau area, within the Kanpur city limits that are using the wastewater as irrigation water for the last five decades. The villages are spread over an area of approximately 2,500 ha, with a population of approximately 50,000. Scheduled Castes and backward castes of Mallahs/Nishads and Yadavs dominate the villages. Most of the population is engaged in farming on small and marginal land holdings or riverbeds, cattle rearing, and fishing in the Ganga. Within this context, the following observations are particularly relevant:

- Flood irrigation is used in wastewater-irrigated areas. Wastewater flows by gravity and this irrigation method requires no distribution network but introduces a considerable level of personal contact with the effluent and increased threat of infection by pathogens. The wastewater provides benefits of irrigational support and minor values of nitrogen, phosphorous, organic carbon, etc. But this method also contaminates soil, vegetable crops or root crops, and exposes farmers to wastewater more than any other method of irrigation. The inadequately treated wastewater from the STPs and CETP are utilized for irrigation by adjoining farmlands in Jajmau area; the sludge generated from the sewage treatment plants is disposed to wastewater-irrigated villages.
- Several hectares of land are degrading due to unscientific use of treated/untreated and heavily contaminated wastewater. The critical levels of the heavy metals in soils displaying negative impacts on agricultural crops are high. Almost all the farmers reported that crop yield has declined by 40-50 percent over the past few years due to wastewater irrigation. Since the current irrigation practice began in the early 1990s, wheat production has decreased by 30-35 percent and rice by 40-45 percent.
- Anecdotal references to spontaneous abortion in 10-40 percent of their cattle and lower milk production by five to six liters a day per buffalo was also reported.

This shows that even when there are real livelihood benefits, irrigation with partially treated wastewater needs to be handled with care. Given that there is potential contamination with heavy metals such as chromium and cadmium in the area, the priority should be to treat completely to ensure that the concentrations are safe for contact with humans, consumption, and irrigation. Project activities that help achieve these objectives simultaneously – enhancing / preserving livelihoods while improving living conditions / health of such vulnerable groups may be given a higher priority.

b) Engaging marginalized fisherfolk in conservation of Flagship Species

Fishing activity in Ganga becomes increasingly important as the river flows towards the sea. A recent policy paper14 from CIFRI (2007) notes that the gangetic system is home to about 265 species of fish. Catch statistics over the years indicate some disturbing trends in the riverine sector, the total average fish landing in the Ganga River system declined from 85.21 t during 1959 to 62.48 t during 2004. This contrasts sharply with the rest of the country since India's inland fish yield went up by eight times in the last four decades. Traditional riverine fisherfolk lose out on this rapid rise which has been attributed to aquaculture. CIFRI carried out a study[15] regarding status of fishers along the Ganga and found that MPCE for the group ranged between `251and `383. Its analysis further showed that on average, fishers spent 66% on food and 34% on non-food items. The major food item of the expenditure was cereals (37%) followed by vegetables (7%). Among non-food items highest expenses were on medical (9%) followed by intoxicants (8%). Several other limitations also contribute to their current neglect. For instance, the Census of India does not have clear classification of the riverine fisherfolk. Neither do they exist in the livestock

[14] Das M. K., Samanta S, and Saha P.K. (2007): Riverine Health and Impact on Fisheries in India; Policy Paper No. 01; Central Inland Fisheries Research Institute; Barrackpore

[15] "Techno-Socio-economic status of Fishers of River Ganga" (2006) Report of ICAR AP Cess Fund Scheme Central Inland Fisheries Research Institute, Barrackpore. 80 p. cited in Current Status of River Ganges

census. A large chunk of the 387 communities of fisherfolk, which the Anthropological Survey of India has identified, is involved in inland fishing[16].

Conflicts also begin to emerge with the other concerns such as conservation of important species at the top of the food webs – such as the Gangetic Dolphin, locally known as Susu, after the river enters the plains at the Uttarakhand/Uttar Pradesh border. World Wide Fund for Nature (WWF) has been working very closely with the local fisherfolk in the stretch between Anupshahr and Narora for protecting the Gangetic Dolphin for several years. One of its recent studies17 inferred that poverty compels the fishermen to fish but the harassment by fish contractors forces them towards excessive fishing. Since most fishermen use large meshed gill-nets they are focused on catching large sized individuals and therefore assumed to be conducting commercial fishing (55%). The study also found that excessive fishing and dolphin-poaching were found to be interrelated which led them to recommend that if fishing can be more effectively managed poaching may automatically decline. 41% of the fishermen interviewed were found to be willing to stop fishing providing adequate alternative livelihoods are provided by the government. Such information, for other areas that are rich in biodiversity, could provide some initial pointers on how the project activities should be aligned with poverty reduction objectives to provide a sound basis for all-round development for these relatively backward communities while furthering conservation efforts.

c) Protecting the most vulnerable and disadvantaged social groups

The age-old practice of depositing human remains in the Ganga also poses health threats because of the unsustainable rate at which partially cremated cadavers are dumped. In Varanasi, some 40,000 cremations are performed each year, most on wood pyres that do not completely consume the body18. Along with the remains of these traditional funerals, there are thousands more who cannot afford cremation and whose bodies are simply thrown into the Ganga. These inadequate cremation procedures contribute to a large number of partially burnt or unburnt

[16] Down To Earth (2002): February 2002; Centre for Science and Environment, New Delhi - Article titled: 'Orphans of the river' has a more detailed and passionate account of their conditions

17 Bashir T., Khan A., Behera S., Gautam P. (2010): Socio-economic factors threatening the survival of Ganges River Dolphin Platanista gangetica gangetica in the upper Ganges River, India; Journal of Threatened Taxa | www.threatenedtaxa.org | July 2010 | 2(8): 1087-1091

[18] http://www.gits4u.com/water/ganga.htm#Pollution%20in%20Ganga%20River accessed on 16th October 2010.

corpses floating down the Ganga. Soot-covered Dom (the custodians of the burning ghats, the funeral ground known as smashan) men carry out the most menial and morose task of raking in the still-glowing ashes, sweeping them into the river. Doms usually represent the lower most level of socio-economic fabric of the society. They have few other skills that can be useful in providing them with income if such activity – open cremation on wood piles, is ceased or restricted as part of the project efforts to reduce the inflow of waste material into the river. Alternative livelihood arrangements such as training into other vocations would need to be blended into the project design in such cases.

3.1.11 Health

Health is an important indicator of human wellbeing. Life expectancy, IMR and maternal mortality rate are some of the important indicators of the health status.

Table 3.26 Life Expectancy at Birth by Sex in India 1996-2002

States/India	1996-00		1997-01		1998-02	
	Male	Female	Male	Female	Male	Female
Bihar	60.9	59.1	61.1	59.3	61.4	59.5
Haryana	64.4	65.1	64.6	65.2	64.7	65.4
Himachal Pradesh	65.4	66	65.5	66.1	65.7	66.3
Madhya Pradesh	56.6	56.3	56.7	56.4	57	56.7
Rajasthan	60.1	61.1	60.3	61.3	60.5	61.6
Uttar Pradesh	59.1	57.9	59.2	58.1	59.4	58.5
West Bengal	63	64.5	63.2	64.6	63.3	64.8
Delhi	N.A	N.A.	N.A.	N.A.	N.A.	N.A.
Uttarakhand	N.A	N.A.	N.A.	N.A.	N.A.	N.A.
Jharkhand	N.A	N.A.	N.A.	N.A.	N.A.	N.A.
India#	61	62.7	61.3	63	61.6	63.3
Ganga main stem (avg)	61.35714	61.42857	61.51429	61.57143	61.71429	61.82857

NA= Not Available

(Sources: Registrar General of India)

Average life expectancy has shown increasing trend from year 1996 to 2002 in all the five states as with the trend shown by the country as well as for the Ganga main stem. Out of the all the basin states, Himachal Pradesh has the highest life expectancy at birth for both sexes (males, females).

Table 3.27 Infant Mortality Rates - 1999-2003 (State-wise and Rural / Urban-wise) (per 1000 live births)

State	Rural					Urban					Combined				
	1999	2000	2001	2002	2003	1998	2000	2001	2002	2003	1999	2000	2001	2002	2003
Bihar	**64**	**63**	**63**	**62**	**62**	**51**	**53**	**52**	**50**	**49**	**63**	**62**	**62**	**61**	**60**
Haryana	70	69	68	64	61	59	57	55	51	49	68	67	66	62	59
Himachal Pradesh	63	62	56	53	51	38	37	32	28	26	62	60	54	52	49
Madhya Pradesh	96	93	92	89	86	56	54	53	56	55	90	87	86	85	82
Rajasthan	85	82	84	81	78	60	58	57	55	53	81	79	80	78	75
Uttar Pradesh	**88**	**87**	**86**	**83**	**79**	**65**	**65**	**62**	**58**	**55**	**84**	**83**	**83**	**80**	**76**
West Bengal	**55**	**54**	**54**	**52**	**48**	**41**	**37**	**37**	**36**	**34**	**52**	**51**	**51**	**49**	**46**
Uttarakhand	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Delhi	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Jharkhand	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Ganga main stem TOTAL	521	510	503	484	465	370	361	348	334	321	500	489	482	467	447

Source: Sample Registration system, Registrar General of India
Latest as provided by RGI

Infant Mortality rates have shown decreasing trends in all the states and Ganga main stem in general from 1999 to 2003. Highest IMR is found in the state of Uttar Pradesh. The same trend is seen in both rural and urban areas that the state of Uttar Pradesh has the maximum cases of IMR. On an average in 2003 the cases of IMR reported in Uttar Pradesh were 76 per 1000 live births.

Table 3.28 State-wise Data on Primary Health Infrastructure

State	Required PHC	In place PHC
Bihar	2489	1641
Uttar Pradesh	4390	3690
Uttarakhand	214	239
Jharkhand	806	330
West Bengal	1993	924

Source: RHS Bulletin, March 2008, M/O Health & F.W., GOI

West Bengal, Bihar and Jharkhand clearly reflects the poor health facility available in the states, the required number of primary health centers is far behind the present

number of primary health centers in the state. The status of health facilities is not satisfactory in all the four states, Uttarkhand only have more than the required number of facilities. Poor health facilities hamper the development and progress of the states.

Table 3.29 State / UT-wise Cases and Deaths due to Dengue in India 2005-2009 (provisional) ICD - 10 Code A90 - A91

S. No.	State / UT	2005		2006		2007		2008		2009	
		Cases	Death	Cases	Death	Cases	Death	Cases	Death	Cases	Death
1	Bihar	0	0	4	0	0	0	1	0	1	0
2	Uttar Pradesh	121	4	639	14	132	2	51	2	168	2
3	West Bengal	6375	34	1230	8	35	4	1038	7	399	0
4	Uttarkhand	0	0	0	0	0	0	20	0	0	0
5	Jharkhand	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Source: Directorate of national Vector Borne Disease Control Programme, Dte. GHS/ MOHFW, GOI

State of West Bengal shows the maximum number of cases due to dengue and hence the cases of deaths due to dengue are also reported high in West Bengal. While in the latest available data of year 2009 there has been no cases of death though the numbers of cases reported due to dengue were 399.

Table 3.30 State / UT wise Cases and Deaths due to Malaria in India 2005-2009 (Provisional) ICD - 10 Code B50 – B54

S. No.	State / UT	2005		2006		2007		2008		2009	
		Cases	Death	Cases	Death	Cases	Death	Cases	Death	Cases	Death
1	Bihar	2733	1	2744	1	1595	1	2541	0	2853	20
2	Uttar Pradesh	105303	0	91566	0	82538	0	93383	0	54488	0
3	West Bengal	185964	175	159646	203	87754	96	89443	104	137768	74
4	Uttarakhand	1242	0	1108	0	953	0	1059	0	1264	0
5	Jharkhand	193144	21	193888	4	184878	31	214299	25	228116	28

(Source: Directorate of national Vector Borne Disease Control Programme, Dte. GHS/ MOHFW, GOI)

State of Jharkhand shows the maximum number of malaria cases; however the cases of deaths due to malaria are reported highest in West Bengal.

Table 3.31 State/UT-wise Cases and Deaths due to Cholera in India 2009 (Provisional) ICD-10 Code A00

S.No.	State / UT	Cases	Deaths
1	Bihar	0	0
2	Jharkhand	0	0
3	Uttarkhand	1	0
4	Uttar Pradesh	0	0
5	West Bengal	486	0

Source: Directorate of national Vector Borne Disease Control Programme, Dte. GHS/ MOHFW, GOI

For cholera, the data available is only for the state of West Bengal, where in 486 cases were reported in the year 2009 and the cases of deaths due to this disease is zero. While all the rest four states shows zero cases in cholera.

Table 3.32 State/UT-wise Cases and Deaths due to Acute Diarrheal Disease in India 2009 (Provisional) ICD - 10 Code A09 (State-wise Inference)

S. No.	State / UT	Male		Female		Total		Reference Period up to
		Cases	Deaths	Cases	Deaths	Cases	Deaths	
1	Bihar	0	0	0	0	0	0	NR
2	Jharkhand	28912	2	26235	2	55147	4	Oct., 09
3	Uttarkhand	59040	41	52200	29	111240	70	Dec., 09
4	Uttar Pradesh	227503	97	181453	54	408956	151	Dec., 09
5	West Bengal	1231941	370	1211343	355	2443284	725	Dec., 09

Source: Monthly Health condition reports from Directorate of Health Services of States / UTs

Diarrheal disease is mainly attributed to poor sanitation and drinking untreated polluted water. West Bengal shows the maximum number of cases of diarrhea disease. While Uttar Pradesh bags the second rank among the data available for four states. In West Bengal females are more prone to diarrhea as compared to males as indicated by the data. And hence the number of deaths due to diarrhea is higher in females of Bengal as compared to males. This clearly reflects the vulnerable and poor status in the society.

Table 3.33 State/UT-wise Cases and Deaths due to Enteric Fever (Typhyoid) in India 2009 (Provisional) ICD - 10 Code A01

S.No.	State / UT	Male		Female		Total		Reference period up to
		Cases	Deaths	Cases	Deaths	Cases	Deaths	
1	Bihar	0	0	0	0	0	0	NR
2	Jharkhand	17225	3	11235	2	28460	5	Oct., 09

3	Uttarkhand	12556	34	10453	15	23009	49	Dec., 09
4	Uttar Pradesh	34024	46	27192	21	61216	67	Dec., 09
5	West Bengal	71504	49	61591	29	133095	78	Dec., 09

Source: Monthly Health condition reports from Directorate of Health Services of States / UTs

High cases of water borne diseases are reported in the states, but they are averted by treatment and fewer numbers of deaths happen due to water borne diseases. High number of water borne diseases could be attributed to inaccessibility to safe drinking water and poor sanitation and hygiene surroundings. Moreover the use of untreated water is also one of the important reasons for such diseases.

3.1.12 Economic Profile

3.1.12.1 Economic Importance

The Ganga main stem with its fertile soil is instrumental to the agricultural economies of India and Bangladesh. The Ganga main stem is one of the most populous regions on Earth, home to 450 million people at an average density of over 550 individuals per square kilometre. In the delta zone this rises to over 900 per square kilometre. As a result, there is strong demand and competition for natural resources, especially water for domestic use and irrigation, and most of the basin tributaries are regulated by barrages. [19]

3.1.12.4 Tourism

Tourism is another related economic activity. Three towns holy to Hinduism – Haridwar, Allahabad, and Varanasi – attract thousands of pilgrims to its waters. Thousands of Hindu pilgrims arrive at these three towns to take a dip in the Ganges, which is believed to cleanse oneself of sins and help attain salvation. The rapids of the Ganges in Rishikesh also are popular for river rafting, attracting hundreds of adventure seekers in the summer months. During festival of Chatth, Ganga ghats at Bihar attracts thousabd sof devotes and tourists. So, the Ganga main stem is a source of economy to the states and country through tourism related activities.[20]

[19] http://wwf.panda.org/about_our_earth/about_freshwater/rivers/ganga/
[20] http://wwf.panda.org/about_our_earth/about_freshwater/rivers/ganga/

Plate 3.6 Pilgrims and tourists taking holi dip

Plate 3.7 Picture showing navigational activity

3.1.13 Work force participation

Table 3.34 Distribution of Population by Occupation

	Uttarakhand	Uttar Pradesh	Bihar	Jharkhand	West Bengal	India
Total Workers	3,134,036	53,983,824	27,974,606	10,109,030	29,481,690	402,234,724
Main workers	2,322,347	39,337,649	21,052,875	6,446,782	23,023,583	313,004,983
Marginal workers	811,689	14,646,175	6,921,731	3,662,248	6,458,107	89,229,741
Non workers	5,355,313	112,214,097	55,023,903	16,836,799	50,694,507	626,375,604
Number of Agricultural Labourers	259,683	13,400,911	13,417,744	2,851,297	7,362,957	10,675,330
Household Industry workers	72,448	3,031,164	1,100,424	430,965	2,172,070	16956942

Source: Census of India 2001

32-38 % population in the five states is falls in category of main or marginal workers out of which U.P is at 32 % and Jharkhand at 38%.

In Uttar Pradesh, Agriculture is the main occupation of 66 per cent of the population of the State[21]. Around 90 % of the total population at Uttarakhand is engaged in the occupation of agriculture.[22] Agriculture is the backbone of Bihar's economy with 81% of workforce and generating nearly 42% of the State Domestic Product.[23] Agriculture and allied activities are the major source of Jharkhand's economy also[24]. It plays a pivotal role in the West Bangal state's economy and nearly three out of every four persons is directly or indirectly involved in agriculture.[25] For all agricultural activities, farmers are dependent on the river water from Ganga.

3.1.14 Housing profile

The table below shows the number of notified and non-notified slums in three main stem states of Ganga.

