Ganga River Basin Environment Management Plan: Interim Report

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by

Consortium of 7 "Indian Institute of Technology"s (IITs)

IIT Bombay | IIT Delhi | IIT Guwahati | IIT Kanpur | IIT Kharagpur | IIT Madras | IIT Roorkee

In Collaboration with

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Preface

In exercise of the powers conferred by sub-sections (1) and (3) of Section 3 of the Environment (Protection) Act, 1986 (29 of 1986), the Central Government constituted the National Ganga River Basin Authority (NGRBA) as a planning, financing, monitoring and coordinating authority for strengthening the collective efforts of the Central and State Governments for effective abatement of pollution and conservation of the Ganga river. One of the important functions of the NGRBA is to prepare and implement a Ganga River Basin Environment Management Plan (GRBEMP). A Consortium of 7 "Indian Institute of Technology"s (IITs) was given the responsibility of preparing the GRBEMP by the Ministry of Environment and Forests (MoEF), GOI, New Delhi. A Memorandum of Agreement (MoA) was signed between 7 IITs (Bombay, Delhi, Guwahati, Kanpur, Kharagpur, Madras and Roorkee) and MoEF for this purpose on July 6, 2010.

This is the Interim "Ganga River Basin Environment Management Plan". The thrust of this Plan is to relate the diverse environmental degradations occurring in the basin with their causal factors, and thereby frame a roadmap for redeeming National River Ganga Basin's Environment. The task involved different thematic groups of experts from 7 IITs and other premier organizations identifying different causal factors and assessing their impacts on the basin to synthesize the findings and recommendations in fulfillment of the important missions identified in the Plan. This report covers the main issues of concern and recommends corrective measures. While major changes in the final Plan are note foreseen, our studies have not achieved closure on all aspects; hence there could be additional actionable recommendations in the final Plan.

The progress in preparing this Plan was affected by several factors. On the one hand, co-ordination between experts working in different institutions was not always speedy. On the other hand, the progress depended on obtaining relevant primary data from nodal government agencies, which was often tardy and circuitous. This also affected the timely co-ordination between related thematic groups. It is hoped that data availability in future will become simpler and faster.

Many people contributed directly or indirectly to the preparation of this Plan. A wide range of stakeholders were consulted through various workshops, seminars and informal discussions, and many people freely gave their suggestions and comments on many substantive issues. This document is therefore truly a collective effort that reflects the cooperation of many people, particularly members of the IIT Team and keenly interested members of the general population.

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Executive Summary

Overview**:** National River Ganga, along with her many tributaries, has been the source of physical and spiritual sustenance of Indian civilization for millennia, and consequently, her well-being is of prime national concern. The physical environment of the National River Ganga Basin (NRGB in short) is governed by a complex combination of natural and manmade processes. With proliferation and diversification of human activities, the resulting environmental degradation has greatly increased in recent decades. The Ganga River Basin Environment Management Plan (GRBEMP) seeks ways and means to strengthen the basin environment against the identifiable adverse impacts. It may be noted here that, since the aquatic systems of NRGB – consisting mainly of rivers/ streams, groundwater and water bodies – are hydraulically connected by groundwater flow in much of the basin (besides other hydrological and ecological connections) the GRBEMP adopts the Ganga river system as the primary environmental indicator of NRGB.

Anthropogenic Factors**:** Uncontrolled anthropogenic activities are a major cause of NRGB's environmental degradation in recent times. The degradations may be grouped under five main heads: (i) over-withdrawal of fresh water from the basin; (ii) discharge of pollutants into the aquatic environment; (iii) reduction in water-holding capacities and replenishment rates into water bodies, aquifers and ecosystems; (iv) mutilation of rivers by piecemeal engineering operations; and (v) changes in geological factors governing aquatic systems. The major human activities affecting the aquatic environment of NRGB in modern times may also be grouped under major heads as follows: Industrialization, Urbanization, Lifestyle Changes, Agricultural and Other Rural Activities, and Deforestation/Denudation.

Key Features of NRGB**:** NRGB is the largest river basin in India, covering more than a quarter of her land area, and hosting about 43% of her population. Annual rainfall in the basin is quite high towards the east and north, but decreases progressively towards the west. On the whole, NRGB is fairly rich in surface and groundwater resources. There are many wetlands (including freshwater and saline lakes) spread across the basin, which perform crucial ecosystem services for the basin. A highly productive multi-aquifer system spread over much of the basin boosts the basin's water yields. The river basin itself was formed by alluvial deposits of Himalayan sediments since the rise of the Himalayan mountain range millions of years ago, and, even in present times, Ganga river carries very high sediment loads to the sea. The river network is characterized by deep gorges in the Himalayan zone, meandering patterns in the plains, and braiding in the delta region. Ganga river's valley mapping shows significant diversity of valley widths and geomorphic features in its different reaches. Flora and fauna in the river also show significant biodiversity, indicating variations in substrate, habitat, and trophic status in the river system.

Concepts and Objectives**:** National River Ganga – whose wholesome qualities have been praised over the ages – has been flowing with her life-giving qualities since ancient times. The wholesomeness of the river may be grasped in terms of four defining concepts**:** *Aviral*

Dhara" (or "Continuous Flow"), "*Nirmal Dhara*" (or "Unpolluted Flow"), Geologic Entity, and Ecological Entity. To plan the recovery of a wholesome National River Ganga, the task of analyzing the environment was broken up from the whole to its parts into eight Thematic Groups, namely**:** *Environmental Quality and Pollution*; *Water Resources Management*; *Fluvial Geomorphology*; *Ecology and Biodiversity*; *Socio-economic and Socio-Cultural*; *Policy, Law and Governance*; *Geo-Spatial Database Management*; and *Communication*. Each thematic study is conducted by select groups of IIT faculty members and experts, and 7 important missions were identified in the Plan for focused interventions**:** "*Aviral Dhara*", "*Nirmal Dhara*", "*Ecological Restoration*", "*Geological Safeguarding*", "*Disaster Management*", "*Sustainable Agriculture*", and "*Environmental Knowledge-Building and Sensitization*". Based on the findings, action plans are formulated to counter harmful anthropogenic activities in NRGB and promote helpful activities.

Mission *Aviral Dhara***:** For a given geological-climatic setting, alluvial rivers achieve stability through long-term balance between various parameters such as water and sediment flow rates, temporal variations of flow, terrain gradient, and seepage flow rates. "*Aviral Dhara*" emanates from this long-term balance of rivers. A direct violation of *Aviral Dhara* is due to dams and barrages, which snap the longitudinal connectivity in rivers and alter river water and sediment flows. However, since NRGB is hydraulically connected by ground water flow, water withdrawals/recharges from different regions of the basin also affect the river. Thus, while longitudinal connectivity in rivers is a prerequisite for *Aviral Dhara*, maintaining Environmental Flows (or E-flows) needed for the sustenance of rivers also depends on judicious management of the basin's waters. Available data indicate that human water use has been increasing rapidly of late, and probably increasing beyond the renewal capacity of the basin. Hence, either (i) water availability in the basin must be increased through *increased storage*, preferably by "distributed storage" in locally manageable and eco-friendly water bodies and aquifers, and/or (ii) water demands must be reduced through more *efficient water use*. These issues call for both technical interventions and changes in government policies on NRGB's water resources. For dams and other structures that disrupt or change river flows, the maintenance of E-flows in the river network is essential, besides fulfilling other safety criteria. The estimated E-Flows for select locations in the Upper Ganga reach – which has many existing and potential hydropower sites – have been presented to enable their inclusion in the design and operation of these dams and barrages.