Table 3.35 Estimated Number of slums in states

State/UT	Estimated					
	Number Of Slums			Number Of Households dwelling in slums		
	Notified Slums	Non Notified Slums	All	Notified Slums	Non Notified Slums	All
Uttar Pradesh	775	1,868	2,643	115,162	112,637	227,799
Bihar	349	977	1,326	26,194	43,168	69,363
West Bengal	2,871	5,253	8,125	797,946	732,975	1,530,920
All India	26,166	25,522	51,688	5,358,272	2,871,472	8,229,744

Source: Ministry of housing and Urban Poverty Alleviation

[21] http://india.gov.in/knowindia/st_uttarpradesh.php
[22] http://www.mapsofindia.com/uttarakhand/information/population.html
[23] http://krishi.bih.nic.in/defolt1.html
[24] http://india.gov.in/knowindia/st_jharkhand.php
[25] http://india.gov.in/knowindia/st_westbengal.php

West Bengal has the highest number of slums compared to Uttar Pradesh and Bihar. Consequently the households dwelling in slums are also highest in West Bengal. Number of non-notified slums is also highest in West Bengal compared to the other two states. Tables appended below provide description about the housing profile of the five states of Ganga main stem:

Table 3.36 Type of Fuel Used (No. of Households)

	Uttarakhand	Uttar Pradesh	Bihar	Jharkhand	West Bengal
Total	1,586,321	25,760,601	13,982,590	4,862,590	15,715,915
Fire wood	865,411	11,401,917	3,984,372	2,720,270	4,746,205
Crop residue	40,995	3,541,376	4,829,522	210,105	3,506,003
Cow dung	55,141	7,043,989	3,923,341	434,454	1,899,208
Coal	565	99,898	284,855	1,031,321	1,951,304
Kerosene	69,903	587,795	156,263	46,078	774,388
LPG	531,076	2,913,579	529,069	327,624	1,962,540
Electricity	1,456	36,228	13,401	32,365	31,501
Biogas	15,452	55,459	16,179	6,722	32,457
Any other	847	35,192	229,499	41,314	663,394

Source: Census of India 2001

Table 3.36 indicates that fire wood, crop residue and cow dung are the major fuel used in all the five states. All five states reflect the same point of excess usage of fuel wood, crop residue by the households. LPG is still not used as a major fuel in all the states except Uttarakhand. While negligible number of households in all the five states uses electricity as fuel. This shows poor development in the area as the cleaner fuel technologies are not widely used. Lower grade fuels are mostly used by the households. Sanitation infrastructure, is depicted through the data described in the tables below indicating the overall status of sanitation and hygiene in the states

Table 3.37 Distribution of Households by Availability of Bathrooms and Toilets

	Uttarakhand	Uttar Pradesh	Bihar	Jharkhand	West Bengal
% households having Bathrooms	38.8	28.7	9.6	15.1	23.6
% urban	77.9	63.8	43.1	54.5	58.6
% rural	26.0	19.9	6.1	4.1	9.4
% households with toilets	45.2	31.4	19.2	19.7	43.7
Pit latrine	18.7	10.3	6.5	3.3	17.5
Water closet	15.4	8.0	7.9	10.7	20.9

Other latrines	11.0	13.2	4.8	5.7	5.2
No latrines	54.8	68.6	80.8	80.3	56.3

Source: Census of India 2001

Less than 50 % of households in all the states have bathrooms in their households, especially the scenario is very poor in rural areas. Majority of the households in all the states have no access to the toilets. The figures presents that rural areas in the states have lack of basic amenities and infrastructure related to sanitation. States of Bihar and Jharkhand are the worst in terms of the household coverage. Poor sanitation facilities impact the socio-economic life of the residents and it also impacts the water quality. Poor sanitation coverage is a cause of serious concern for the quality of River Ganga.

Table 3.38 Distribution of Households Connected by Drainage System

	Uttarakhand	**Uttar Pradesh**	**Bihar**	**Jharkhand**	**West Bengal**
Number of households connected by					
Closed drains	164,438	2,456,926	623,258	309,494	1,148,754
Open drains	597,929	15,700,507	4,697,088	1,131,148	3,685,306
No drains	823,954	7,603,168	8,662,244	3,421,948	10,881,855

Source: Census of India 2001

High numbers of households are without any drainage system, which is another indicative of poor sanitation coverage in all the states, which show that all the waste water is drained into open areas, which may run into nearby water bodies, and ground water causing pollution and inviting serious health implications.

Table 3.39 Distribution of Households by Availability of Kitchen

	Uttarakhand	**Uttar Pradesh**	**Bihar**	**Jharkhand**	**West Bengal**
Number of households having separate kitchen	1,131,016	13,127,343	5,429,945	2,915,082	10,616,983
Not available	340,597	8,253,707	5,511,958	1,528,371	2,659,334
Cooking in Open	109,233	4,334,383	3,024,598	406,800	2,290,683

Source: Census of India 2001

Uttarakhand has the maximum number of households having separate kitchen (72%), while Bihar is the state without separate kitchen. (39%) and also takes the lead in having the maximum number of households where kitchen is not available. Hence in

Uttar Pradesh there are maximum number of households where in cooking is done in open. Kitchen availability is an indication of better hygiene practice.

Table 3.40 Distribution of Households by Availability of Electricity and Toilets

	Uttarakhand	Uttar Pradesh	Bihar	Jharkhand	West Bengal
Electricity and toilets both available	38.6	20.0	7.9	15.8	30.1
Electricity available but no toilet	21.7	11.9	2.4	8.5	7.4
Toilet but no electricity	6.6	11.4	11.3	3.8	13.6
Both not available	33.1	56.7	78.4	71.9	48.9

(Source: Census of India 2001)

Electricity and toilets are indicative of the access to basic services of the households, all the states show low coverage in terms of availability of both essential infrastructure. Bihar and Jharkhand shows the worst coverage with only 7.9% of households in Bihar and 15.8% of households in Jharkhand have access to both toilets and electricity.

Table 3.41 Distribution of households by availability of drinking water sources

	Uttarakhand	Uttar Pradesh	Bihar	Jharkhand	West Bengal
% households having drinking water facility within the premises	44.8	46.0	39.6	20.0	32.1
% households having drinking water facility near the premises	38.5	44.0	48.2	55.5	49.9
% households having drinking water facility away from the premises	16.7	10.1	12.2	24.5	18.0

(Source: Census of India 2001)

Jharkhand has very low percentage of households (20%) which have drinking water facility within their premises. While the majority of the households in the state have water facilities near the premises. While compared to all five states, Uttarakhand indicates best of statistics in terms of percentage coverage of households having drinking water facility within the premises.

Table 3.42 Sources of Safe Drinking Water

% households	Uttarakhand	Uttar Pradesh	Bihar	Jharkhand	West Bengal
Tap	65.9	23.7	3.7	12.6	21.4
Hand pump	19.8	63.4	77.9	27.0	55.8
Tube well	1.0	0.7	5.0	3.1	11.3
Well	1.2	11.6	12.6	51.8	10.0
Tank / Pond	1.2	0.0	0.0	0.4	0.2
River / Canal	1.9	0.1	0.2	2.7	0.3
Spring	2.1	0.1	0.1	1.4	0.7
Others	6.9	0.4	0.5	1.1	0.4

Source: Census of India 2001

The importance of safe drinking water for health and development has been reflected in the outcomes of many international policy forums. States of Uttar Pradesh, Bihar and West Bengal have majority of households having access to safe drinking water from handpump, while tap is major source in Uttarakhand and well in Jharkhand. Very few households in all the five states rely on the river water directly for drinking purpose.

Table 3.43 Distribution of Households by Banking Services and Asset Ownership

	Uttarakhand	Uttar Pradesh	Bihar	Jharkhand	West Bengal
% households availing banking services	59.8	44.1	21.3	30.1	36.8
% households owning following assets					
Radio	49.7	39.6	27.8	26.4	38.6
Television	42.9	25.0	9.1	17.2	26.6
Telephone	9.9	5.6	2.2	3.3	6.7
Refrigerator					
Bicycle	30.9	69.5	40.6	50.3	52.6
Scooter / Motorbike/ Moped	11.9	10.4	3.6	9.3	5.0
Car / Jeep	2.7	2.2	0.9	1.5	1.9

Source: Census of India 2001

Asset ownership and banking services of the households in the states indicate the basic socio-economic status of the households in the states. Bihar has low percentage

of households having access to banking services and even the asset ownership by the households in the state is poor as compared to rest four states.

Table 3.44 Brief Economic Profile of Ganga main stem

State	Economic issues
Uttarakhand	Essentially a religious centre, Haridwar is also known as a centre of herbal medicine, and traditional studies at Gurukul Kangri and today, Haridwar is a bustling urban centre of the new state of Uttarakhand. Tourism industry is based on these festivals and religious importance of the holy Ganges at this pious site. Livelihood of many people depends on the tourist inflow in the city of Haridwar.[26]
Uttar Pradesh	Uttar Pradesh encompasses a huge part of the superiorly fertile upper Gangetic plain which is instrumental to the predominantly agriculture based economy of Uttar Pradesh. Agriculture is the main occupation of 66 per cent of the population of the State. Use of the Ganges water for irrigation, either when the river is in flood or by means of gravity canals, has been common since ancient times. The cultivated area of the Ganges valley in Uttar Pradesh and Bihar benefits from a system of irrigation canals that has increased the production of such cash crops as sugarcane, cotton, and oilseeds (http://www.britannica.com/EBchecked/topic/ 225359/Ganges-River/48081/Economy). Fisheries along the river are also of considerable economic value and their output makes a major contribution to regional nutritional needs (http://assets.panda.org/ downloads/ mrwgangacasestudy.pdf). Lucknow, the capital of Uttar Pradesh, over the years has experienced an economic boom. And today, the city has become one of the fastest developing urban cities of India. Kanpur is the largest city of Uttar Pradesh, and is the principal industrial base of the state (http://india.mapsofindia.com/top-10-cities/in-uttar-pradesh.html).
Bihar	Agriculture is the bedrock of Bihar's economy, employing 80% of the workforce and generating nearly 40% of its gross domestic product (Bihar; Towards a development strategy, A World Bank report, http:// siteresources.worldbank.org/INTINDIA/Resources/Bihar_report_final_June 2005.pdf). Agriculture has been the sole source of wealth in Bihar. The cultivated area of the Ganges valley in Uttar Pradesh and Bihar benefits from a system of irrigation canals that has increased the production of such cash crops as sugarcane, cotton, and oilseeds (http://www.britannica.com/ EBchecked/topic/225359/Ganges-River/48081/Economy). Commercial fisheries in the Ganga River System are an important source of economic revenue for Bihar as well. The river Ganga is also the main source of

[26] www.discoverindia.net/yoga-meditation-tours.html

State	Economic issues
	electricity supply in the many parts of Bihar. The Ganga flowing through the town of Gaya in Bihar is considered to be the most auspicious and holy after Varanasi and Allahabad. Thousands of devout Hindus come to the ghats of Gaya to pray for their ancestors (http://www.holidayiq.com/states/experiences/Bihar-Hindu-Pilgrimage-Ganga-Gaya-Holiday-Experiences-Travel-Themes-5-177) Pilgrimage and the associated tourism it brings along is a major source of revenue for this religious town and its people.
Jharkhand	Ganga of Jharkhand is intrinsically linked to the economy of the state. It provides the necessary silt in much of the land around it, increasing its fertility. Paddy is the greatest crop of the region. Therefore, the significance of Ganga in the state increases manifold. Many towns in Jharkhand are primarily industrial. Ganga provides the necessary infrastructure for the factories to perform. Thus, the importance of Ganga at Jharkhand cannot be fathomed. It is not surprising that the inhabitants consider Ganga as the reigning deity and worship it with all devotion and faith.[27]
West Bengal	The Bhāgirathi-Hooghly river system is an essential lifeline for the people of West Bengal. It is through this river that the East India Company sailed in to Bengal and established their trade settlement - Calcutta, which later grew up to be one of the greatest cities of the world and capital of the erstwhile British India. People from other countries like French, Dutch, Portuguese, etc. all had their trade settlement by the banks of this river. The river provides perennial supply of water to the plain of West Bengal for irrigation and human & industry consumption. The river is navigable and the major transport system in the region with a huge traffic flow. For a long time, the Calcutta Port was the biggest port of India. Though in the past its significance had gone down, but recently it had again came up to the 3rd position in the list of Indian Ports. The fish from the river are important to the local economy. The modern container port of Haldia, on the intersection of lower Hooghly and Haldi River, now carries much of the region's maritime trade. One new port will be built in the deep sea to reduce load on Calcutta port. Hooghly river valley was the most important industrial area of erstwhile state of Bengal. Due to declining jute industry, the prime industry of this region, it lost its glory and partitioning of Bengal. But still it is one of the biggest industrial areas of India. Except Kolkata and Howrah it has number of small cities which forms the Greater Kolkata Agglomeration, the second biggest Indian city and former capital[28]

[27] moef.nic.in/downloads/public-information/Vol-1.pdf
[28] www.**westbengal**tourism.gov.in/.../dream_**river_westbengal**.html

3.2 Cultural Practices of Communities

The river Ganga is also mentioned in the Rig-Veda, the earliest of the Hindu scriptures. Hindus treat Ganga like a Goddess rather than a river and it is considered highly sacred. It is worshipped in India and holds an important place in the Hindu religion. Hindu belief holds that bathing in the river on certain occasions causes the forgiveness of sins and helps attain salvation. People travel from distant places to immerse the ashes of their kin in the waters of the Ganga; this immersion also is believed to send the ashes to heaven. Several places which lie along the banks of the river Ganga are considered sacred for Hindus, including Haridwar and Kashi.

The religious importance of the Ganges may exceed that of any other river in the world. It has been revered from the earliest times and today is regarded as the holiest of rivers by Hindus. While places of Hindu pilgrimage, called tirthas, are located throughout the subcontinent, those that are situated on the Ganges have particular significance.

Table 3.45 below describes in brief for each state the social, cultural and economic issues related to the river Ganga. It presents significance as well as the issue related to the contamination of the pious river.

Table 3.45 Cultural Profile of the States

State	General Information	Social and Cultural Significance
Uttarakhand	▪ Uttarakhand is located at the foothills of the Himalayan mountain ranges; it is largely a hilly State (93% of its total geographic area is mountainous), having international boundaries with China (Tibet) in the north and Nepal in the east. On its north-west lies Himachal Pradesh, while on the south is Uttar Pradesh. It is rich in natural resources especially water and forests with many glaciers, rivers, dense forests and snow-clad mountain peaks (http://ua.nic.in/uk.gov.in/pages/display/115-about-us). ▪ The provisional capital of	▪ Also known as Dev Bhumi, Uttaranchal is a boon for the pilgrim tourists. The Maha Kumba Mela, the Char Dham Yatra and the Kailash Mansarovar Yatra give Uttaranchal an international recognisance. The major pilgrim places include Haridwar, Rishikesh, Kedarnath, Badrinath, Gangotri, Yamunotri, Devprayag, Nandadevi and Purnagiri. Haridwar is also the second most populated district of Uttarakhand, after Dehradun (http://www.euttaranchal.com/uttaranchal/explore_uttaranchal.php).

State	General Information	Social and Cultural Significance
	Uttarakhand is Dehradun which is also a rail-head and the largest city in the region. ▪ There are 13 districts in Uttarakhand which are grouped into two divisions, Kumaon division and Garhwal division. Garhwal division comprises of 7 districts while Kumaon division has 6 districts. (http://ua.nic.in/uk.gov.in/) ▪ Garhwal, or Gadhwal, is a region and administrative division of Uttaranchal, lying in the Himalayas. It is bounded on the north by Tibet, on the east by Kumaon region, on the south by Uttar Pradesh, and on the west by Himachal Pradesh. It includes the districts of Chamoli, Dehradun, Haridwar, Pauri (Pauri Garhwal), Rudraprayag, Tehri (Tehri Garhwal), and Uttarkashi. The administrative center for Garhwal division is the town of Pauri (http://www.euttaranchal.com/culture/garhwal/).	▪ The culture of the present Kumaon, a division of Uttarakhand, is a blend of influences from the indigenous population as well as from the immigrants to this region. Consequently, the myths, dialects, languages, folk literature, festivals, fairs and forms of artistic expression are examples of the creative influences of the different cultural groups that constitute Kumaon (http://www.euttaranchal.com/culture/kumaon/). ▪ The city of Haridwar is associated as the Gateway to both Lord Shiva and Lord Vishnu, as 'Hardwar' and 'Haridwar' respectively. Haridwar is also rightfully called 'Gangadwar', as the holy river Ganga which flows down the Himalayas, enters the plains at Haridwar and spreads over the northern plains. ▪ Haridwar is among the seven sacred cities of Hindu culture in India. Hardiwar is also one of the four venues in the country for the *Kumbh Mela* and Ardh *Kumbh Mela*, held every twelve and six years respectively. Haridwar is known for its temples, bathing ghats and tanks.
Uttar Pradesh	• The state of Uttar Pradesh shares its borders with Nepal and the Indian states of Bihar, Jharkhand, Chhattisgarh, Madhya Pradesh, Rajasthan, Haryana, Uttarakhand and Delhi. • Uttar Pradesh is India's most populous state with a population of over 190 million people. The state covers total area of 243,286 km2 with population density of 792 per km2 .	• The history of Uttar Pradesh is very ancient and interesting. It is recognised in the later Vedic Age as Brahmarshi Desha or Madhya Desha. Many great sages of the Vedic times like Bhardwaja, Gautam, Yagyavalkaya, Vashishtha, Vishwamitra and Valmiki flourished in this state. Several sacred books of the Aryans were also composed here. Two great

State	General Information	Social and Cultural Significance
	• Lucknow is the administrative and legislative capital of Uttar Pradesh whereas Kanpur is the financial and industrial capital. Few other big cities of Uttar Pradesh are Meerut, Agra, Aligarh, Bareilly, Allahabad, Ghaziabad and Noida. • The 70 districts of Uttar Pradesh are clubbed under 18 divisions which are Agra, Aligarh, Allahabad, Azamgarh, Bareilly, Basti, Chitrakoot, Devipatan, Faizabad, Gorakhpur, Jhansi, Kanpur , Lucknow , Meerut, Mirzapur, Moradabad, Saharanpur, Varanasi (http://www.mapsofindia.com/maps/uttarpradesh/uttar-pradesh-district.htm). • Uttar Pradesh forms a major area of the Northern fertile plain or the Indo-Gangetic plain. • The city of Allahabad is among the largest cities of Uttar Pradesh and situated at the confluence of three rivers- Ganga, Yamuna and the invisible Saraswati. It has 8 tehsils, listed as following: Koraon, Soraon, Meja, Handia, PhulPur, Bara, Sadar, Karchhana.	epics of India, Ramayana and Mahabharata, appear to have been inspired by Uttar Pradesh (http://india.gov.in/knowindia/st_uttarpradesh.php). • In the sixth century B.C., Uttar Pradesh was associated with two new religions - Jainism and Buddhism. • Besides ancient places of pilgrimage like Varanasi, Vindhyachal, Ayodhya, Chitrakoot, Prayag, Naimisharanya, Mathura, Vrindavan, Dewa Sharief, Dargah of Sheikh Saleem Chisti in Fatehpur Sikri, Sarnath, Shravasti, Kushinagar, Sankisa, Kampil, Piprahwa and Kaushambi, places like Agra, Ayodhya, Sarnath, Varanasi, Lucknow, Jhansi, Gorakhpur, Jaunpur, Kannauj, Mahoba, Devgarh, Bithur, and Vindhyachal have rich treasures of Hindu and Islamic architecture and culture. • Nestled on the banks of the river Ganga, Kanpur stands as one of North India's major industrial centres with its own historical, religious and commercial importance. ▪ "Sangam" or "Triveni" at Allahabad, is the holy confluence of the Ganga, Yamuna and the mythical Saraswati and it is revered by millions. The biggest congregation, perhaps of the world, Kumbha Mela is held at this Sangam every twelfth year and Ardh kumbh Mela every sixth year. Magh Mela is also held at Allahabad in January during which people come in large number to have a dip in the holy Sangam. Among other

State	General Information	Social and Cultural Significance
		festivals, Ganga Mela is a unique festival that is celebrated only in Kanpur, 7 days after the festival Holi (http://india.gov.in/knowindia/st_uttarpradesh.php). The major polluting industries on the Ganga main stem in Uttar Pradesh are the leather industries, especially near Kanpur, which use large amounts of Chromium and other toxic chemical waste, and much of it finds its way into the meager flow of the Ganga. People near the river bank have developed yellow spots all over their bodies (http://ibnlive.in.com/news/kanpurs-ganga-is-an-unholy-mess/26303-3.html)
Bihar	▪ Bihar is located in the eastern part of the country. It is an entirely land–locked state, although the outlet to the sea through the port of Kolkata is not far away. Bihar lies mid-way between the humid West Bengal in the east and the sub humid Uttar Pradesh in the west which provides it with a transitional position in respect of climate, economy and culture. It is bounded by Nepal in the north and by Jharkhand in the south. The Bihar plain is divided into two unequal halves by the river Ganga which flows through the middle from west to east (http://gov.bih.nic.in/Profile/default.htm) ▪ Patna district is one of the thirty-eight districts of Bihar state, with Patna as the district headquarters. Patna district is a part of Patna division . ▪ Sub Divisions: (6 Nos) : Patna Sadar, Patna City, Barh,	▪ Chhath is an ancient Hindu festival dedicated to the worship of the Lord Sun and is mainly celebrated in the northeast region of India chiefly in Bihar, Madhya Pradesh, Uttar Pradesh, some parts of Chhattisgarh, Jharkhand on the banks of Ganga. It goes without mention that the river Ganges is one of the most important rivers of Jharkhand: the other rivers in Jharkhand flow as tributaries to the river Ganga. (http://www.mapsofindia.com/jharkhand/geography-and-history/rivers.html). ▪ Bihar finds mention in the Vedas, Puranas, Epics etc and was the main scene of activities of the Buddha and the 24 Jain Tirthankaras. ▪ The festivals in Bihar can be divided as religious festivals and Tribal Festivals. Known as the cradle of Buddhism, Bihar has an immense Hindu majority (http://www.webindia123.com/Bihar/festivals/index.html).

State	General Information	Social and Cultural Significance
	DanaPur, Masaurhi, Paliganj. Blocks: Patna Sadar, Phulwari sharif, Sampatchak, Fatuha, Khusrupur, Daniyawaan, Barh, Bakhtiarpur, Belchi, Athmalgola, Mokama, Pandarak, Ghoswari, Bihta, Maner, Danapur, Naubatpur, Masaurhi, Dhanarua, Punpun (http://www.biharonline.gov.in/Site/Content/General/Dist.aspx?typ=B&id=24&AspxAutoDetectCookieSupport=1). ▪ Bihar has a network of rivers. This is the most striking feature about the geography of Bihar. ▪ Among the rivers flowing through Bihar, the Ganges river is most dominant and is joined by the three mighty rivers, Ghagra, Gandak, and Sone. ▪ One of the most striking feature of the river system of Bihar is the dominant role of Ganga. The important rivers that join the Ganga from the north are, from west to east, Ghaghra, the Gandak, the Burhi Gandak, the Kosi, the Mahananda and its tributaries (http://www.bihardiary.com/bihar/geography.asp).	▪ The river Ganga is of great importance to Bihar. Most of its streams flow through Bihar. It has a historical importance for Bihar. The Patliputra (now Patna), which is the state capital of Bihar has been located on its banks. Other cities are also located on its banks, such as Hazipur, Munger, etc. River Ganga supports Bihar in agriculture, mostly. ▪ River Kosi also called the sorrow of Bihar is one of the largest tributaries of river Ganga. After flowing 58 km in Nepal, it enters the north Bihar plains near Bhimnagar and after another 260 km, flows into the Ganges near Kursela. The river travels a distance of 729 km from its source to the confluence with the Ganga. Kosi is prone to flood the Bihar region almost every year, hence this name "the sorrow of Bihar". ▪ Sonpur, which is situated along Ganga's bank in Bihar, is famous for the great bathing festival which is the occasion for the greatest cattle and elephant fair in the world (http://www.bihardiary.com/bihar/geography.asp).
Jharkhand	▪ It has 18 districts: Garhwa, Palamau, Lohardaga, Chatra, Hazaribagh, Kodarma, Bokaro, Giridih, Deogarh, Dhanbad, Dumka, Pakaur, Godda, Sahibganj, Ranchi Gumia, West Singhbhum, East Singhbhum ▪ In Jharkhand, the river passes through Sahibganj and Rajmahal. ▪ More than 80 km of the river Ganga flows through Jharkhand. ▪ Wastes generated by towns in	▪ Ganga played a very important role in the formation of the very structure of Jharkhand. It can be said to be the very source of the riverine civilization that grew around the Gangetic plains. Ganga divides, what was previously, Bihar into two clear halves. The Southern part became Jharkhand and the Northern part remained Bihar. Because of the fertile lands that it creates through its silt

State	General Information	Social and Cultural Significance
	Sahibganj, cremation of bodies on the riverbank, industrial and mining waste are the major polluters. ▪ While the population of Sahibganj is about five lakh, that of Raj Mahal is about 50,000.	deposits, Ganga in Jharkhand is appropriately revered and respected by the inhabitants of the state. The districts that are lined by the Ganga in its course are Sahebganj, Bokaro and Hazaribagh. (http://www.mapsofindia.com/jharkhand/geography-and-history/ganga.html). ▪ River Ganga girdles the state, which lies in its lap, as it flows across the region. Situated on the right bank of the river Ganges, Rajmahal is a small but historically important town. It was the seat of Government during the Mughal period when Raja Man Singh, general of Emperor Akbar made Rajmahal the capital of Bengal in 1592. Even today relics of the old and prosperous Rajmahal are visible in this one time capital of Bengal (http://sahibganj.nic.in/tourism.htm).
West Bengal	▪ West Bengal is now divided into nineteen districts under three divisions. ▪ The urban agglomeration of Kolkata comprises 72 cities and 527 towns and villages.[47] The suburban areas of Kolkata metropolitan district incorporates parts of the districts North 24 Parganas, South 24 Parganas, Howrah, Hooghly and Nadia. ▪ The river Ganga was an important transportation channel in the early history of Bengal, and later with the colonial trading ports. The river's presence is one of the reasons chosen by the British to settle there at Calcutta. The Dutch/French colony at Chandannagar on the Hooghly	▪ Ganga Sagar Mela, also known as Ganga Dussehra Mela is held in the month of January, on the occasion of Makar Sankranti at Sagardwip, about 105 km. south of Kolkata. Sagardwip is the island situated at the mouth of Ganga where the Hooghly river joins the sea. This is the largest fair of the West Bengal and celebrated for three days. On this day, a large number of Hindu pilgrims collect here and take bath in the holy waters and visit the Kapil Muni Temple. (http://www.indovacations.net/english/BengalFestival.htm) ▪ Like the rest of the Ganges, the Bhāgirathi-Hooghly is considered sacred to Hindus, and its water is considered holy. ▪ About 150 large industrial plants

State	General Information	Social and Cultural Significance
	was once the rival of British Calcutta, but was eclipsed by Calcutta in the colonial wars of the 18th century. The river banks hosted several battles and skirmishes towards the start of the colonial era, including the Battle of Plassey Palashi, as well as earlier wars against Maratha raiders. On eastern bank lie many historic and wealthy towns like Murshidabad, Jangipur and Ziaganj.	are lined up on the banks of the Hooghly River around Kolkata. Together, these plants contribute 30 percent of the total industrial effluent reaching the mouths of the Ganga. Of this, half comes from pulp and paper industries, which discharge a dark brown, oxygen-craving slurry of bark and wood fiber, mercury and other heavy metals which accumulate in fish tissues, and chemical toxins like bleaches and dyes, which produce dioxin and other persistent compounds. ▪ CNN-IBN-Outlook State of the Environment Poll has found that 77 per cent people have voted cleaning of rivers by government as the top priority. The findings are especially significant in Kolkata as its main river Hooghly is congested with solid waste and effluents. It is said that the character of a city is best judged by how well it maintains its sea or river front. ▪ Several bridges run over the Hooghly at Kolkata – Howrah Bridge, Vidyasagar Setu, Vivekananda Setu, Nivedita Setu (second Vivekananda Bridge), Jubilee Bridge(chinsurah) and Iswar Gupta Setu (chinsurah).

3.2.1 Fest and Festivals

Most of the places along the Ganga main stem witness festivals through out the year. Ther major ones are Kumbh festival which takes place on Allahabad and Haridwar. Fest and Festivals happening at the ghats and river basin at different time periods of the year attracts millions of tourist and pilgrimages. With improper sanitation facilities and poor river front management, these activities add to the load of contamination in the river thus degrading the river water quality. The pious refuses and the customs of disposing unburnt and partially burnt increase the woes of water

quality of the Ganga main stem. The beliefs of people are tied with the sacredness of the Ganges, and over the years it is growing in terms of the people coming during these festivals. The Allahabad witnessed around 13 million pilgrims in 1977 and over 18 million in 1989 and then 60 million in 2001 during Mahakumbh, a major festival along the Ganga. [29]

Special provision of sanitation facilities should be arranged during the festivals when thousands of pilgrims visit holy places along the banks to take dip in sacred river. At present the facility of sanitation for pilgrims is not up to the mark. Better management of the basin with proper facilities should happen in coordination with the local communities.

Plate 3.8 Festivals at Ganga Ghat

[29] **(www.kumbhmela.net/).**

3.2.2 Sanitation

Less than 50 % of households in all the states have bathrooms in their households; especially the scenario is very poor in rural areas. Majority of the households in all the states have no access to the toilets. The figures presents that rural areas in the states have lack of basic amenities and infrastructure related to sanitation. Poor sanitation, open defecation are important factors contributing to the pollution of water. Some of the cultural beliefs in people don't permit them to use toilet, they prefer going out for defecation generally near the drains. Table 15 and 16 in the previous section reflects on the status of households having access to bathrooms, toilets and connection to drains. The results are not promising and it is severely affecting the water quality of Holy Ganges.

With the rising awareness communities have started understanding the importance of river water quality and how poor quality can affect their health also. But still, large section of society needs to be trained about the environmental and economical significance of the river water, besides social and cultural significance.

3.3 Vulnerable Communities

Society is witness of the poor development and indiscrimination cause against the marginalized sections of the society generally classified as 'Scheduled Tribes'. As identified by the demographic tables all the five states have tribal population, which are regarded as the indigenous group. Jharkhand has the maximum number of ST natives living in the state. Table below describes the number of different scheduled castes and scheduled tribes residing in major districts of all the five states of Ganga main stem.

Table 3.46 SC and ST Population in the Major Districts of the Main Stem States

Site	Scheduled Castes (SC)	Scheduled Tribes (ST)
Jharkhand (District Sahibganj)	Total: 59,750 Chamar etc: 12,030 Dusadh etc: 9,960 Rajwas: 6,731	Total: 270,423 Santhal: 205,209 Mal Pahariya: 20,020 Sauria Paharia: 16,298
West Bengal (Kolkata)	Total: 274,835 Namasudra: 60,912 Pod etc.: 40,756 Chamar etc. 37,157	Total: 9 ,810 Generic Tribes: 1,989 Santal: 1,967 Oraon: 1 ,351

Site	Scheduled Castes (SC)	Scheduled Tribes (ST)
Bihar (Patna)	Total: 729,988 Dusadh etc.: 277,756 Chamar etc.: 199,423 Pasi: 93,200	Total: 9 ,236 Oraon: 2,341 Munda: 1,889 Gond: 1 ,556
Uttarakhand (Haridwar)	Total: 313,976 Chamar etc.: 268,489 Balmiki: 24,360 Generic Castes: 4,231	Total: 3, 139 Buksa: 2,890 Generic Tribes: 122 Bhotia: 64
Kanpur Dehat	Total: 685,809 Chamar etc.: 304,424 Kori : 95,008 Pasi : 89,895	Total : 2, 051 Tharu : 1,248 Generic Tribes : 433 Buksa : 237
Kanpur Dehat	Total: 388,419 Chamar etc.: 234,591 Kori : 44,780 Dhanuk : 37,732	Total : 382 Tharu : 267 Generic Tribes : 111 Raji : 4
Uttar Pradesh Allahabad	Total: 1,065,097 Pasi etc.: 412,466 Chamar etc.: 402,347 Kol: 106,164	Total: 4, 273 Generic Tribes: 3,322 Tharu: 870 Jaunsari: 57

Source: Census of India 2001

3.3.1 Health indicators in Five States

As per the Ministry of Health and Family Welfare, Government of India,

- Health indicators of West Bengal show that the Total Fertility Rate of the State is 1.9. The Infant Mortality Rate is 35 and **Maternal Mortality Ratio is 141** (SRS 2004 - 2006) which are lower than the National average.

- Health indicators of Uttar Pradesh indicate that the Total Fertility Rate of the State is 3.8. The Infant Mortality Rate is 67 and **Maternal Mortality Ratio is 440** (SRS 2004 - 2006) which are higher than the National average.

- Health indicators of Uttarakhand depicts that the Total Fertility Rate of the State is NA. The Infant Mortality Rate is 44 and **Maternal Mortality Ratio is 440** (SRS 2004 - 2006) which are higher than the National average.

- Health indicators of Bihar reflect that the Total Fertility Rate of the State is 3.9. The Infant Mortality Rate is 56 and **Maternal Mortality Ratio is 312** (SRS 2004 - 2006) which are higher than the National average.

- Health indicators of Jharkhand infer that the Total Fertility Rate of the State is 3.2. The Infant Mortality Rate is 46 and Maternal Mortality Ratio is 312 (SRS 2004 - 2006) which are higher than the National average.

Maternal mortality ratio also indicates that women are not given proper care and their chances of development are also very poor.

Table 3.32 in the previous section also indicates that in West Bengal more number of females are getting diarrhea as compared to males and hence more females are dying because of diarrhea as compared to men. This could be attributed to poor sanitation facilities available to women in the society.

Thus women and indigenous people are the most vulnerable groups who are deprived of education, proper health facility and basic needs like access to safe drinking water and proper sanitation

Moreover proper education to these groups can help in better community sensitization for the issues related to maintaining river health and water quality. Educated mothers help in educating children better, and educated children are the torch bearers of the future, who can bring significant changes. Health and educated females and indigenous group is important to bring about any change in the river basin.

3.4 Key Stakeholders

Table 3.47 Identified Key Stakeholders

S No	State	Key stakeholders identified
1	Uttarakhand	Government officials including representatives from Uttarakhand Payjal Nigam, PHED, ward members
		Research institutes like IIT Roorkee, WWF-India, G.B. Pant Institute of Himalayan Environment and Development
		NGOs and CSOs like People's Science Institute, Dehradun, Disha Foundation, Shree Hari Ganga Samiti, Samaj Sewa Sansthan, Dharam Gramin Uthan Sansthan, Himalayan Orginasation For Progress And empowerment
2	Uttar Pradesh	Government officials including representatives from Ganga Pollution Control Unit, U.P Jal Nigam, U.P Jal Nigam, PHED

		Research institutes like IIT Kanpur, WWF-India
		NGOs and CSOs like Ganga Sewak Samaj - Allahabad, Maa Shakuntla Devi Shikhsha evam Vikas Samiti, Kanpur, Eco Friends Kanpur,
3	Bihar	Government officials including representatives from Urban Development Department, PHED, ward members
		Research institutes like WWF-India, Centre for Flood Management Studies (National Institute of Hydrology)
		NGOs and CSOs like Institute of Environment and Eco Development, Centre for Environment Education
4	Jharkhand	Government officials including representatives from Urban Development Department, PHED, ward members
		Research institutes like WWF-India
		NGOs and CSOs like Krishi Gram Vikas Kendra
5	West Bengal	Government officials including representatives from Urban Development Department, PHED, ward members
		Research institutes like IIT Kharagpur, WWF-India, Calcutta University, Indian Institute of Bio-Social Research and Development, Indian Institute of Environmental Studies and Wetland Management
		NGOs and CSOs like Peoples Green Society, Ramakrishna Mission

The key stakeholders insisted on the important fact of coordination amongst all the important stakeholders at different levels to ensure proper and sustainable implementation of various projects. Management of the river is a joint and coordinated responsibility; hence transparency and proper coordination is necessary.

3.5 Key social and cultural issues

Ganga is an issue of national importance it is a national heritage and all the concerned stakeholder should work jointly to make Ganges pollution free. Many Hindus keep water from the Ganga in glass bottles as a sacred relic, or for use in religious ceremonies. The river becomes the final resting place for thousands of Hindus, whose cremated ashes or partially burnt corpses are placed in the river for spiritual rebirth. Cultural aspects like celebrating festivals can be well managed through development of better river front development project. All the states should coordinate their

activity. Upstream states should be responsible in their activities which might impact the water received by downstream states through the river flow.

Some of the key issues identified by the stakeholders are ;

- Involvement of community in all the projects related to River Ganga.
- Making Ganga pollution free and maintaining minimum environment flows in the river.
- Environment benign cultural rituals and practices on banks of Ganga
- Maintaining minimum water quality and quantity of the river for meeting community requirements
- Provision of basic amenities like safe drinking water and proper sanitation facilities to the communities especially women and children.
- Inclusion of social development plan with the emphasis on vulnerable group in the portfolio of projects.
- Planning project by taking future socio-economic scenarios well into consideration
- Community monitoring of disposal of any kind of refuse into the river water
- Creating mass awareness through different medias like street plays, advertisements etc and using school children as a vehicles of change

Plate 3.9 Disposal of pious refuse into the river water

Chapter 4

Sources of Pollution in Ganga

4.1 General

The economic significance of river Ganga and its religious and cultural value demand that sustained efforts be made to preserve the river water quality. The river provides water for domestic, industrial and agricultural use to the numerous settlements along its course, and is used by millions of people for their cultural and spiritual needs, including ritual bathing and other religious practices. Protecting the river water quality from sources of pollution is therefore essential not only for maintaining its designated best use along different stretches but also for assuring the ecological sustainability of the riverine system.

Increasing population, urbanization, industralisation, and the use of agricultural chemicals, continue to pose a significant threat to water quality in the Ganga basin today. Among the major sources of pollution are both point sources such as domestic and industrial wastewater discharges; and non-point sources such as run-off from agricultural fields and uncontrolled solid waste dump sites, and river front activities like dhobi ghats, cremation grounds, bathing ghats, sacred offerings and other rituals.

The population and urban pressures are evident from the fact that the urban population in the Ganga basin has increased from 88 million in 1991 to 125 million in 2001 (a growth of about 42 percent in a decade). As shown in Table 4.1, 27 percent of the urban population in the basin resides in Uttar Pradesh and Uttarakhand, followed by 17% of the population in West Bengal. Detailed information on population of class I and class II cities in the Ganga basin is presented in Appendix 3.1. Major cities located along the mainstem of the Ganga include Rishikesh, Haridwar, Kannauj, Kanpur, Allahabad, Varanasi, Patna, Howrah and Kolkatta.

Table 4.1 Distribution of Towns and Cities in Ganga basin

S. No.	State	Total Number of Towns and Cities in 2001	Total Population in 2001	Per cent of Total Population in Basin	Number of Class I and Class II Cities in Year 2001	Class I and Class II Cities Population in Year 2001
1	Haryana	97	6115304	4.8	25	4790801
2	Uttar Pradesh & Uttarakhand	670	34539582	27.0	106	24908554
3	Bihar & Jharkhand	215	14675541	6.8	51	11031546
4	West Bengal	239	22427251	17.6	43	19704870
5	Rajasthan	216	13214375	20.8	46	9402940
6	Madhya Pradesh incl. Chattisgarh	452	20152892	12.5	64	13791699
7	Himachal Pradesh	56	595581	0.5	1	144975
8	Delhi	4	12905780	10.1	1	12877470
	Ganga basin	1949	124626306	100	337	96652855

Source: Census 2001

The following sections briefly present an analysis of the pollution sources of significance in the Ganga basin.