Mission *Nirmal Dhara***:** The Ganga river's present-day water quality is abysmal due to anthropogenic wastes polluting the river network in various ways. The main approach in GRBEMP has been to identify the types of pollutants, their sources of generation, and the feasibility of collecting and treating them to the degree needed for reuse and/or safe environmental disposal. Urban and industrial wastewaters are major point sources of pollution that need immediate remediation. For municipal wastewaters it was found that it is economically feasible to treat them to the point where they can be re-used for non-contact purposes, the cost of such additional treatment being only about 1 paisa per litre at

2010 price levels. It is therefore recommended that all Class 1 Towns of NRGB immediately embark on such treatment through competent service providers under the Design-Build-Finance-Operate model, whereby the service provider receives remuneration for providing reusable-quality water over a reasonably long contract period. It is also recommended that all fresh water withdrawals from the basin be priced at least 50% higher than the recycled water, considering the minimum costs of full treatment in nature. For major polluting industries (*such as tanneries, pulp and paper units, distilleries* and *dyeing units*) in NRGB, the cost of treatment for reuse purposes are higher, but these costs are much less than the damage caused to NRGB otherwise, justifiying the expenditure on such treatment.

Mission *Ecological Restoration*: The ecological balance in the Ganga river network has been critically affected in recent times, with major indicator species (such as Dolphins, Trouts, Carps and Hilsa fishes) having dwindled or disappeared. The analyses indicate that the ecological status can be largely restored by adhering to the principles of "Aviral Dhara" and "Nirmal Dhara" by ensuring unpolluted E-flows and variable flow regimes, protection of spawning and breeding grounds of native species, elimination of competing exotic species from the Ganga river network, and protection from human encroachments.

Mission *Geological Safeguarding*: Modern human activities – such as underground explosions, excavations, tunneling, rock fracturing, mining, and operation of large reservoirs – can damage the geological formations supporting the basin's aquatic systems. Over-withdrawal of ground water from confined/ semi-confined aquifers may also create unbearable overburden pressures, causing land subsidence. Geomorphologically, rivers and wetlands are vulnerable to various land-use stresses. Land-uses needing immediate control are deforestation, construction activities on riverbanks and fragile slopes, agricultural practices that increase soil erosion, sand mining from river beds, urban, industrial and infrastructure projects that adversely affect drainage patterns, and local flood control works and river bank modifications.

Mission *Disaster Management*: The main potential disasters arising from the Ganga River network are floods and water-borne diseases. While the causes of floods in mountainous reaches and in plains are different, floods are not really preventable, and protection of life and valuables are the main option. Besides, flood waters carry valuable nutrient-rich silt to floodplains, enhancing soil fertility. For control of floods in floodplains, natural flood attenuation methods such as forests and wetlands are preferable to ill-conceived structural measures. On the other hand, water-borne diseases from rivers can be largely controlled by the twin focus on Aviral Dhara and Nirmal Dhara in the Ganga River System.

Mission *Sustainable Agriculture*: Agriculture has grown tremendously in NRGB since the 1960's, and irrigation water use has also increased concomitantly. Hence water depletion in NRGB is significantly attributable to growing agricultural consumption, calling for more efficient irrigation practices and alternate cropping patterns. Besides, agriculture is also a major source of water pollution, especially due to chemical fertilizers and pesticides, many of which may be highly toxic, chemically stable, and/or biomagnifying through the food

chain. This necessitates the promotion of bio-fertilizers and bio-pesticides in place of chemical fertilizers and pesticides.

Mission *Environmental Knowledge-Building and Sensitization*: Environmental planning and management combines diverse fields such as water resources, land resources, biological resources, river dynamics, geological phenomena and atmospheric processes as well as traditional wisdom and grassroots knowledge. Hence, it is necessary to build an environmental data bank to enable meaningful analyses and obtain quantitative indicators of environmental status. This data bank should also be accessible to citizens to inform and sensitize them about NRGB's environment and to enable people's participation in the environmental upkeep of NRGB. The data bank, therefore, needs to be complemented with community-specific educational material and programmes on NRGB's environment.

Conclusions: Specific anthropogenic activities that should be *Prohibited*, *Restricted* or *Promoted* in NRGB have been identified in GRBEMP. Their implementation and future development would require the co-ordinated efforts and co-operation of government and non-government institutions, key stakeholders and civil society. It is envisaged that only a dedicated, knowledge-based, empowered and stakeholder-involving agency would be able to pool in the collective knowledge and resources for environmental rejuvenation of NRGB. The implementation, monitoring, review and evaluation of environmental problems and pertinent interventions on a long-term basis are therefore recommended through an independent Commission. The said Commission would need adequate resources and authority to co-ordinate and oversee the activities of multiple sectoral organizations and informal sectors of society for the environmental conservation of NRGB in a transparent manner. GRBEMP, therefore, includes the functional requirements of the Commission proposed to be established by an Act of Parliament to bring the Commission into effect.