4.2 Point Sources of Polution

4.2.1 Domestic wastewater discharges

Water consumption in the basin for domestic and industrial purposes has a direct impact on the river water quality, as a large proportion of the wastewaters from urban areas are discharged directly into the Ganga River and its tributaries. As presented in Table 4.2, the 232 Class I cities and 149 Class II cities in the Ganga basin are supplied about 19000 MLD and 1300 MLD of water respectively.

The total water supply in the five states in the main stem accounts to about 10,600 MLD in Class I cities (about 55 percent of the total) and 900 MLD (about 69 percent of the total) in Class II cities. Considering the fact that the population coverage is only about 3-6% in these states (excluding West Bengal), and the per capita supply is below the norms in many cities, the water supply volumes are expected to increase further, as many ongoing urban infrastructure development programs are expected to improve the water supply situation in these states.

With regards to the wastewater generatation, information is available for about 179 class I cities and 147 class II cities of the Ganga basin. As presented in Table 4.3, 36 class I cities and 14 class II cities discharge their wastewater directly into the Ganga river and 113 class I cities and 18 class II cities discharge the wastewater into the tributaries of the Ganga. The remaining 30 class I cities and 115 class II cities have land disposal.

Table 4.2 Water Supply in Class I and class II Cities in the Ganga basin

State/UT	No. of Cities	Municipal Population in Year 2008	Water Supply (MLD)	No of Cities in Different Categories of Per Capita Water Supply (lpcd)				Percent Population covered by Organised Water Supply
				<100	Between 100-200	Between 200-300	>300	
Class I cities								
Bihar & Jharkhand	37	10747725	2300.25	-	11	26	-	3%
Delhi	1	14701150	4346	-	-	1	-	100%
Haryana	20	5494110	783.39	2	16	1	1	12%
Himachal Pradesh	1	163490	36.18	-	-	1	-	-
Madhya Pradesh	25	10795000	1560.91	10	14	1	-	41%
Rajasthan	24	9611490	1727.96	9	14	1	-	20%
Uttar Pradesh & Uttarakhand	65	26346330	4613.8	7	52	5	1	6%
West Bengal	59	19699751	3702.6	17	38	1	3	56%
Ganga basin	232	97559046	19071.1					
Class II cities								
Bihar & Jharkhand	24	1940100	232.04	-	24	-	-	2%
Haryana	7	544040	49.68	7	-	-	-	10%
Madhya Pradesh	23	1745050	163.64	18	4	1	-	31%
Rajasthan	21	1599260	184.76	18	2	-	1	47%
Uttar Pradesh & Uttarakhand	47	3451980	443.53	3	44	-	1	23%
West Bengal	27	2004440	225.56	4	21	2	-	35%
Ganga basin	149	11284870	1299.21					

Source: Status of water supply, wastewater generation and treatment in class-I cities and class-II towns of India, CPCB, 2010

In terms of volume, the 179 class I cities generate about 11100 MLD of wastewater, and the 147 class II cities generate about 1000 MLD of wastewater. Overall, nearly 2760 MLD of wastewater is being generated by class I and class II cities discharging directly into the river Ganga.

The city-wise wastewater generation data for class I and class II cities discharging directly into the river Ganga is presented in Table 4.4 below. As seen from the Table, 23 class I cities of West Bengal generate 47 percent (about 1300 MLD), and 7 class I cities of Uttar Pradesh generate 30 percent (about 835 MLD) of the total sewage generated by cities discharging into the Ganga.

Table 4.4 also shows the wide gap that exists in the wastewater generation and available treatment capacity. Out of the 36 class I cities discharging wastewater into the Ganga, only 7 are fully covered, whereas 8 do not have any treatment capacity and of the remaining 21, only 10 cities have more than 50% treatment capacity coverage. Among the class II cities, 11 out of 14 are discharging wastewater into the Ganga river without treatment.

Review of city-wise data further reveals that the highest generators of domestic wastewater along the river Ganga are Kolkatta (618 MLD), Kanpur (339 MLD), Patna (249 MLD), Allahabad (208 MLD), Varanasi (187 MLD), Howrah (136 MLD). The sewage generation in the remaining cities is below 100 MLD. The gap in treatment capacity is also maximum in Kolkatta (446 MLD), Kanpur (168 MLD), Patna (180 MLD), Allahabad (119 MLD) and Howrah (72 MLD). Although sewage generation in Varanasi is more than the remaining cities, Bhagalpur and Maheshtal have a higher treatement capacity gap, that is, 50 and 48 MLD respectively, as compared to 46 MLD for Varanasi.

When carrying out an assessment of point sources of pollution such as domestic wastewater, attention also must be given to cities and towns of pilgrimage and cultural significance that may not figure as the highest sewage generators. For example, towns such as Rishikesh and Haridwar are of great religious significance. Of these, Haridwar is a class I city with sewage generation of 39.6 MLD and a treatment capacity gap of 21 MLD, wheareas Rishikesh is a class II town with sewage generation of 10.7 MLD and treatment capacity of 6.3 MLD. Wastewater generation data for class I and class II cities discharging into the tributaries of the Ganga and on land is given in Appendix 4.2.

Table 4.3 Municipal Wastewater Generation and Mode of Disposal in the Ganga basin

S. No.	State/UT	No. of Cities	Municipal Population	Total Volume of Waste Water Generated (MLD)	Wastewater generation (MLD) and mode of disposal			No. of Cities with Various Mode of Disposal		
					Ganga River	Other Rivers (Tributaries)	Land	Ganga River	Other Rivers (Tributaries)	Land
A	**Class I cities**									
1	Bihar & Jharkhand	24	7399891	1045.6	376.5	562.8	106.3	4	16	4
2	Haryana	18	4952990	389.6	-	250.3	139.3	-	8	10
4	Madhya Pradesh	18	8415820	898.9	-	877.4	21.5	-	17	1
5	Rajasthan	7	5148920	696.5	-	313.3	383.2	-	5	2
6	Uttar Pradesh & Uttarakhand	55	25620720	3017.5	950	2051.3	16.2	9	45	1
7	West Bengal	56	19422911	2197.2	1311.3	644.7	241.2	23	21	12
8	Delhi	1	14858800	2948	-	2948	-	-	1	-
	Ganga basin	179	85820052	11193.3	2637.8	7647.8	907.7	36	113	30
B	**Class II cities**									
9	Bihar & Jharkhand	27	2354872	191.6	30.7	14.8	146.1	4	2	21
10	Haryana	2	180550	10.1	-	-	10.1	-	-	2
11	Madhya Pradesh	18	1513530	124.1	-	40.4	83.7	-	5	13
12	Rajasthan	13	1460740	122.5	-	37.5	85	-	6	7
13	Uttar Pradesh & Uttarakhand	59	4621792	411.1	85.2	36.5	289.4	9	4	46
14	West Bengal	28	2095384	164.3	6	5.3	153	1	1	26
	Ganga basin	147	12226868	1023.7	121.9	134.5	767.3	14	18	115

Source: Status of water supply, waste water generation and treatment in class-I cities and class-II towns of India, CPCB, 2010

Table 4.4 Wastewater Generation and Treatment Capacity for Class I and Class II Cities discharging Wastewater into Ganga River

Class I cities

S. No.	City/Town	State/UT	Population	Total Sewage generation (in MLD)	Treatment Capacity (in MLD)	Percentage covered	Treated sewage Disposal
1	Bhagalpur	Bihar	381190	61.6	11	18	Ganga river basin
2	Patna	Bihar	1542184	249.2	109	44	Ganga river basin
3	Munger	Bihar	209790	34	13.5	40	Ganga river basin
4	Katihar	Bihar	196190	31.7	31.7	100	Ganga river basin
5	Kanpur	Uttar Pradesh	3114530	339.3	171.1	50	Ganga river basin
6	Varanasi	Uttar Pradesh	1353920	187.1	141	75	Ganga river basin
7	Allahabad	Uttar Pradesh	1218070	208	89	43	Ganga river basin
8	Farrukhabad-cum-Fatehgarh	Uttar Pradesh	280290	30.5	8.3	27	Ganga river basin
9	Mirzapur-Vindhyachal	Uttar Pradesh	252470	27.5	14	51	Ganga river basin
10	Unnao	Uttar Pradesh	178250	23.9	19.4	81	Ganga river basin
11	Ballia	Uttar Pradesh	125740	18	-	0	Ganga river basin
12	Dehradun	Uttarakhand	550800	76.1	-	0	Ganga river basin
13	Hardwar	Uttarakhand	215260	39.6	18	45	Ganga river basin
14	Kolkata	West Bengal	5267630	618.4	172	28	Ganga river basin
15	Haldia	West Bengal	196300	24.5	24.5	100	Ganga river basin
16	Santipur	West Bengal	158920	18.7	18.7	100	Ganga river basin
17	Nabadwip	West Bengal	132290	15.5	10	65	Ganga river basin
18	Basirhat	West Bengal	130090	15.3	-	0	Ganga river basin
19	Bangaon	West Bengal	117430	13.8	-	0	Ganga river basin
20	South Dumdum	West Bengal	450970	53	52.9	100	Ganga river basin
21	Rajpur Sonarpur	West Bengal	386850	33.6	45.4	100	Ganga river basin
22	Kamarhati	West Bengal	361480	48.8	40	82	Ganga river basin
23	North Dumdum	West Bengal	253040	29.7	-	0	Ganga river basin
25	Ulberia	West Bengal	232410	27.3	24	88	West Bengal
26	Kanchrapara	West Bengal	145040	17	-	0	Ganga river basin
27	Halisahar	West Bengal	143150	16.8	-	0	Ganga river basin
28	North Barrackpur	West Bengal	142050	19.2	16.7	87	Ganga river basin

29	Rishra	West Bengal	130250	13.5	15.3	100	Ganga river basin
30	Ashoknagar Kalyangarh	West Bengal	128200	17.3	15	87	Ganga river basin
31	Haora	West Bengal	1160010	136.2	63.9	47	Ganga river basin
32	Bhatpara	West Bengal	508250	59.7	28.5	48	Ganga river basin
33	Maheshtala	West Bengal	447600	52.5	3.9	7	Ganga river basin
34	Serampore	West Bengal	227650	26.7	18.9	71	Ganga river basin
35	Chandannagar	West Bengal	186490	16.1	22.7	100	Ganga river basin
36	Habra	West Bengal	146850	17.2	-	0	Ganga river basin
	Total		2,09,19,384	2637.7	1174.4		

Class II cities

S. No.	City/Town	State/UT	Population	Total Sewage (in MLD)	Treatment Capacity (in MLD)	Percentage Covered	Treated Sewage Disposal
1	Buxar	Bihar	82975	7.6	2	26	Ganga river basin
2	Sitamarhi	Bihar	56769	6.5	-	0	Ganga river basin
3	Begusarai	Bihar	93378	8.6	-	0	Ganga river basin
4	Mokameh	Bihar	56400	8	-	0	Ganga river basin
5	Najibabad	Uttar Pradesh	79087	7.6	-	0	Ganga river basin
6	Bijnor	Uttar Pradesh	79368	7.6	8.1	100	Ganga river basin
7	Mughalsarai	Uttar Pradesh	88386	16	-	0	Ganga river basin
8	Ghazipur	Uttar Pradesh	95243	10.7	-	0	Ganga river basin
9	Kannauj	Uttar Pradesh	71530	7	-	0	Ganga river basin
10	Deoband	Uttar Pradesh	81706	7.8	-	0	Ganga river basin
11	Gangaghat	Uttar Pradesh	70817	6.8	-	0	Ganga river basin
12	Rishikesh	Uttarakhand	59671	10.7	6.3	59	Ganga river basin
13	Roorkee	Uttarakhand	97064	11	-	0	Ganga river basin
14	Ranaghat	West Bengal	68754	6	-	0	Ganga river basin
	Total			122	16.4	13	Ganga river basin

Source: Status of water supply, waste water generation and treatment in class-I cities and class-II towns of India, CPCB, 2010

4.2.2 Industrial Wastewater

According to a recent survey by CPCB, there are 478 grossly polluting industries in the Ganga basin, discharging effluent BOD of 100kg/ day or more into the Ganga river and its tributaries. Presently, 155 grossly polluting industries are identified on the main stem of the river Ganga. These industries contribute about 20% of the total pollution load by volume; however their impact on river water quality is much greater due to the higher strength of the industrial wastewaters. As shown in Table 4.5, 95 of these units have effluent treatment plants (ETPs) operating satisfactorily, 22 have ETPs that were not operating satisfactorily, and 38 have closed down.

Table 4.5 Details of Grossly Polluting Industries discharging Effluent in to Ganga and its tributaries

as on September 2009

Rivers	Status of Effluent Treatment Plants			
	Operating satisfactorily	Not operating satisfactorily	Unit closed	Total
Betwa	0	1	0	1
Chambal	0	0	0	0
Damodar	3	0	0	3
Gandak	0	0	0	0
Ganga	95	22	38	155
Ghaghra	2	0	1	3
Gomti	21	5	4	30
Hindon	26	0	4	30
Kali	45	0	10	55
Khan	0	0	0	0
Kosi	1	3	0	4
Kshipra	0	0	0	0
Ramganga	30	17	4	51
Yamuna	125	8	13	146
Total	348	56	74	478

Source: MoEF

Industries in the Ganga main stem also generate significant quantities of hazardous waste. As shown in Table 4.6, the hazardous waste generation in districts located along the Ganga mainstream is 109357 MTA. If this waste finds its way into the river due to improper handling and management, it could be highly toxic to humans and aquatic organisms and significantly affect the ecology of the river.

Table 4.6 Hazardous Waste from Industries in District along River Ganga

S. No.	State/Districts	Hazardous Waste Generation in MTA			
		Land Disposable Waste	Incinerable Waste	Recyclable Waste	Total Waste
Uttar Pradesh					
1	Kanpur & Kanpur Dehat	14471	499	0	14971
2	Farrukhabad	0	0	0	0
3	Kannauj	0	0	0	0
4	Allahabad	46	0	5414	5460
5	Mirzapur	697	0	2112	2809
6	Fatehpur	860	0	19844	20704
7	Saharanpur	878	16	23000	23894
8	Bulandshahar	483	10	53	546
9	Varanasi	9	0	6	15
10	Ghajipur	0	0	200	200
11	Ajamgarh	0	2	0	2
12	Ballia	1	2	0	3
13	Raebareli	1	1885	593	2479
14	Bijnor	126	27	10	163
	Total	17572	2441	51232	71246
West Bengal					
15	24 Pgs (N)	776	7500	28	776
16	24Pgs (S)	24301	1407	67	24301
17	Hooghly	7329	551	333	7329
18	Howrah	2287	7324	258	2287
19	Malda	-	-	11	-
	Total	34693	16782	686	34693
Bihar					
20	Begusarai	2790	8	-	2798
21	Munger	-	2	5	7
22	Bhagalpur	-	21	-	21
23	Patna	556	33	-	589
24	Katihar	-	2	-	2
25	Vaishali	1	0	-	1
	Total	3347	66	5	3418
	Jharkhand	NA	NA	NA	NA
	Uttarakhand	NA	NA	NA	NA
	Ganga main stem	55612	19289	51923	109357

Source: National inventory of hazardous waste generating industries & hazardous waste management in India, CPCB, 2009

4.3 Non-Point Sources of Pollution

4.3.1 Agricultural Sources

Besides municipal and industrial wastewater, another source of pollution in the Ganga basin is the application of agricultural chemicals such as fertilizers, and pesticides. As discussed in the previous chapter, the Ganga basin states consume nearly 10 million tonnes of chemical fertilizers per year, which constitutes 45 percent of the total chemical fertilizer consumption in the country. Of this, Uttar Pradesh alone consumes 38% of the fertilizer used. The problem with such intensive use of fertilizer is that agricultural runoff into surface water bodies may carry high levels of nitrogen and phosphorus. It has been estimated that 10 to 15 per cent of the nutrients added to the soils through fertilizers eventually find their way to the surface water systems. Runoff from arable lands may contain nitrogen up to 70 mg/l and phosphorus ranging from 0.05 to 1.1 mg/l, with potential to raise the nutrient level to a considerable degree in stream waters.

Similarly, pesticide consumption in the Ganga basin states is about 21,000 tonnes per year (47.6% of the total pesticide consumption in the country). Although the quantity of pesticides used is much less than the total amount of the chemical fertilizers used, pesticides are highly toxic and chemically more stable than the fertilizer residues. Pesticide residues in water, even in trace(s), could potentiallty affect human health adversely when used as a drinking water source. Presence of pesticides in water even at trace levels is highly toxic to aquatic fauna.

Unfortunately, the available data relating to the pesticide and nutrient levels in the Ganga water are not sufficient to draw any definitive conclusions at present; however, given the extensive use of agricultural chemicals in the region, a continued focus and further study in this area is warranted.

4.3.2 Municipal Solid Wastes

Cities along the river Ganga, as elsewhere in India, are unable to cope with the increasing levels of solid waste generation. Inadequate collection and disposal results in numerous uncontrolled dump sites, and solid wastes

can be seen strewn along the bathing ghats of the river. Runoff from these solid waste dumps constitutes another significant source of river pollution.

Table 4.7 provides information on solid waste generation and mode of disposal in five major cities along the river Ganga. As seen from the Table, Kolkatta produces the maximum quantity of waste (2653 TPD). None of these major cities have any waste processing facilities. The number of landfill sites is presented in Table 4.8. No sanitary landfills exist, though, in any of these cities, although new sites are proposed in some cases.

Table 4.7 Waste Generation and Status of Implementation of MSW (Management & Handling) Rules, 2000 in Cities along River Ganga

S.No.	Name of City	Population (as per 2001 census)	Area (sq. km.)	Waste Quantity (TPD)	Waste Generation Rate (Kg / c/d)
Cities having Population between 5-10 lakhs					
1	Allahabad	9,75,393	71	509	0.52
2	Varanasi	10,91,918	80	80	0.39
3	Patna	13,66,444	107	511	0.37
4	Kanpur	25,51,337	267	1100	0.43
5	Kolkata	45,72,876	187	2653	0.58

Source: Assessment of status of municipal solid waste management in metro cities and state capitals, CPCB, 2006

Table 4.8 Landfill Sites in Cities along River Ganga

S. No.	Name of City	No. of Landfill Sites	Area of Landfill (ha)	Life of Landfill (Years)	New Site Proposed
1	Patna	-	-	-	Yes
2	Allahabad	2	-	-	No
3	Varanasi	1	2.00	-	Yes
4	Kanpur	1	27.00	-	No
5	Kolkata	1	24.70	35	Yes

- Data not available

Source: Assessment of status of municipal solid waste management in metro cities and state capitals, CPCB, 2006

4.3.3 Other non-point sources

Other non-point sources which need consideration are river front activities such as on dhobi ghats, cremation grounds, and numerous ghats where religious bathing and other rituals are performed. Dumping of carcasses into the river and open defecation also affect the water quality. The issues pertaining to these are often closely tied with the social and cultural fabric and therefore need to be addressed in a manner that preserves the sacred practices while improving the environmental conditions on the river front.

4.4 Government Initiatives in Pollution Abatement

Recognizing the critical need to address pollution in the river Ganga, the GOI launched the Ganga Action Plan (GAP) in the year 1985, with objectives to abate pollution from point as well as non-point sources and thus to improve the water quality in river Ganga. The main focus of GAP I was on interception, diversion, and treatment municipal sewage draining into the river. In addition to the core works relating to sewerage and sewage treatment, non-core works like afforestation, crematoria, low cost sanitation and river front development, were also taken up. The plan was later extended to Ganga Action Plan Phase II (launched in 1993). Besides the Ganga, GAP II included its major tributaries viz. Yamuna, Gomti, Damodar and Mahananda.

As shown in Table 4.9, under the Ganga Action Plan (Phase I & II), the target was to install a cumulative sewage treatment plant capacity of 1098 MLD. Out of this, 1017 MLD has been installed in the five GAP states, namely Bihar, Jharkhand, Uttar Pradesh, West Bengal and Uttarakhand.

Table 4.9 Target and STP Capacities installed under Ganga Action Plan

S. No.	State	Phase	STP Created (MLD)		Cost (Rs. Lakh)	
			Target	Actuals	Actual	Completion Cost
1	Bihar	GAP I	111	111	1467.18	1420.38
		GAP II	24.5	11	434.44	184.7
2	Jharkhand	GAP I	–	–	–	–
		GAP II	–	–	–	–
3	Uttar Pradesh	GAP I	349.5	349.5	9367.6	9701.35
		GAP II	80.67	35.56	2536.28	2079.7
4	West Bengal	GAP I	376.6	372.6	7179.99	6913.79
		GAP II	117.34	108.47	2435.25	1584.36
5	Uttarakhand	GAP I	24.33	24.33	857.6	921.88
		GAP II	13.95	4.17	473.49	27.06
	Total		1097.89	1016.63	24751.83	22833.22

The estimated sewage generation / projections, treatment capacity created and/or proposed to be created under different schemes in the six major cities of GAP states are given in Table 4.10. It can be seen from the table that the STP capacity in these six cities is 664 MLD, which constitute only 52% of the total needed capacity as of 2008. Even if all the projects considered under Jawaharlal Nehru National Urban Renewal Mission (JNNURM) become operational – a very unlikely prospect – the STP capacity created would still be inadequate to meet the needs of these cities beyond 2010 and therefore these cities will continue to discharge untreated sewage in River Ganga.

Table 4.10 Sewage Generation, Treatment Capacity Created / Proposed in Six Selected Towns of GAP-I

S. No.	State	City / Town	Sewage Generation (MLD)				Treatment Capacity Created so far Under GAP I& II (MLD)	Treatment Capacity Being Created Under GAP II (MLD)	Treatment Capacity Under JNNURM (MLD)
			1985	2008	2010*	2020*			
1	Uttarakhand	Rishikesh, Haridwar	24.33	65	75	94	28.5	43	–
2	Uttar Pradesh	Kanpur	205	400	411	555	171	–	268 (Sanctioned)
3	Uttar Pradesh	Allahabad	110	210	213	242	89	–	60 (Projects under consideration of MoUD)
4	Uttar Pradesh	Varanasi	147	292	317	350	101.8	37	120 (Sanctioned)
5	Bihar	Patna	100	210	236	316	109	–	246 (Projects under preparation)
6	West Bengal	Howrah	75	111	121	142	85	–	–
	Total		661.33	1288	1373	1699	584.3	80	694

* Projected
Source: MoEF

4.5 Water Quality of River Ganga

Various sources of pollution described above, have a significant impact on the water quality. As presented in Figure 4.1, in the year 2009 the average BOD concentration (5 to 7 mg /l) in the mainstream of the Ganga exceeded the bathing water quality standard (3mg/l) at several locations such as Kannauj, Kanpur, Allahabad and Varanasi. The BOD concentration however, is much lower than the BOD concentrations (7 to 17 mg/l) in 1986 (pre-GAP), and several locations record acceptable values. These mainly appear at the upper and lower reaches, whereas the middle reaches (from Kannuaj to Varanasi) continue to show evidence of organic pollution. In the down stream reaches such as Patna in Bihar and beyond, the water quality improves substantially due to the high river discharge and associated dilution of wastewater.

Based on a more detailed perusal of station wise and year wise data, the MoEF has reported that the BOD values have exceeded the acceptable standard (3.0 mg/L) at Rishikesh and haridwar only once or twice, whereas between Kannauj and Kanpur, the values have exceeded the acceptable level frequently. The most critical stretch is between Kannauj and

Allahabad downstream. The highest value of BOD (65.8 mg/L) was recorded at Kanpur during lean flow.

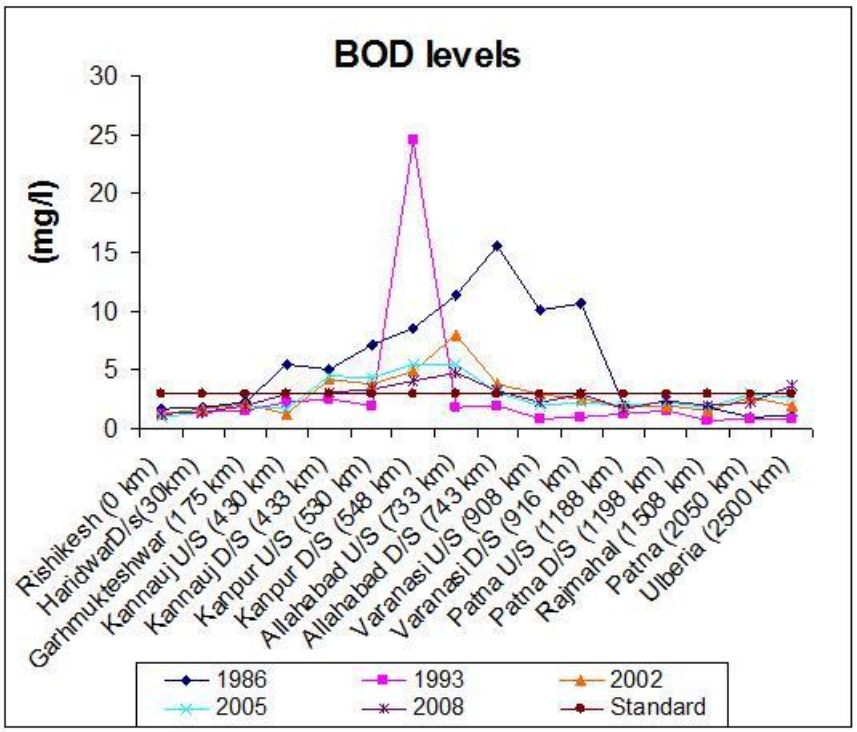


Figure 4.1 BOD levels in river Ganga during year 1986 and 2009
Source: http://moef.nic.in/

As regards the DO levels in river Ganga, the concentrations at various locations are observed to be largely within the acceptable limits. As seen from Figure 4.2, the DO levels are above 5.0 mg/L at all locations. Further, the DO levels between Kanpur and Patna are seen to have improved over the years. As per the Status of River Ganga reported by the MoEF, in 22 years of monitoring at 16 stations, DO levels below 5.0 mg/L were recorded only in 2.6% cases. In these cases, the values were between 3.2 and 4.9 mg/L, and these were observed between Kannauj and Kanpur.

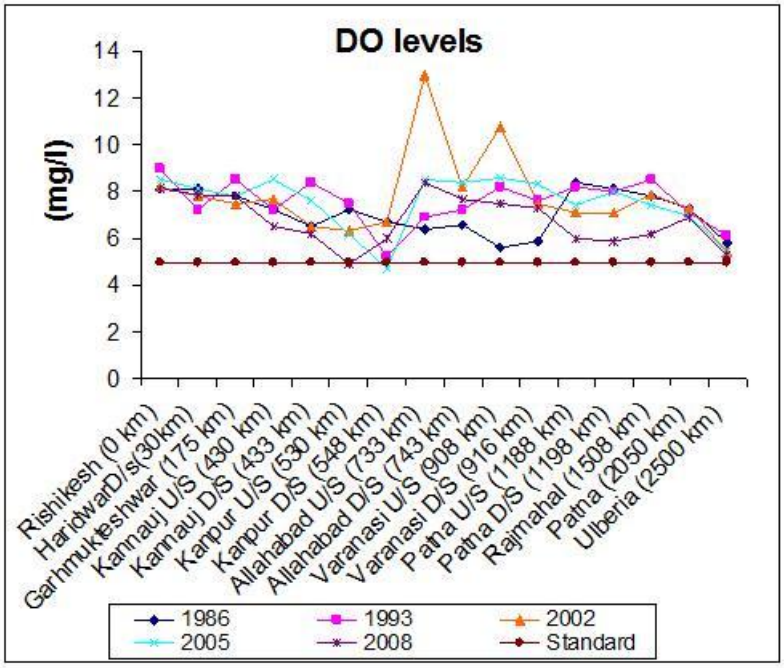


Figure 4.2 DO levels in river Ganga during year 1986 and 2009

Source: http://moef.nic.in/

Figures 4.3 to 4.7 present the fecal coliform levels along the Ganga progressively from the upstream to the downstream reaches. As seen from the Figures, the coliform levels have exceeded the standard more frequently than BOD and DO at almost all locations except Uttarakhand. The fecal coliform concentrations complied with the standard only at one location (Narora) at Uttar Pradesh. At Bihar and West Bengal, fecal coliform concentrations do not confirm to the standard at any location.

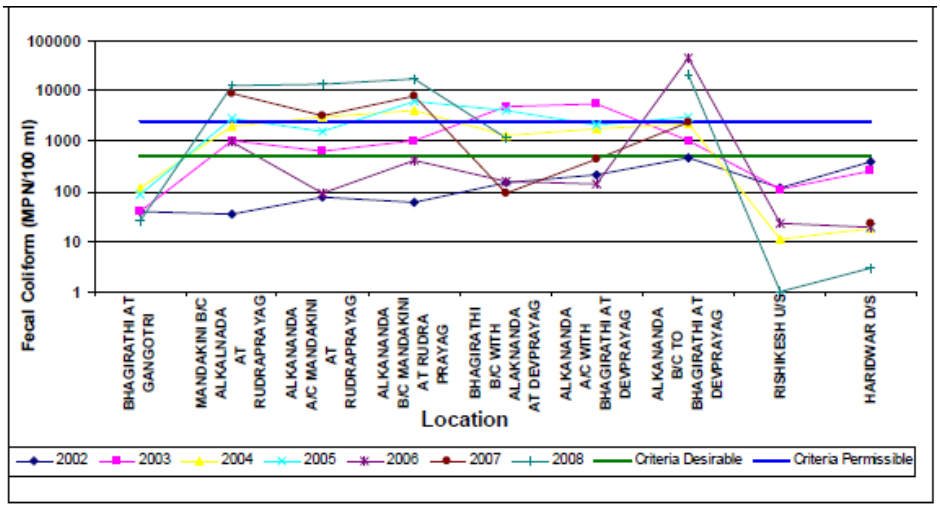


Figure 4.3 Water quality of river Ganga (Uttaranchal segment)

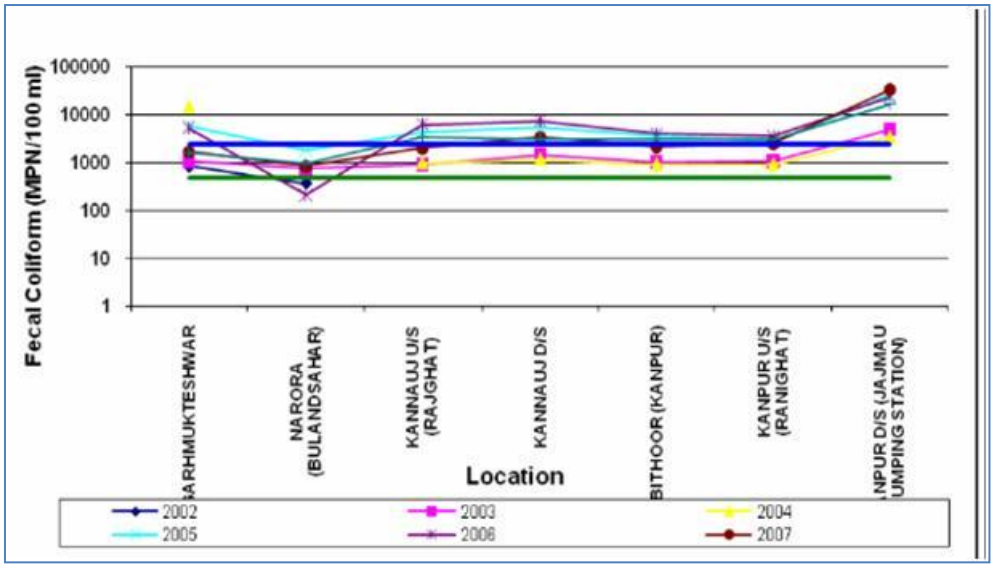


Figure 4.4 Water quality of river Ganga (U.P upper segment)

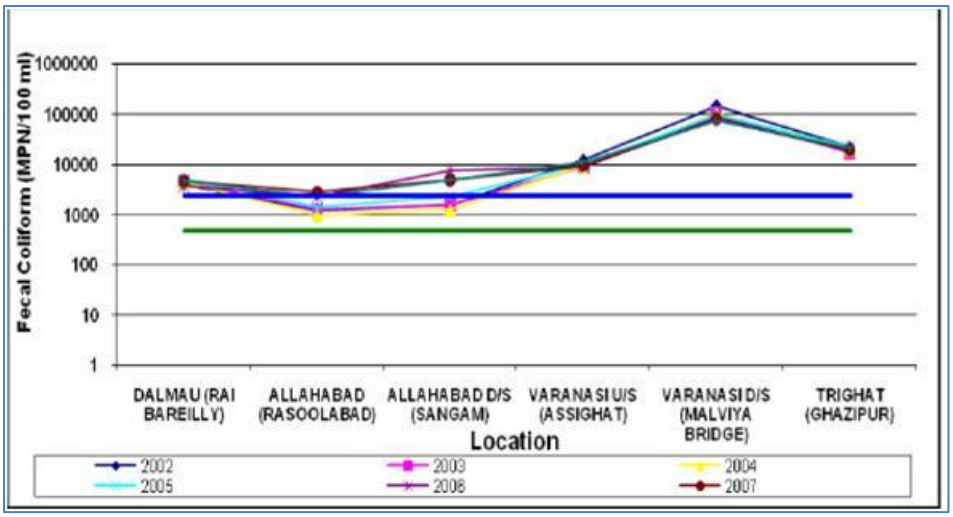


Figure 4.5 Water quality of river Ganga (U.P lower segment)

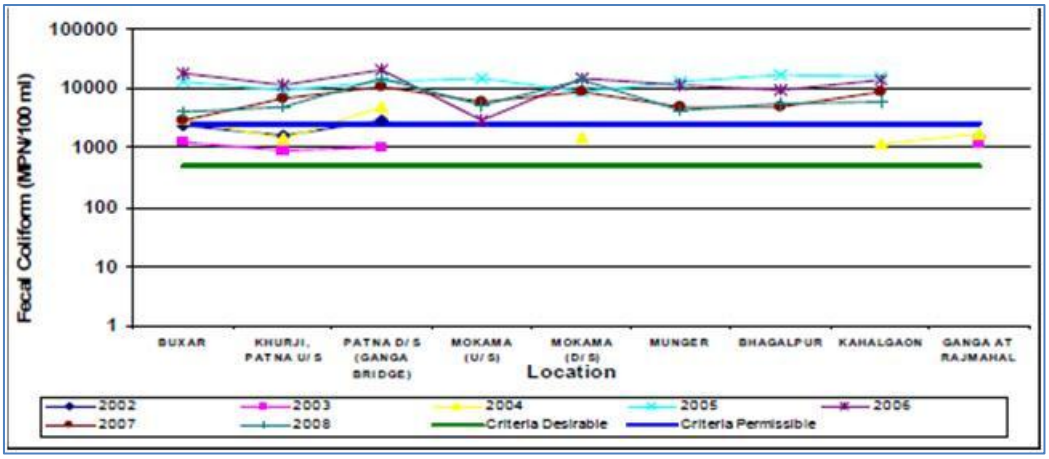


Figure 4.6 Water quality of river Ganga (Bihar segment)

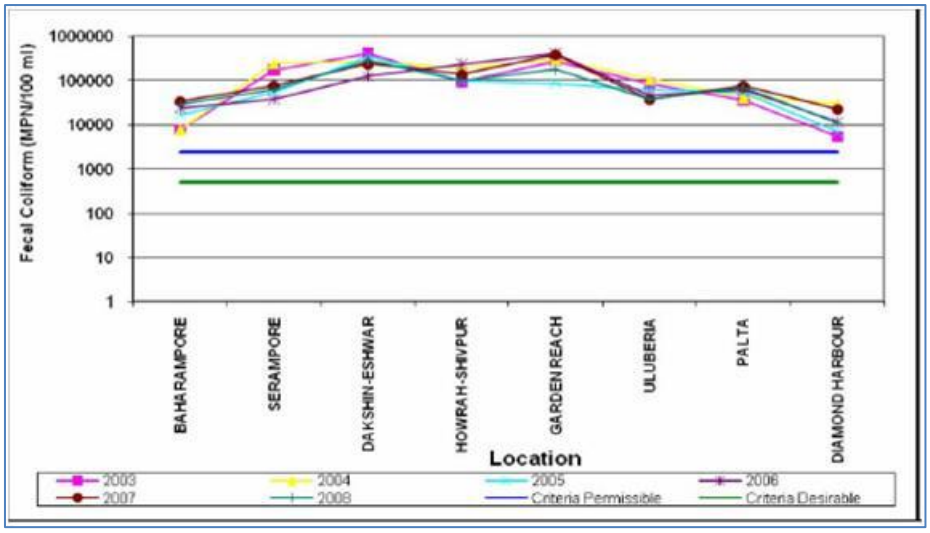


Figure 4.7 Water quality of river Ganga (West Bengal segment)

Source: CPCB annual report 2008-09

When the pollution levels at different locations along the Ganga are compared with the designated best uses, it is observed that at nearly all locations the parameters exceed the water quality criteria, rendering the water unsuitable for its designated best use, that is, outdoor bathing. The observed class and critical parameter at different locations on the river is given in Table 4.11. At several locations observed class is found to be class D, which is suitable only for propagation of wildlife and fisheries, and not fit for human consumption or bathing.