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1. Introduction

1.1. The Ganga River Basin in Environmental Perspective

Indian civilization grew up under the care of River Ganga for thousands of years, nourished for generations by her generous bounties. River Ganga – along with her many tributaries – provided material, spiritual and cultural sustenance to millions of people who lived in and around her basin. And all through the ages, Indians held the munificent River Ganga as a Divine Body who descends from the mysterious heights of the Himalayas and winds all the way down to the sea, distributing her blessings to all and sundry. To the Indian mind, River Ganga is not only the holiest of rivers and purifier of mortal beings, but also a living goddess! Very aptly is she personified in Indian consciousness as "MOTHER GANGA".

The religious and cultural pre-eminence of Ganga river in the Indian ethos since the ages testifies to her centrality in Indian civilization. And this significance is so lasting that, even today, River Ganga remains the physical and spiritual lifeline of India. It is fitting, therefore, that the Ganga river was declared as India's **National River** by the government in 2008. But national concern about environmental degradation of the Ganga river and her basin had also become serious by then. It was against this backdrop that the "Consortium of Seven IITs" was assigned the task of preparing an Environment Management Plan for the Ganga River Basin. The Interim Environment Management Plan is presented here.

The physical environment of National River Ganga Basin (hereinafter referred to as "NRGB") is governed by a complex combination of natural and manmade processes which have been changing and evolving over time. With human activities multiplying and diversifying in the industrial age, the resulting environmental degradations have also been pronounced in recent times. Specifically, the aquatic environment – which governs human life and ecology of the area to a large extent – is perceived by many to be in an already critical state. The Ganga River Basin Environment Management Plan focuses on the aquatic environment and the major factors affecting it – especially the rapidly changing anthropogenic activities, and seeks ways and means to strengthen the environment against identifiable adverse impacts. GRBEMP attempts to assess the critical issues at stake and formulate a comprehensive plan to safeguard the aquatic environment in the foreseeable future. For, only thus can we secure the environmental foundation of NRGB for the good of one and all.

Human civilization has always considered its aquatic environment as an asset rather than a liability – hence the term "*water resource*", though the actual resources are much more than only water. In fact, natural waters – bound up with other environmental components – are an essential resource for human settlements and the ecology of an area. The general features of typical terrestrial aquatic environments can be seen in Figure 1.1. In NRGB, the water resources may be classified in three main groups, viz. surface water courses (e.g. rivers, streams, and rivulets or gullies or "nala"s), surface water bodies (lakes, ponds, marsh-lands and snow-packs), and ground water (water table and deep ground water). Among these, ground water has been in extensive use over the last 5 or 6 decades (since the advent

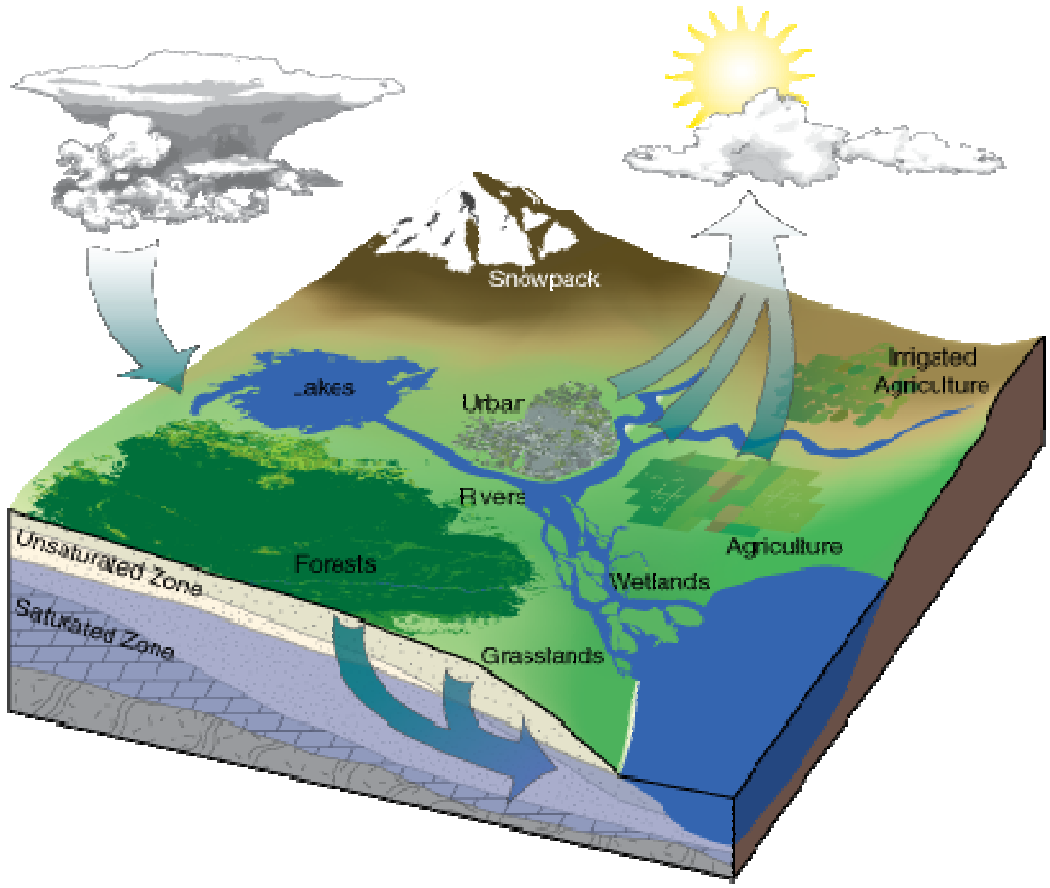

Figure 1.1: Illustrative Sketch of a Terrestrial Aquatic Environment [*MSU, 2013*]

[Note: All lakes may not be of "drainage-type", i.e. being drained by rivers as shown above; on the other hand, big lakes usually have streams conveying surface runoff into them.]

of economic tube-well technologies), while surface sources have been more widely used by people since millennia, with rivers and streams fulfilling major water needs in much of the NRGB. This is partly due to poor rainfall over long dry periods of 8–9 months a year, resulting in inadequate surface storage; but it is also because the Ganga river flows perennially, its head-streams and Himalayan tributaries being fed by snow- and ice-melt in the non-winter seasons (see Box 1.1). It should be also noted here that, apart from water, the Himalayan tributaries probably also bring valuable minerals from glacial and mountain rocks in their upper reaches, thereby providing long-term fertility to the basin [Diamond, 2005]. Historically, therefore, the Ganga river system has been the mainstay of civilization and ecology in NRGB.

Box 1.1

The Himalayan (Mountain) Range has a total area of 33,050 km^2 of glaciers … with a total ice volume of ca 3,421 km^3, (approx.) which provides important short and long-term water storage facilities. … Water from both permanent snow and ice and seasonal snow is released by melting … In the 'shoulder seasons', before and after precipitation from the summer monsoon, snow and ice melt contribute about 70% of the flow of the main Ganges river. – [*Eriksson et al., 2009*]

Snow and glacier melt contribute 29% to the annual flow at Devprayag. … Besides Gangotri (glacier), other glaciers in the headwaters region of Alaknanda, Yamuna, Ghaghara, Kosi, etc. also contribute to the flow in the Ganga. – [*Jain, 2008*]

In surveying the above hydrological setup of NRGB, it is easily seen that, while the overall water environment is a combination of three major types of water resource, these three types are not independent but are hydraulically connected in most of the alluvial basin by groundwater flow. Thus, while both surface and ground water reservoirs are replenished by monsoon rains, the productivity of surface water sources during the long dry periods depends much on the contemporary state of water table aquifers – water-filled aquifers boost their productivity, while depleted aquifers suck out the surface waters (*see Figure 1.2*). Directly and indirectly, therefore, the National River Ganga (along with her tributaries and distributaries), not only is a major source of the region's water needs, but is also a definitive indication of the aquatic health of the basin as a whole. Hence, the GRBEMP adopts the Ganga River Network as the primary environmental indicator of NRGB.