Table 4.11 Classification of Ganga at Various Locations

Locations	Desired Class	Observed Class and Critical Parameter					
		1997	1998	1999	2000	2001	2008
Ganga at Rishikesh	A	D (CF)	B (CF)	C (CF)	NA	C (CF)	B
Haridwar	B	C (CF)	C (CF)	C (CF)	NA	C (CF)	B
Garhmuktesar (UP)	B	B (BOD)	--	D (BOD)	NA	D (BOD, CF)	NA
Kannauj U/s U.P	B	D (BOD, CF)	D (BOD)	D (CF)	D (BOD, CF)	D (BOD, CF)	C (CF)
Kannuaj D/S UP	B	D (BOD, CF)	D (BOD)	D (CF)	D (BOD, CF)	D (BOD, CF)	C (BOD, CF)
Kanpur U/S UP	B	D (BOD, CF)	NA	D (CF)	D (CF)	D (CF)	D (CF)
Kanpur D/S U.P	B	D (BOD, CF)	D (BOD)	D (CF)	D (BOD, CF)	D (BOD, CF)	D (BOD, CF)
Raibareilly U.P	B	D (CF)	D (CF)	C (CF)	NA	NA	NA
Allahabad U/S UP	B	D (BOD, CF)	E (CF)	D (CF)	NA	NA	C (BOD, CF)
Allahabad D/S UP	B	D (BOD, CF)	E (CF)	D (CF)	NA	NA	D (BOD, CF)
Varanasi U/S U.P	B	D (BOD, CF)	D (BOD)	D (CF)	-	D (CF)	D (BOD, CF)
Varanasi D/S U.P	B	E (DO, BOD, CF)	E (BOD, DO)	D (BOD)	NA	NA	D (BOD, CF)
Gazipur U.P.	B	D (BOD, CF)	D (BOD)	D (BOD)	D (CF)	NA	NA
Buxar	B	D (BOD)	D (CF)	D (CF)	D (CF)	D (CF)	C (CF)
Patna U/S	B	D (CF)	D (CF)	D (CF)	D (CF)	D (CF)	NA
Patna D/S	B	D (CF)	D (CF)	D (CF)	D (CF)	D (CF)	NA
Rajmahal	B	D (CF)	D (CF)	D (CF)	D (CF)	D (CF)	D (CF)
Palta (WB)	B	D (BOD)	B	NA	D (BOD, CF)	D (BOD, CF)	D (CF)
Uluberia (WB)	B	D	B	NA	D	D (BOD, CF)	D (BOD, CF)

Source: MoEF

Overall, the trends for key water quality parameters in Ganga indicate that the BOD levels are broadly non-compliant in the river stretch between Kannauj to Varnasi, DO levels are generally compliant and the fecal coliforms are high in almost all the stretches except at Gangotri, Devprayag, Haridwar and Narora.

Chapter 5
Limiting Factors in Environmental and Social Analysis of Ganga Basin

5.1 Environmental Profile

The environmental profile of the river Ganga has been prepared based on the latest available secondary information from various government agencies associated with water resources development, irrigation, agriculture, forest, meterology, etc. Based on the analysis of current environmental aspects of Ganga basin, a brief summary of issues is been highlighted below.

5.1.1 The Ganga Basin

The Ganga basin, which is the largest river basin in India, is described in terms of its catchment area, state wise distribution of the river, its tributaries and stream flow characteristics, along with a basin map depicting the river course.

Issues:

- The mean annual flow of only a few streams of river Ganga is available, but the details of annual flow along with catchment details of major streams/ tributaries were not available.
- Information about the seasonal variation of the streams flow and the annual flow at 90, 50 and 10- percentile level in Ganga basin was also not available.
- The flow variation details helps in understanding water availability in the streams which is an important factor not only for water management but also for planning and implementing any pollution control and prevention management programme in the basin.

Data on these aspects of flow and its variations need to be generated / collated in order to better understand the hydrologic characteristics of the river and also the basin.

5.1.2 Land use

State-wise land use pattern in the Ganga basin has been used for analyzing the land use patterns including forest, agriculture, fallow and non-arable land. However, in many cases including the state of Uttar Pradesh, not the entire state is located in the Ganga Basin. A more detailed analysis of the land use data, in terms of specific district and geographical area

located in the Ganga Basin, is hence required to anlayse the land use characterstics and its changes in the Basin. Such analysis could not be done in the current document, owing to lack of adequate data.

5.1.3 Irrigation

Ganga basin is one of the most extensively irrigated basins in the world, constituting nearly 57 percent of the net irrigated area of India as a whole. However, data on water consumption requirements for various uses including irrigation use could not be analysed due to the factors.

- absence of basin specific information on intensity of irrigation and sources of irrigation
- details of irrigation requirement in the basin for various regions, along with usage of surface and groundwater resources

5.1.4 Water logging, Salinity and Land Degradation problems

The extensively irrigated Ganga basin also suffers from water logging and salinity problems mainly due to increased irrigation practices and high groundwater extraction. Further other types of land degradation may be due to natural calamities or from human actions. The details of various kinds of land degradation have been described based on the available information. However, a detailed analysis is required to better understand the magnitude of these problems and establish the factors to contributing to the degradation especially in the Ganga Basin

5.1.5 Vegetation and Forest

The vegetation type of the basin has been analysed based on the lateset available information. However, the analysis is based on the state wide information and not specific to the basin. Similarly, the Macrophytic and Riparian Vegetation is historic and represents the ideal base line scenario of Ganga Basin. This data needs to be updated to understand the flora and fauna characteristics of the basin, which can further help desgning environmental management strategies in the basin.

5.1.6 Sensitive Environment Habitats

The Ganga Basin has number of environmentally sensitive areas such as biosphere reserves, wildlife sanctuaries, national parks and tiger reserves. While these habitats are located in the

basin, the exact location of these habitats and possible impacts of NGRBA activities could not be established in the analysis, for want of exact details such boundary of the habitiat, profile of various flora / fauna, etc. Such an analysis would be very important for planning various NGRBA activities and also suitable management strategies for these sensitive habitats.

5.1.7 Socio-Economic Profile

Similar to the other base line parameters, the socio-economic profile of the basin is prepared by obtaining the available state level and district level information available in the respective states. However, a more focused analysis especially on the economic, religious and cultural importance of Ganga and its linkages with the the local communities is essential to integrate these aspects in to overall NGRBA program.

5.1.8 Issues of Water Quality and Pollution Sources

The analysis of base line data in the earlier sections also brings out the absence of an inventory of pollution sources, contribution from each source, magnitude of pollution, for important source such as industries, hazardous waste, solid waste and non-pont sources across the basin. In the absence of such data, development of an integrated approach to the improvement of water quality of the basin becomes very difficult. This further gets complicated with inconsistent base line water quality data, which doesn't reflect the seasonal changes and also interrelationship between BOD and DO levels. Condiering this fact, a detailed inventory of pollution sources, detailed and continous monitoring of rivers flows and water quality needs to be carried out to establish the quantitative and qualitative aspects of pollution in the river. In order to provide a meaningful input to overall program, the assessment shall be carried out (i) at city level; (ii) at tributary level within basin; and iii) at seasonal level.

Appendices

Appendix 2.1- Ground Water Quality of state districts under Ganga main stem

Sl. No	States	Affected districts					
		Fluoride (>1.5 mg/l)	**Iron (>1.0 mg/l)**	**Nitrate (>45 mg/l)**	**Arsenic (>0.05 mg/l)**	**Salinity (EC > 3000 µS/cm at 25 ° C)**	**Chloride (> 1000 mg/l)**
1	**Bihar**	Aurangabad, Banka, Buxar, Bhabua(Kaimur), Jamui, Munger, Nawada, Rohtas, Supaul	Aurangabad, Begusarai, Bhojpur, Buxar, Bhabua(Kaimur), East Champaran, Gopalganj, Katihar, Khagaria, Kishanganj, Lakhiserai, Madhepura, Muzafferpur, Nawada, Rohtas, Saharsa, Samastipur, Siwan, Supaul, West Champaran	Aurangabad, Banka, Bhagalpur, Bhojpur, Bhabua, Patna, Rohtas, Saran, Siwan	Begusarai, Bhagalpur, Bhojpur, Buxar, Darbhanga, Katihar, Khagaria, Kishanganj, Lakhiserai,Munger, Patna, Purnea, Samastipur, Saran, Vaishali		
2	**Jharkhand**	Bokaro, Giridih, Godda, Gumla, Palamu, Ranchi	Chatra, Deoghar, East Singhbhum, Giridih, Ranchi, West Singhbhum	Chatra, Garhwa, Godda, Gumla, Lohardega, Pakur, Palamu, Paschimi Singhbhum, Purbi Singhbhum, Ranchi, Sahibganj			
3	**Delhi**	East Delhi, North West Delhi, South Delhi, South West Delhi, West Delhi		Central Delhi, New Delhi, North Delhi, North West Delhi, South Delhi, South West Delhi, West Delhi		North West, West, South West	North West, West, South West
4	**Haryana**	Bhiwani,	Ambala, Bhiwani,	Ambala, Bhiwani,		Bhiwani,Farida	Rohtak,

Sl. No	States	Affected districts					
		Fluoride (>1.5 mg/l)	**Iron (>1.0 mg/l)**	**Nitrate (>45 mg/l)**	**Arsenic (>0.05 mg/l)**	**Salinity (EC > 3000 µS/cm at 25 ° C)**	**Chloride (> 1000 mg/l)**
		Faridabad, Gurgaon, Hissar, Jhajjar, Jind, Kaithal, Kurushetra, Mahendergarh, Panipat, Rewari, Rohtak, Sirsa, Sonepat	Faridabad, Fatehabad, Gurgaon, Hissar, Jhajjar, Jind, Kaithal, Karnal, Kurukshetra, Mahendergarh, Panipat, Rohtak, Sirsa, Sonepat, Yamuna Nagar	Faridabad, Fatehabad, Gurgaon, Hissar, Jhajjar, Jind, Kaithal, Karnal, Kurukshetra, Mahendergarh, Panchkula, Panipat, Rewari, Rohtak, Sirsa, Sonepat, Yamuna Nagar		bad, Fatehabad, Gurgaon, Hissar, Jhajjar, Kaithal, Mahendergarh, Panipat, Rewari, Rohtak, Sirsa, Sonepat,yamunanagar.	Bhiwani, Gurgaon,Jhajjar,Mahendragarh,sirsa, Sonipat.
5	**Himachal Pradesh**			Una		Mandi	
6	**Uttarakhand**			Dehradun, Hardwar, Udhamsinghnagar			
7	**West Bengal**	Bankura, Bardhaman, Birbhum, Dakhindinajpur, Malda, Nadia, Purulia, Uttardinajpur	Bankura, Bardhaman, Birbhum, Dakhindinajpur, E. Midnapur, Howrah, Hugli, Jalpaiguri, Kolkatta, Murshidabad, N-24praganna, Nadia, S-24pragannas, Uttardinajpur, West Midnapur	Bankura, Bardhaman	Bardhaman, Hooghly, Howrah, Malda, Murshidabad, Nadia, North 24 Praganas, South 24 Pragannas	Bankura,Haora, Medinipur,N-24 pargana, S- 24 Parganas,	N-24 pargana, S-24 Parganas, Haora.
8	**Uttar Pradesh**	Agra, Aligarh, Etah, Firozabad,	Azamgarh, Balia, Balrampur, Etawah, Fatehpur, Gazipur,	Agra, Aligarh, Allahbad, Ambedkar Nagar, Auraiyya,	Agra, Aligarh, Balia, Balrampur, Gonda, Gorakhpur,	Agra,Allahabad,Aligarh,Hamirpur,Hathras,Jyo	Aligarh,Hathras,Mathura, Agra

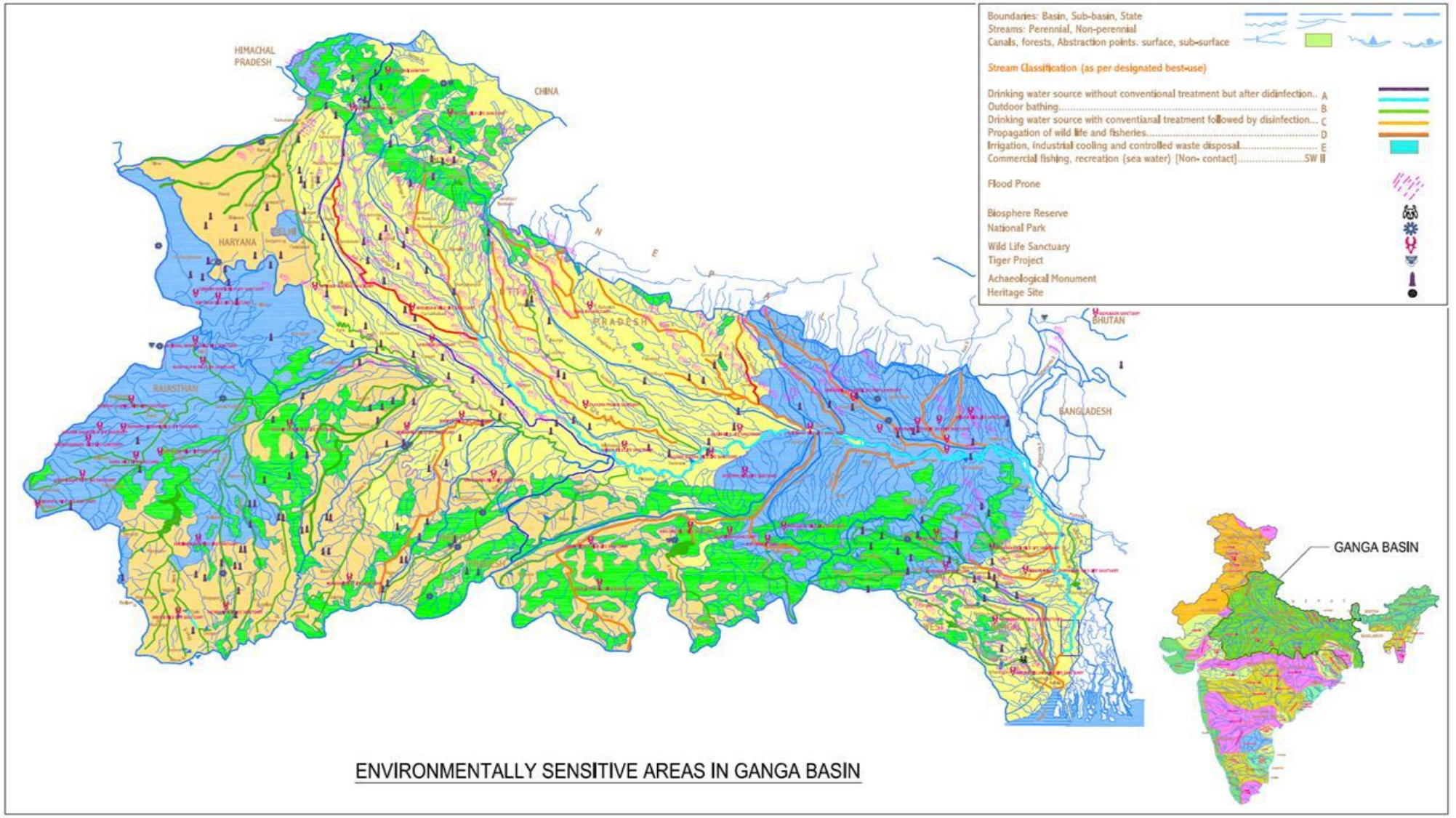
Sl. No	States	Affected districts					
		Fluoride (>1.5 mg/l)	**Iron (>1.0 mg/l)**	**Nitrate (>45 mg/l)**	**Arsenic (>0.05 mg/l)**	**Salinity (EC > 3000 µS/cm at 25 ° C)**	**Chloride (> 1000 mg/l)**
		Jaunpur, Kannauj, Mahamaya Nagar, Mainpuri, Mathura, Mau.	Gonda, Hardoi, Kanpur Dehat, Kanpur Nagar, Lakhimpur, Lalitpur, Mau, Siddartnagar, Unnao	Badaun, Baghpat, Balrampur, Banda, Barabanki, Bareilly, Basti, Bijnour, Bulandsahar, Chitrakoot, Etah, Etawa, Fatehpur, Firozabad, GB Nagar, Ghaziabad, Ghazipur, Hamirpur, Hardoi, Jaunpur, Jhansi, Kannauj, Kanpur Dehat, Lakhimpur, Mahoba, Mathura, Meerut, Moradabad, Muzaffarnagar, Raibarelli, Rampur, Sant Ravidas Nagar, Shajahanpur, Sitapur, Sonbhadra, Sultanpur, Unnao	Lakhimpur Kheri*, Mathura, Muradabad	tibaphulenagar, Mathura.	
9	**Rajasthan**	Ajmer, Alwar, Banaswara, Barmer, Bharatpur, Bhilwara, Bikaner, Bundi,	Ajmer, Alwar, Banswara, Baran, Bharatpur, Bhilwara, Bikaner, Chittaurgarh, Churu, Dausa, Dhaulpur, Dungarpur,	Ajmer, Alwar, Banaswara, Baran, Barmer, Bharatpur, Bhilwara, Bikaner, Chittaurgarh, Churu, Dausa, Dhaulpur,		Ajmer, Alwar, Barmer, Bharatpur, Bhilwara, Bundi, Bikaner, Churu,	Barmer, Bharatpur, Bikaner, Bundi,Churu, Chittaurgarh

Sl. No	States	Affected districts					
		Fluoride (>1.5 mg/l)	**Iron (>1.0 mg/l)**	**Nitrate (>45 mg/l)**	**Arsenic (>0.05 mg/l)**	**Salinity (EC > 3000 µS/cm at 25 ° C)**	**Chloride (> 1000 mg/l)**
		Chittaurgarh, Churu, Dausa, Dhaulpur, Dungarpur, Ganganagar, Hanumangarh, Jaipur, Jaisalmer, Jalor,Jhunjhunu, Jodhpur, Karauli, Kota, Nagaur, Pali, Rajasamand, Sirohi, Sikar, SawaiMadhopur, Tonk, Udaipur	Ganganagar, Hanumangarh, Jaipur, Jaisalmer, Jhalawar, Jhunjhunu, Jodhpur, Karauli, Kota, Nagaur, Pali, Rajasamand, Sikar, Sawai Madhopur, Tonk, Udaipur	Dungarpur, Ganganagar, Hanumangarh, Jaipur, Jaisalmer, Jalor, Jhalawar, Jhunjhunu, Jodhpur, Karauli, Kota, Nagaur, Pali, Partapgarh, Rajasamand, Sirohi, Sikar, Swai Madhopur, Tonk, Udaipur		Chittaurgarh, Dhaulpur, Dausa, Ganganagar, Hanumangarh, Jaipur, Jaisalmer, Jalor,Jhunjhunun, Karoli, Nagaur, Neemuch,pali, Raja Samand, Sirohi, Sikar, Sawai Madhopur, Tonk, Udaipur	, dausa, Ganganagar, Hanumangarh, Jaipur, Jaisalmer, Jalor, Jhunjhunun, Jodhpur ,Karauli, Nagaur,Pali, Sirohi, Sawai Madhopur, Nagaur, Sikar, Tonk, Udaipur
10	**Madhya Pradesh**	Bhind, Chhatarpur, Chhindwara, Datia, Dewas, Dhar, Guna, Gwalior, Harda, Jabalpur, Jhabua, Khargaon, Mandsaur,	Balaghat, Betul, Bhind, Chhatarpur, Chhindwara, Guna, Gwalior, Hoshangabad, Narsinghpur, Panna, Raisen, Rajgarh, Rewa, Sagar, Satna, Sehore, Seoni, Shahdol, Shajapur, Sidhi, Ujjain, Umaria, Vidisha, Dindori, East Nimar	Anuppur, Ashok Nagar, Balaghat, Barwani, Betul, Bhind, Bhopal, Burhanpur, Chhatarpur, Chhindwara, Damoh, Datia, Dewas, Dhar, Gwalior, Harda, Hoshangabad,		Bhind, Indore, Jhabua, Sheopur, Ujjain	Bhind, Ujjain

Sl. No	States	Affected districts					
		Fluoride (>1.5 mg/l)	**Iron (>1.0 mg/l)**	**Nitrate (>45 mg/l)**	**Arsenic (>0.05 mg/l)**	**Salinity (EC > 3000 µS/cm at 25 ° C)**	**Chloride (> 1000 mg/l)**
		Rajgarh, Satna, Seoni, Shajapur, Sheopur, Sidhi		Indore, Jabalpur, Jhabua, Katni, Khandwa, Khargaon, Mandla, Mandsaur, Morena, Narsimhapur, Neemuch, Panna, Raisen, Rajgarh, Ratlam, Rewa, Sagar, Satna, Sehore, Seoni, Shahdol, Shajapur, Sheopur, Shivpuri, Sidhi, Tikamgarh**,** Ujjain, Umaria, Vidisha			