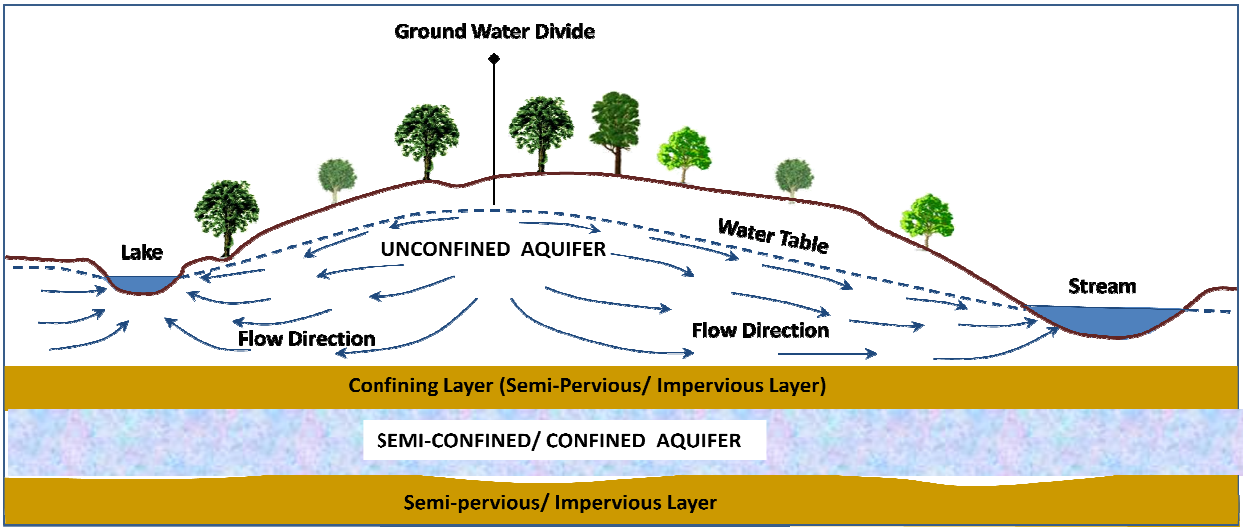

Figure 1.2: Schematic of hydraulic connectivity between water resource types in NRGB

1.2. Issues and Concerns of the NRGB Environment

Various anthropogenic factors have contributed directly to the degradation of NRGB's aquatic environment in recent times. Broadly, five major types of degradation factors are noticeable: (i) over-withdrawal of natural waters due to growing industrial, urban and rural consumption; (ii) discharge of pollutants into the aquatic environment causing deterioration in quality of natural waters; (iii) reduction in the rate of replenishment and water-holding capacities of natural reservoirs (which include both surface water bodies and groundwater aquifers); (iv) mutilation of rivers by piecemeal engineering operations; and (v) possible changes in geological factors governing the aquatic resources. Some environmental changes (such as change in rainfall patterns) may also have been produced by anthropogenic activities – either by external activities or indirectly by local activities. However, since such issues are often inadequately understood and/or not locally amendable, they are excluded from the scope of this phase of GRBEMP.

The major human activities affecting the aquatic environment of NRGB in modern times, and the reasons for their adverse effects, are broadly identified as follows:

1) **Industrialization**: (i) Over-withdrawal of fresh water from surface and ground water sources; (ii) discharge and dumping of industrial wastes and leakage of industrial pollutants into the aquatic environment.
2) **Urbanization**: (i) Over-withdrawal of water from surface and ground water sources for domestic, commercial and institutional activities; (ii) discharge of urban wastes and pollutants (including eroded soils and construction debris) into water courses/ bodies; (iii) reduction of surface water and ground water recharges; and (iv) changes in geo-morphological parameters governing water resources due to land-use changes.
3) **Lifestyle Changes**: (i) Over-withdrawal of water from surface and ground water sources; (ii) discharge of emerging contaminants into the aquatic environment.
4) **Agricultural & Other Rural Activities**: (i) Over-withdrawal of water from surface and ground water sources; and (ii) discharge of agricultural and rural wastes (including chemical fertilizers and pesticides) into the aquatic environment.
5) **Deforestation/ Denudation Activities**: Loss of vegetal cover due to deforestation, overgrazing, etc. resulting in rapid surface runoff; hence: (i) reduced groundwater recharge, (ii) increased runoff and soil erosion, with eroded soil eventually depositing in water courses and water bodies, and (iii) changes in geo-morphological parameters governing the region's water resources due to land-use changes.