Source: Groundwater Quality in Shallow Aquifers of India, CGWB, 2010

Appendix 2.2: Environmentally Sensitive Areas in Ganga Basin



Appendix 2.3 Wildlife Sanctuaries in Ganga Basin

State	Wildlife Sanctuary	District	Area (Sq. Km.)
Bihar	Barela S.A.Z.S.	Vaishali	1.96
Bihar	Bhimbandh	Munger	681.99
Bihar	Kanwarjheel	Begusarai	63.11
Bihar	Valmiki	Pashchim Champaran	544.67
Bihar	Vikramshila Gangetic Dolphin	Bhagalpur	0.5
Delhi	Indira Priyadarshani (Asola)	Delhi	13.2
Haryana	Abubshehar	Sirsa	115.3
Haryana	Bhindawas	Rohtak	4.12
Haryana	Bir Bara Ban	Jind	4.19
Haryana	Chhilchila	Kaithal	0.29
Haryana	Kalesar	Yamuna Nagar	100.28
Haryana	Khaparwas	Jhajjar	0.83
Haryana	Nahar	Rewari	2.11
Haryana	Saraswati Plantation	Kurukshetra, Kaithal	44.53
Himachal Pradesh	Chail	Solan	108.54
Himachal Pradesh	Churdhar	Sirmaur	56.15
Himachal Pradesh	Daranghati	Shimla	167
Himachal Pradesh	Darlaghat	Solan	140
Himachal Pradesh	Majathal	Solan	40
Himachal Pradesh	Renuka	Sirmour	4.02
Himachal Pradesh	Shilli	Solan	2.13
Himachal Pradesh	Shimla Water Catchment	Shimla	10.25
Himachal Pradesh	Simbalbara	Sirmour	19.03
Himachal Pradesh	Talra	Shimla	26
Jharkhand	Udhwa Lake	Sahebganj	0.57
Madhya Pradesh	Bagdara	Sidhi	478
Madhya Pradesh	Gandhi Sagar	Mandsaur	368.62
Madhya Pradesh	Ghatigaon	Gwalior	511
Madhya Pradesh	Karera	Shivpuri	202.21
Madhya Pradesh	Ken Gharial	Panna, Chhatarpur	45.2
Madhya	National Chambal	Morena, Bhind	435

State	Wildlife Sanctuary	District	Area (Sq. Km.)
Pradesh			
Madhya Pradesh	Narsinhgarh	Raigarh	59.19
Madhya Pradesh	Nauradehi	Damoh, Sagar, Narsimhapur	1194.67
Madhya Pradesh	Orcha	Tikamgarh	44.91
Madhya Pradesh	Palpur-Kuno	Morena	344.68
Madhya Pradesh	Panna (Gangau)	Panna	68.14
Madhya Pradesh	Panpatha	Shahdol	245.84
Madhya Pradesh	Ralamandal	Indore	2.34
Madhya Pradesh	Sailana	Ratlam	12.96
Madhya Pradesh	Sanjay Dubri	Sidhi	364.59
Madhya Pradesh	Son Gharial	Sidhi, Shahdol, Satna	41.8
Madhya Pradesh	Veerangna Durgawati	Damoh	23.97
Rajasthan	Bandh Baratha	Bharatpur	192.76
Rajasthan	Bassi	Chittaurgarh	152.9
Rajasthan	Bhensrodgarh	Chittaurgarh	229.14
Rajasthan	Darrah	Kota	265.8
Rajasthan	Jaisamand	Rajsamand	52
Rajasthan	Jamwa Ramgarh	Kaipur	300
Rajasthan	Jawahar Sagar	Kota	100
Rajasthan	Kela Devi	Sawai Madhopur	676.38
Rajasthan	Kesarbagh	Dholpur	14.76
Rajasthan	Kumbhalgarh	Udaipur, Plai	578.25
Rajasthan	Nahargarh	Jaipur	50
Rajasthan	National Chambal	Kota	280
Rajasthan	Mount Abu	Sirohi	288.84
Rajasthan	Phulwari Ki Nal	Udaipur, Plai	511.41
Rajasthan	Ramgarh Vishdhari	Bundi	301
Rajasthan	Ramsagar	Dholpur	34.4
Rajasthan	Sajjangarh	Udaipur	5.19
Rajasthan	Sariska	Alwar	492
Rajasthan	Sawai Man Singh	Sawai Madhopur	103.25
Rajasthan	Shergarh	Kota	98.71
Rajasthan	Sitamata	Chittaurgarh, Udaipur	422.94
Rajasthan	Tadgarh Raoli	Ajmer, Rajsaman, Plai	495.27
Rajasthan	Van Vihar	Dhaulpur	59.93
Uttar Pradesh	Kaimur	Mirzapur, Sonbhadra	500.73

State	Wildlife Sanctuary	District	Area (Sq. Km.)
Uttar Pradesh	Lakh Bahosi	Farrukhabad	80.24
Uttar Pradesh	Samaspur	Rae Bareli	7.99
Uttar Pradesh	Surha Tal	Ballia	34.32
Uttar Pradesh	Turtle	Varanasi	7
Uttarakhand	Govind Pashu Vihar	Uttarkashi	481
West Bengal	Buxa	Jalpaiguri	268.99
West Bengal	Bihutibhusan	North 24-Paraganas	0.64
West Bengal	Haliday Island	South 24-Paraganas	5.95
West Bengal	Lothian Island	South 24-Paraganas	38
West Bengal	Narendrapur	South 24-Paraganas	0.1
West Bengal	Sajnekhali	South 24-Paraganas	362.4
Ganga Basin Total	**75 Wildlife Sanctuaries**		**14086.18**

Appendix 4.1 Sewage Generation and treatment capacity of Class I cities in Ganga Basin (Disposal In tributaries)

S. No.	City/Town	State/UT	Population	Total Sewage (in MLD)	Treatment Capacity (in MLD)	Percentage covered	Treated sewage Disposal
1	Muzaffarpur	Bihar	342120	55.3	-	0%	Budhi Gandak
2	Bihar Sharif	Bihar	259810	42	-	0%	Phalgun
3	Gaya	Bihar	429180	69.4	-	0%	Phalgun
4	Bettiah	Bihar	130700	21.1	-	0%	Budhi Gandak
5	Motihari	Bihar	113690	18.4	-	0%	Budhi Gandak
6	Hajipur	Bihar	133590	21.6	-	0%	Gandak
7	Darbhanga	Bihar	298850	48.3	-	0%	Ghughri
8	Chapra	Bihar	200300	32.4	2	6%	Ghaghara
9	Sasaram	Bihar	146770	23.7	-	0%	Chandrabhaga
10	Siwan	Bihar	121150	19.6	-	0%	Daha
11	Arrah	Bihar	227800	36.8	-	0%	Son
12	Dehri	Bihar	133290	21.5	-	0%	Son
13	Saharsa	Bihar	138900	22.4	-	0%	Simrahi Stream
14	Yamunanagar	Haryana	250250	18.6	35	100%	WJC
15	Bokaro	Jharkhand	484830	71.3	-	0%	Damodar
16	Dhanbad	Jharkhand	1064357	36	-	0%	Damodar
17	Hazaribagh	Jharkhand	156510	23	-	0%	Damodar
18	Morena	Madhya Pradesh	197670	17.4	-	0%	Kunwari
19	Indore	Madhya Pradesh	1885510	212.5	90	42%	Khan, Shipra
20	Sagar	Madhya Pradesh	304340	26.7	-	0%	Dhasan
21	Bhind	Madhya Pradesh	201440	17.7	-	0%	Chambal
22	Neemuch	Madhya Pradesh	140820	12.4	-	0%	Chambal
23	Mandsaur	Madhya Pradesh	152590	15.8	-	0%	Chambal
24	Dewas	Madhya Pradesh	302160	26.5	-	0%	Chhoti Kali Sindh
25	Vidisha	Madhya Pradesh	164350	14.4	9	63%	Betwa
26	Bhopal	Madhya Pradesh	1878380	255.2	17.64	7%	Betwa
27	Rewa	Madhya Pradesh	240030	21.1	-	0%	Baichaiya
28	Guna	Madhya Pradesh	179640	15.8	-	0%	Sindh
29	Damoh	Madhya Pradesh	146930	14.1	-	0%	Sonar, Bearma
30	Satna	Madhya Pradesh	295360	26	-	0%	Tons
31	Shivpuri	Madhya Pradesh	192390	17	-	0%	Sindh
32	Singrauli	Madhya Pradesh	243110	21.3	-	0%	Gopad,Sone
33	Gwalior	Madhya Pradesh	1083260	114.1	-	0%	Vaishali
34	Ujjain	Madhya Pradesh	563210	49.4	-	0%	Shipra

S. No.	City/Town	State/UT	Population	Total Sewage (in MLD)	Treatment Capacity (in MLD)	Percentage covered	Treated sewage Disposal
35	Tonk	Rajasthan	166870	21.4	-	0%	Banas
36	Kota	Rajasthan	855960	145	-	0%	Chambal
37	Udaipur	Rajasthan	478860	61.5	-	0%	Banas/Berach
38	Bhilwara	Rajasthan	344630	44.3	-	0%	Banas
39	Alwar	Rajasthan	320100	41.1	-	0%	Arvari
40	Moradabad	Uttar Pradesh	788730	86	-	0%	Ramganga
41	Deoria	Uttar Pradesh	128190	14	-	0%	Lttle Gandak
42	Rampur	Uttar Pradesh	346310	37.7	-	0%	Kosi
43	Banda	Uttar Pradesh	165830	18.1	-	0%	Ken
44	Aligarh	Uttar Pradesh	821310	89.5	-	0%	Karwan
45	Meerut	Uttar Pradesh	1321300	144	-	0%	Kali
46	Muzaffarnagar	Uttar Pradesh	389040	58	32	55%	Kali
47	Gonda	Uttar Pradesh	150260	16.4	-	0%	Ghaghara
48	Hapur	Uttar Pradesh	260740	28.4	-	0%	Kali
49	Bulandshahr	Uttar Pradesh	216790	23.6	-	0%	Kali
50	Modinagar	Uttar Pradesh	148300	15.1	-	0%	Kali
51	Ghaziabad	Uttar Pradesh	1191280	129.8	126	97%	Hindon River
52	Saharanpur	Uttar Pradesh	557100	60.7	38	63%	Hindon River
53	Gorakhpur	Uttar Pradesh	768220	83.7	-	0%	Haldi, Rapti
54	Sultanpur	Uttar Pradesh	123100	13.4	6.4	48%	Gomti River
55	Lucknow	Uttar Pradesh	2715030	295.8	417	100%	Gomti River
56	Jaunpur	Uttar Pradesh	196800	21.4	-	0%	Gomti
57	Bahraich	Uttar Pradesh	207100	22.6	-	0%	Ghaghara
58	Faizabad	Uttar Pradesh	178260	19.4	-	0%	Ghaghara
59	Basti	Uttar Pradesh	131590	14.3	-	0%	Ghaghara
60	Lakhimpur	Uttar Pradesh	148300	16.2	-	0%	Ghaghara
61	Shahjahanpur	Uttar Pradesh	366460	40	-	0%	Deoha
62	Pilibhit	Uttar Pradesh	152620	16.6	-	0%	Deoha
63	Maunath Bhanjan	Uttar Pradesh	258390	28.2	-	0%	Chhoti Saryu
64	Azamgarh	Uttar Pradesh	129080	14.1	-	0%	Chhoti Saryu
65	Jhansi	Uttar	471400	51.4	-	0%	Betwa

S. No.	City/Town	State/UT	Population	Total Sewage (in MLD)	Treatment Capacity (in MLD)	Percentage covered	Treated sewage Disposal
		Pradesh					
66	Lalitpur	Uttar Pradesh	137530	15	-	0%	Betwa
67	Chandausi	Uttar Pradesh	127620	14	-	0%	Badaun Streatm
68	Sambhal	Uttar Pradesh	225000	24.5	-	0%	Badaun Stream
69	Amroha	Uttar Pradesh	202810	22.1	-	0%	Badaun Stream
70	Budaun	Uttar Pradesh	182210	20	-	0%	Badaun Stream
71	Sitapur	Uttar Pradesh	186750	20.3	-	0%	Sarangan
72	Bareily	Uttar Pradesh	860800	93.8	-	0%	Ramganga
73	Rae Bareli	Uttar Pradesh	208220	22.7	-	0%	Sai
74	Etah	Uttar Pradesh	131730	15.8	-	0%	Sirsa
75	Hardoi	Uttar Pradesh	138340	15.1	-	0%	Sai
76	Kathgodam-Haldwani	Uttarakhand	158840	17.3	-	0%	Ramganga
77	Kharagpur	West Bengal	239180	28.1	-	0%	Kosai
78	Medinipur	West Bengal	176350	20.7	-	0%	Kosai
79	Krishnanagar	West Bengal	159930	18.8	-	0%	Jalangi
80	Puruliya	West Bengal	130830	15.4	-	0%	Haldi
81	Asansol	West Bengal	1090171	65.7	-	0%	Damodar
82	Durgapur	West Bengal	566950	66.6	-	0%	Damodar
83	Raniganj	West Bengal	190010	16.6	-	0%	Damodar
84	Baharampur	West Bengal	184190	21.6	8	37%	Beel
85	Bankura	West Bengal	148130	17.4	-	0%	Roopnarayan
86	Barasat	West Bengal	266240	31.3	-	0%	Bidyadhari
87	Kulti	West Bengal	333570	39.2	-	0%	Damodar
88	Jamuria	West Bengal	148870	17.5	-	0%	Damodar
89	Bardhaman	West Bengal	328750	38.6	-	0%	Damodar
90	Panihati	West Bengal	400640	47	16.5	35%	Irrigation , Pissic,Canal
91	Bally	West Bengal	300810	35.3	45	100%	Irrigation, Pissic,Canal
92	Titagarh	West Bengal	142830	16.8	23	100%	Irrigation, Pissicult, Khal
93	Siliguri	West Bengal	540820	63.5	-	0%	Mahananda
94	Hugli-Chinsurah	West Bengal	195730	23	-	0%	Mahananda
95	Raiganj	West Bengal	190010	22.3	-	0%	Mahananda
96	Balurghat	West Bengal	155840	18.3	-	0%	Padma
97	Madhyamgram	West Bengal	178830	21	-	0%	Sunti
98	Delhi	Delhi	14858800	2948	2330	79%	Yamuna
99	Palwal	Haryana	132700	10	9	90%	Yamuna
100	Faridabad	Haryana	1392570	118.2	115	97%	Yamuna
101	Panipat	Haryana	345400	26.7	45	100%	Yamuna
102	Sonipat	Haryana	285400	21.2	30	100%	Yamuna

S. No.	City/Town	State/UT	Population	Total Sewage (in MLD)	Treatment Capacity (in MLD)	Percentage covered	Treated sewage Disposal
103	Karnal	Haryana	277830	28.6	48	100%	Yamuna
104	Gurgaon	Haryana	229080	17	30	100%	Yamuna
105	Jagadhri	Haryana	133720	10	-	0%	Yamuna
106	Agra	Uttar Pradesh	1549770	211.7	90.25	43%	Yamuna
107	Mathura	Uttar Pradesh	367560	40	27	68%	Yamuna
108	Noida	Uttar Pradesh	361510	39.4	70	100%	Yamuna
109	Firozabad	Uttar Pradesh	242930	37.4	-	0%	Yamuna
110	Etawah	Uttar Pradesh	260100	28.3	10.45	37%	Yamuna
111	Fatehpur	Uttar Pradesh	186660	20.3	-	0%	Yamuna
112	Hathras	Uttar Pradesh	151590	16.5	-	0%	Yamuna
113	Orai	Uttar Pradesh	171520	18.7	-	0%	Yamuna
	Total			7841.5			
Sewage Generation of Class I cities in Ganga main stem (Disposal In Land)							
1	Dinapur Nizamat	Bihar	191780	31	-	0%	Land
2	Rohtak	Bihar	145980	23.6	-	0%	Land
3	Hisar	Haryana	378540	28.1	-	0%	Land
4	Bhiwani	Haryana	338990	25.2	-	0%	Land
5	Hansi	Haryana	223640	17.6	-	0%	Land
6	Narnaul	Haryana	99210	5.6	-	0%	Land
7	Thanesar	Haryana	81340	4.5	-	0%	Land
8	Jind	Haryana	158500	11.8	-	0%	Land
9	Bahadurgarh	Haryana	179640	13.3	-	0%	Land
10	Rewari	Haryana	158190	11.7	-	0%	Land
11	Kaithal	Haryana	133250	10	-	0%	Land
12	Mango	Haryana	154740	11.5	-	0%	Land
13	Adityapur	Jharkhand	204290	30.1	-	0%	Land
14	Murwara	Jharkhand	146640	21.6	-	0%	Land
15	Katni)	Madhya Pradesh	244630	21.5	-	0%	Land
16	Jaipur	Rajasthan	2858910	367.2	54	15%	Land
17	Jhunjhunun	Rajasthan	123590	16	-	0%	Land
18	Loni	Uttar Pradesh	148410	16.2	-	0%	Land
19	Baranagar	West Bengal	288210	33.8	44.5	100%	Land
20	Rajarhat Gopalpur	West Bengal	312550	36.7	-	0%	Land
21	Bidhan Nagar	West Bengal	193030	22.7	-	0%	Land
22	English Bazar	West Bengal	185670	21.8	-	0%	Land
23	Uttarpara Kotrung	West Bengal	172730	20.3	-	0%	Land
24	Dumdum	West Bengal	116520	13.7	-	0%	Land
25	Barrackpur	West Bengal	165980	19.5	22.15	100%	Land
26	Khardaha	West Bengal	133690	15.7	3	19%	Land