In addition to the environmental effects listed above, piecemeal river-based projects (for hydropower, water supply, flood control, etc.) often directly infringe on river functioning, thereby producing complex, basin-wide environmental repercussions. Finally, various modern anthropogenic activities may also pose threats to geological formations governing the basin's water resources. Such activities include the depletion of deep aquifers, reservoir operation, construction works on fragile slopes, underground tunneling, excavations, and mining, and hydraulic fracturing of rocks. Likewise, land-use/ land-cover changes due to urban/ industrial/ infrastructure projects may affect the natural drainage pattern or cause other morphological changes, with consequent adverse effects on the aquatic environment. Since geological damages may be compounded by natural earth processes and are, moreover, not easily detected before they reach alarming proportions, these issues may need special precautions and long-term monitoring. The major disruptive modern activities and the consequent degradation factors are schematically shown in Figure 1.3.

The impact of environmental damages in NRGB on human beings may be gauged in terms of "ecosystem service" losses, which are losses of the multiple benefits that we normally derive from our environment (and which we often take for granted). "Ecosystem services" are commonly categorized as**:** (i) provisioning services or products which are visible and tradable items such as food, freshwater, fibres, and energy; (ii) regulating services e.g. flood attenuation, groundwater recharge, prevention of salt water intrusion; (iii) supporting services e.g. nutrient recycling, soil formation, biodiversity maintenance; and (iv) cultural services e.g. recreation, spiritual fulfillment [*UN-Water, 2013; Smith and Barchiesi, 2009*]. Even without quantitative economic evaluation of the ecosystem service losses, it should be

evident that all the service categories have been significantly affected in the NRGB, calling for urgent need to repair the environment.