S. No.	City/Town	State/UT	Population	Total Sewage (in MLD)	Treatment Capacity (in MLD)	Percentage covered	Treated sewage Disposal
27	Baidyabati	West Bengal	124470	14.6	2	14%	Land
28	Bhadreswar	West Bengal	121840	14.3	6	42%	Land
29	Bansberia	West Bengal	120120	14.1	2.8	20%	Land
30	Champdani	West Bengal	118720	14	12	86%	Land
	Total			907.4	146.45	16%	
Sewage Generation of Class II cities in Ganga main stem (Disposal In tributaries)							
1	Jehanabad	Bihar	98070	7.5	-	0%	Punpun
2	Aurangabad	Bihar	95220	7.3	-	0%	Punpun
3	Dhar	Madhya Pradesh	77740	5.4	-	0%	Chambal
4	Nagda	Madhya Pradesh	99420	7	9	100%	Chambal
5	Sehore	Madhya Pradesh	93660	7	-	0%	Kali Sindh
6	Chhatarpur	Madhya Pradesh	102500	7.2	-	0%	Ken
7	Mhow Cantt.	Madhya Pradesh	87570	13.8	-	0%	Khan River
8	Chittaurgarh	Rajasthan	109470	6.4	-	0%	Berach
9	Baran	Rajasthan	89340	5.3	-	0%	Chambal
10	Gangapur City	Rajasthan	110350	6.4	-	0%	Chambal
11	Bundi	Rajasthan	100680	6.2	-	0%	Chambal
12	Dhaulpur	Rajasthan	105040	6.8	-	0%	Chambal
13	Sawai Madhopur	Rajasthan	111140	6.4	-	0%	Chambal
14	Khurja	Uttar Pradesh	114550	9.4	-	0%	Kali
15	Kasganj	Uttar Pradesh	107650	9.2	-	0%	Kali
16	Kashipur	Uttarakhand	108230	9.4	-	0%	Kosi
17	Rudrapur	Uttarakhand	103270	8.5	-	0%	Yamuna
18	Bishnupur	West Bengal	70180	5.3	-	0%	Damodar
	Total		1592206	134.6	9	7%	
Sewage Generation of Class II cities in Ganga main stem (Disposal In Land)							
1	Lakhisarai	Bihar	93410	7.2	-	0%	Land
2	Madhubani	Bihar	79540	6.1	-	0%	Land
3	Jamalpur	Bihar	115990	9	-	0%	Land
4	Nawada	Bihar	98750	7.6	-	0%	Land
5	Bagaha	Bihar	109660	8.4	-	0%	Land
6	Samastipur	Bihar	66710	5.1	-	0%	Land
7	Araria	Bihar	72710	5.6	-	0%	Land
8	Gopalganj	Bihar	65300	5	-	0%	Land
9	Jamui	Bihar	80100	6.1	-	0%	Land
10	Kishanganj	Bihar	102590	9.6	-	0%	Land
11	Phulwari Sharif	Bihar	63800	5	-	0%	Land
12	Supaul	Bihar	64820	5	-	0%	Land
13	Ambikapur	Chhatisgarh	74580	4.8	-	0%	Land
14	Hansi	Haryana	99210	5.6	-	0%	Land
15	Narnaul	Haryana	81340	4.5	-	0%	Land
16	Phusro	Jharkhand	100160	7.7	-	0%	Land
17	Daltonganj	Jharkhand	85570	6.6	-	0%	Land

S. No.	City/Town	State/UT	Population	Total Sewage (in MLD)	Treatment Capacity (in MLD)	Percentage covered	Treated sewage Disposal
18	Ramgarh Cantt.	Jharkhand	88150	7.2	-	0%	Land
19	Juumri Tilaiya	Jharkhand	83330	7.3	-	0%	Land
20	Giridih	Jharkhand	118280	9.1	-	0%	Land
21	Deoghar	Jharkhand	118050	9.1	-	0%	Land
22	Sindri	Jharkhand	92190	7.1	-	0%	Land
23	Jharia	Jharkhand	98370	7.5	-	0%	Land
24	Bina Etawa	Madhya Pradesh	52720	7.2	-	0%	Land
25	Datia	Madhya Pradesh	85220	6	-	0%	Land
26	Shahdol	Madhya Pradesh	80940	5.7	-	0%	Land
27	Tikamgarh	Madhya Pradesh	70630	4.9	-	0%	Land
28	Murwara (Katni)	Madhya Pradesh	244630	21.5	-	0%	Land
29	Pithampur	Madhya Pradesh	70090	5	-	0%	Land
30	Ashok Nagar	Madhya Pradesh	59410	4.2	-	0%	Land
31	Dabra	Madhya Pradesh	58360	4.1	-	0%	Land
32	Jaora	Madhya Pradesh	65650	4.6	-	0%	Land
33	Seoni	Madhya Pradesh	92490	8.4	-	0%	Land
34	Shajapur	Madhya Pradesh	51590	3.6	-	0%	Land
35	Sheopur	Madhya Pradesh	56680	4	-	0%	Land
36	Basoda	Madhya Pradesh	64230	4.5	-	0%	Land
37	Jhunjhunun	Rajasthan	123590	16	-	0%	Land
38	Kishangarh	Rajasthan	142870	18.4	-	0%	Land
39	Bharatpur	Rajasthan	251480	32.3	-	0%	Land
40	Makrana	Rajasthan	94950	5.5	-	0%	Land
41	Nawalgarh	Rajasthan	64390	3.7	-	0%	Land
42	Hindaun	Rajasthan	96650	5.6	-	0%	Land
43	Nimbahera	Rajasthan	60790	3.5	-	0%	Land
44	Tanda	Uttar Pradesh	96700	8	-	0%	Land
45	Baraut	Uttar Pradesh	99900	8.2	-	0%	Land
46	Balrampur	Uttar Pradesh	84060	7	-	0%	Land
47	Shahabad	Uttar Pradesh	78760	6.5	-	0%	Land
48	Chandpur	Uttar Pradesh	79570	6.6	-	0%	Land
49	Nagina	Uttar Pradesh	83000	6.8	-	0%	Land
50	Sahaswan	Uttar Pradesh	67740	5.6	-	0%	Land
51	Sikandrabad	Uttar Pradesh	81370	6.7	-	0%	Land
52	Shikohabad	Uttar Pradesh	102520	8.5	-	0%	Land
53	Mubarkpur	Uttar Pradesh	59460	6.3	-	0%	Land
54	Pilkhua	Uttar Pradesh	78210	6.5	-	0%	Land
55	Mahoba	Uttar Pradesh	91730	7.6	-	0%	Land
56	Mainpuri	Uttar Pradesh	104220	10	-	0%	Land

S. No.	City/Town	State/UT	Population	Total Sewage (in MLD)	Treatment Capacity (in MLD)	Percentage covered	Treated sewage Disposal
57	Mawana	Uttar Pradesh	80550	6.6	-	0%	Land
58	Kairana	Uttar Pradesh	85030	7	-	0%	Land
59	Shamli	Uttar Pradesh	104600	8.6	-	0%	Land
60	Tanda	Uttar Pradesh	96700	8	-	0%	Land
61	Bela Pratapgarh	Uttar Pradesh	83620	8	-	0%	Land
62	Bhadohi	Uttar Pradesh	86650	7.1	-	0%	Land
63	Agga Cantt.	Uttar Pradesh	65410	5.4	-	0%	Land
64	Auraiya	Uttar Pradesh	75190	6.2	-	0%	Land
65	Nawabganj	Uttar Pradesh	87400	7.2	-	0%	Land
66	Baheri	Uttar Pradesh	68180	5.6	-	0%	Land
67	Faridpur	Uttar Pradesh	71030	6	-	0%	Land
68	Sherkot	Uttar Pradesh	61540	5.1	-	0%	Land
69	Kiratpur	Uttar Pradesh	64380	5.3	-	0%	Land
70	Ujhani	Uttar Pradesh	59420	5	-	0%	Land
71	Jahangirabad	Uttar Pradesh	59790	5	-	0%	Land
72	Dadri	Uttar Pradesh	66880	5.5	-	0%	Land
73	Muradnagar	Uttar Pradesh	86230	7.1	-	0%	Land
74	Behta Hajipur	Uttar Pradesh	119900	9.1	-	0%	Land
75	Rath	Uttar Pradesh	65110	5.4	-	0%	Land
76	Jalaun	Uttar Pradesh	58240	4.8	-	0%	Land
77	Konch	Uttar Pradesh	59050	5	-	0%	Land
78	Mauranipur	Uttar Pradesh	59230	5	-	0%	Land
79	Hasanpur	Uttar Pradesh	62090	5.1	-	0%	Land
80	Chhibramau	Uttar Pradesh	58520	4.8	-	0%	Land
81	Gola Gokarannath	Uttar Pradesh	62660	5.2	-	0%	Land
82	Khatauli	Uttar Pradesh	68090	5.6	-	0%	Land
83	Bisalpur	Uttar Pradesh	70630	5.8	-	0%	Land
84	Gangoh	Uttar Pradesh	62790	5.2	-	0%	Land
85	Tilhar	Uttar Pradesh	61590	5.1	-	0%	Land
86	Laharpur	Uttar Pradesh	58290	4.8	-	0%	Land
87	Obra	Uttar Pradesh	60990	5	-	0%	Land
88	Renukoot	Uttar Pradesh	62300	5.1	-	0%	Land
89	Vrindavan	Uttar Pradesh	65900	5.4	4.5	83%	Land
90	Katwa	West Bengal	81090	6.2	2.3	37%	Land
91	Suri	West Bengal	70040	6	-	0%	Land
92	Contai	West Bengal	87800	6.7	-	0%	Land
93	Bolpur	West Bengal	74390	5.6	-	0%	Land
94	Arambag	West Bengal	63590	4.8	-	0%	Land
95	Jangipur	West Bengal	84370	6.4	-	0%	Land
96	Chakdaha	West Bengal	98530	8.3	-	0%	Land
97	Kalna	West Bengal	59120	4.5	-	0%	Land
98	Rampurhat	West Bengal	57340	4.4	-	0%	Land
99	Gangarampur	West Bengal	60670	4.6	-	0%	Land
100	Alipurduar	West Bengal	82760	6.3	-	0%	Land
101	Koch Bihar	West Bengal	87030	9.5	-	0%	Land
102	Old Maldah	West Bengal	71320	5.4	-	0%	Land
103	Ghatal	West Bengal	58450	4.4	-	0%	Land
104	Jhargram	West Bengal	60230	4.6	-	0%	Land

S. No.	City/Town	State/UT	Population	Total Sewage (in MLD)	Treatment Capacity (in MLD)	Percentage covered	Treated sewage Disposal
105	Kharagpur Rly. Settlement	West Bengal	100090	7.6	-	0%	Land
106	Kandi	West Bengal	57040	4.3	-	0%	Land
107	Dhulian	West Bengal	82600	6.3	-	0%	Land
108	Phulia	West Bengal	56940	4.3	-	0%	Land
109	New Barrackpur	West Bengal	94250	7.2	-	0%	Land
110	Islampur	West Bengal	59780	4.5	-	0%	Land
111	Konnagar	West Bengal	81820	6.2	22	100%	Land
112	Gayespur	West Bengal	62350	4.7	-	0%	Land
113	Kalyani	West Bengal	92890	7.1	17	100%	Land
114	Garulia	West Bengal	86460	6.6	7.9	100%	Land
115	Budge Budge	West Bengal	85500	6.5	0.18	3%	Land
	Total			767.3	53.88	7%	

Source: Status of water supply, waste water generation and treatment in class-I cities and class-II towns of India, CPCB, 2010

Appendix 4.2 List of Water Quality Parameters Analyzed under National Water Quality Monitoring Programme

S. No.	Parameters	S. No.	Parameters
	Core Parameters (9)		**Field Observations (7)**
1	PH	1	Weather
2	Temperature	2	Depth of main stream/depth of water table
3	Conductivity, µmhos/cm	3	Color and intensity
4	Dissolved Oxygen, mg/L	4	Odor
5	BOD, mg/L	5	Visible effluent discharge
6	Nitrate – N, mg/L	6	Human activities around station
7	Nitrite – N, mg/L	7	Station detail
8	Fecal Coliform, MPN/100 ml		**Trace Metals (9)**
9	Total Coliform, MPN/100 ml	1	Arsenic, µg/L
	General Parameters (19)	2	Cadmium, µg/L
1	Turbidity, NTU	3	Copper, µg/L
2	Phenolphthalein Alkalinity, as CaCO3	4	Lead, µg/L
3	Total Alkalinity, as CaCO3	5	Chromium (Total), µg/L
4	Chlorides, mg/L	6	Nickel, µg/L
5	COD, mg/L	7	Zinc, µg/L
6	Total Kjeldahl - N, as N mg/L	8	Mercury, µg/L
7	Ammonia - N, as N mg/L	9	Iron (Total), µg/L
8	Hardness, as CaCO3		**Pesticides (15)**
9	Calcium, as CaCO3	1	Alpha BHC, µg/L
10	Sulphate, mg/L	2	Beta BHC, µg/L
11	Sodium, mg/L	3	Gama BHC (Lindane), µg/L
12	Total Dissolved Solids, mg/L	4	O P DDT, µg/L
13	Total Fixed Dissolved Solids, mg/L	5	P P DDT, µg/L
14	Total suspended Solid, mg/L	6	Alpha Endosulphan, µg/L
15	Phosphate, mg/L	7	Beta Endosulphan, µg/L
16	Boron, mg/L	8	Aldrin, µg/L
17	Magnesium, as CaCO3	9	Dieldrin, µg/L
18	Potassium, mg/L	10	Carboryl (Carbamate), µg/L
19	Fluoride, mg/L	11	2-4 D, µg/L
	Bio-Monitoring (3)	12	Malathian, µg/L
1	Saprobity Index	13	Methyl Parathian, µg/L
2	Diversity Index	14	Anilophos, µg/L
3	P/R Ratio	15	Chloropyriphos, µg/L

Source: Central Pollution Control Board

Appendix 4.3 Water Quality trends of river Yamuna (2005-2009)

Location	pH					B.O.D (Mg/l)					DO (mg/l)					FECAL COLIFORM (MPN/100 ml)					TOTAL COLIFORM (MPN/100ml)				
	2005	2006	2007	2008	2009	2005	2006	2007	2008	2009	2005	2006	2007	2008	2009	2005	2006	2007	2008	2009	2005	2006	2007	2008	2009
Yamuna at Yamunotri	7.0	-	7.2	7.2	7.0	1.0	-	-	1.0	1.0	8.4	-	11.4	9.1	8.1	80	-	37000	1300	1750	18	-	-	66000	16100
Shyama Chatti. UT	7.0	-	7.2	7.6	7.1	1.0	-	-	6.0	2.0	10.2	-	9.0	9.2	8.7	1650	-	82500	23000	3300	360	-	-	87000	22000
Yamuna at U/S of Lakhwar Dam. UT	7.8	7.7	7.4	7.6	8.0	0.9	1.0	0.7	1.2	0.7	9.9	10.4	9.8	8.7	8.2	3925	1254	86333	50910	10100	1155	730	1275	366600	63500
Yamuna at U/S of DAK Patthar UT	7.9	7.6	7.3	7.3	8.3	1.2	1.0	1.0	1.8	1.7	9.3	9.6	8.5	8.3	7.8	104946	2033	363000	109200	14750	2445	206	12550	723670	73256
River Yamuna, U/S Paonta Sahib, H.P.	8.3	9.1	7.7	7.9	7.7	2.5	4.6	0.9	1.2	1.2	7.6	8.0	8.5	8.5	7.3	53	17	2821500	29088	157733	18	11	46582	984586	1615833
River Yamuna, D/S Paonta Sahib, H.P.	8.3	9.2	7.8	8.2	8.2	4.3	4.3	0.5	2.3	1.0	7.0	8.1	8.2	7.9	7.8	49	21	-	1200	14	29	15	-	2233	27
Yamuna at Hathnikund Haryana	7.5	7.9	7.7	7.9	7.7	1.6	1.5	1.2	1.4	1.2	9.2	8.6	9.2	9.6	9.1	619673	67250	3909667	25360	97055	9023	1113	44770	395545	829727
Yamuna at Kalanaur, Yamuna Nagar	7.9	7.7	7.7	7.8	7.7	1.8	2.0	2.0	1.9	2.1	8.1	8.5	7.6	7.6	7.8	616125	259000	2702333	66476	154350	12881	3145	147880	873455	1407300
Yamuna at Sonepat	7.7	7.8	7.7	7.8	7.8	2.8	4.0	2.8	2.7	3.8	7.5	7.1	7.1	7.2	6.9	910783	329000	691250	152033	173483	14309	3948	26165	1220000	7401833
Yamun at Wazirabad, Delhi	7.6	7.6	7.8	7.9	7.9	1.9	3.5	3.0	1.5	2.3	8.4	7.1	8.3	8.1	7.3	40842	112250	1643667	18600	16117	2930	4025	5617	146727	311167
Yamuna at Nizamuddin, Delhi	7.4	7.3	7.5	7.6	7.6	23.0	36.0	23.8	25.7	23.4	2.1	-	0.3	0.5	0.0	31786556	36225000	50172000	1064545	5799167	2351938	1772500	3757583	8918182	97191667
Yamuna at Okhla Bridge (inlet of Agra Canal), Delhi	7.3	7.4	7.2	7.7	7.7	14.8	30.5	1.9	12.8	14.5	1.5	-	7.4	0.2	0.1	13986000	11150000	300	709900	3094546	943273	1670000	-	6512000	38727273
Yamuna at Okhla after meeting of Shahdara Drain	7.2	7.3	7.4	7.6	7.3	29.7	94.8	47.7	61.8	51.3	2.9	-	0.0	0.0	0.0	51313636	62640000	62640000	4788333	216378000	1691455	4068000	7441667	48683333	2475240000
Yamuna at Mazawali	7.8	7.7	7.7	7.8	7.8	17.0	33.8	17.8	16.3	18.2	3.6	2.4	2.5	1.3	2.1	4924000	9117500	4942500	427818	540917	822300	2110250	384742	8772727	9210909
Yamuna at Mathura U/S U.P.	7.7	7.7	7.8	7.9	7.8	10.0	16.8	10.8	8.9	9.2	6.4	4.9	5.8	4.9	5.7	759300	2017500	520333	178100	89950	60682	74750	17550	2895091	2389182
Yamuna at Mathura D/S U.P.	7.7	7.7	7.8	7.9	7.7	8.0	15.3	9.3	10.6	9.4	5.7	5.9	5.8	5.8	6.0	1262727	1880000	1469167	311109	182417	334200	821000	50692	2831818	664333
Yamuna at Agra U/S	7.9	7.9	7.8	7.8	7.9	9.0	12.0	10.2	7.7	8.1	8.5	5.3	7.0	5.9	6.3	5892364	5114250	1184000	205718	232818	246909	132275	70475	1285455	6380636
Yamuna at D/S of Agra, U.P.	7.7	7.7	7.8	7.8	7.8	13.0	19.7	16.7	14.0	14.5	5.3	2.9	4.9	5.3	4.1	10313750	30225000	9425000	459364	1403546	1758182	759500	1483675	7672727	31799091
Yamuna at Bateswar	8.1	7.7	7.8	8.0	7.8	11.0	15.5	11.4	12.2	12.3	10.2	7.5	8.2	8.8	8.9	16838333	596000	1920333	83727	236530	23858	27333	43167	694091	2920300
Yamuna at Etawah, U.P.	8.3	8.4	7.8	8.0	7.9	14.0	18.3	10.2	11.2	13.2	11.6	16.5	10.1	9.6	11.5	14492750	613000	917333	80018	273273	17983	31875	38417	824455	2270909
Yamuna at Juhika B/C with Chanbal, Etawah, U.P.	8.1	8.4	7.8	8.0	7.9	5.0	6.5	4.2	4.2	4.4	8.4	11.0	9.3	10.5	9.8	232800	139250	567917	193909	248700	9897	4475	21692	1349364	1819546
Yamuna at Hamirpur	-	-	-	7.8	8.0	-	-	-	2.0	2.5	-	-	-	6.6	7.6	-	-	-	49050	266250	-	-	-	782500	1876667
Yamuna at Allahabad U.P.	8.0	7.9	8.0	-	-	2.0	5.0	2.2	-	-	7.3	6.7	8.7	-		1299000	161000	1700	-	-	17050	47000	1100	-	-
Yamuna at Allahabad D/W (Balua Ghat), U.P.	7.7	8.1	8.1	8.2	8.1	2.0	2.1	2.5	2.2	1.8	7.6	7.6	8.5	7.9	7.3	1842	1988	3158	2250	1167	1166	1288	1775	3925	1933

Source: CPCB