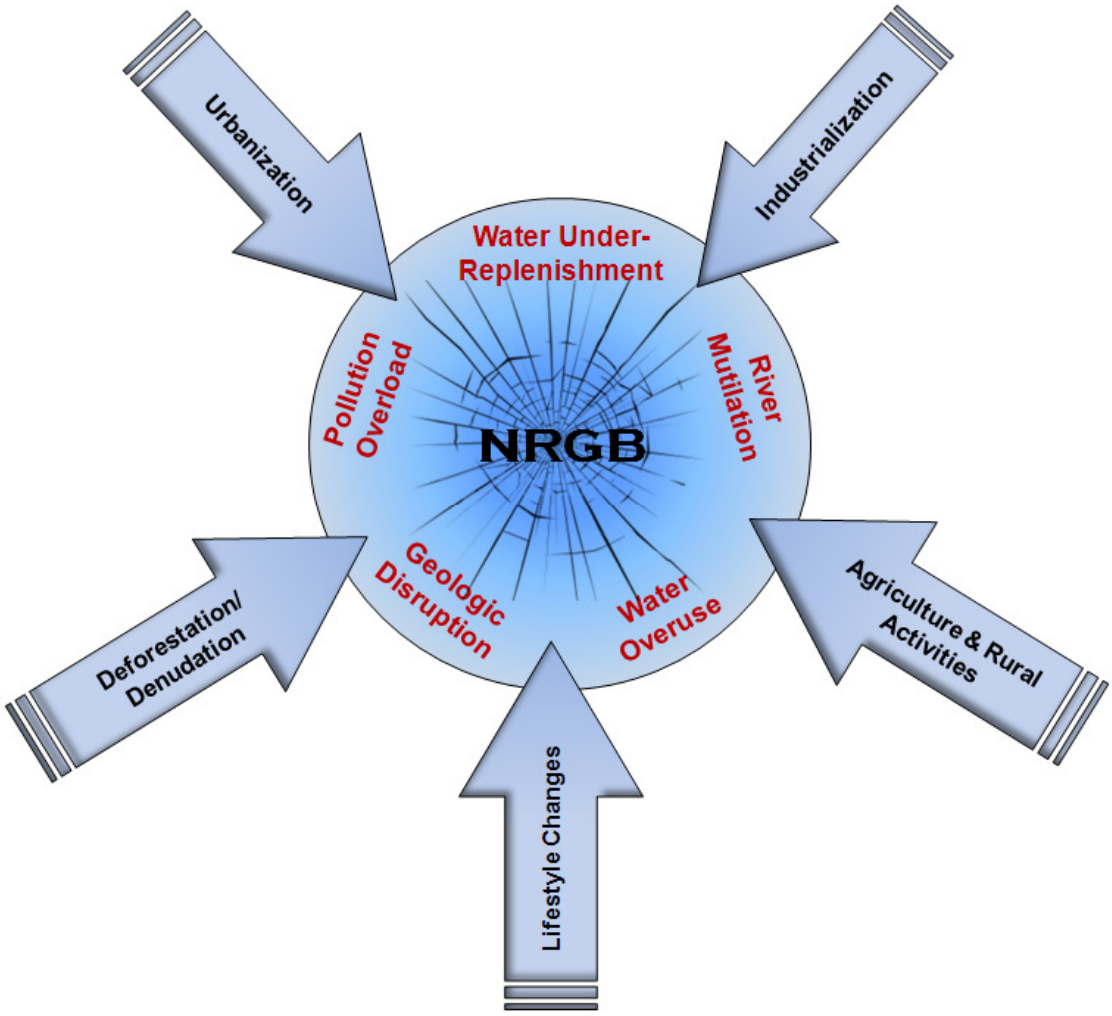

Figure 1.3: Major Adverse Impacts of Anthropogenic Activities on the NRGB Environment.

Among the five main types of environmentally significant human activities stated above, the first three are related predominantly to profitable activities or activities of relatively affluent sections of society. It must be very much possible, therefore, to review these activities and modify them suitably to minimize their adverse environmental impacts, even if some immediate costs are involved. On the other hand, certain activities (such as the fourth category above) often concern basic needs and livelihoods of relatively poor or marginal sections of society, and attempts to modify them significantly can cause social and financial distress. However, in such cases too, if the environmental impacts are significantly adverse, then suitable means must be devised to abate the negative impacts and ensure a wholesome environment in the NRGB. The GRBEMP attempts to provide a viable roadmap to mitigate such adverse environmental impacts in the foreseeable future, and thereby enable human communities to flourish and life to thrive in its myriad forms in the NRGB.

2. Key Features of National River Ganga Basin

2.1. Hydrology

The Ganga River Basin, spread over four nations (India, Nepal, China and Bangladesh) covers an area of about 1,080,000 sq.km of which the major part – the NRGB – of about 862,000 sq.km lies within India [*Jain et al., 2007; Wikipedia, 2013*]. The NRGB is the largest river basin of India, covering more than 26% of her geographical area (*see Figure 2.1a*). The region gets significant annual rainfall (apart from snowfall in higher reaches), but the rainfall varies considerably over the catchment**:** it is much higher towards NRGB's eastern and northern ends than towards the west (*see Figure 2.1b*). As per government data [*CWC, 2010; MoWR, 2002*], out of the total surface and ground water availability of 1,869 km^3/yr in India, the total water availability of NRGB is estimated to be 525 km^3/yr. Within India, only the combined Brahmaputra-Barak basin has higher water availability of 585.6 km^3/yr. However, much of that "available water" cannot be tapped, often causing devastating floods in some of the riparian states. Thus, the total surface water that can be utilized in NRGB (250 km^3/yr as per government estimate) is much higher than that of any other Indian basin, making it the most water-rich basin in the country (*vide Figure 2.1c*) that supports a staggering 43% of the Indian population [*IIT_GRB Thematic Report Code: 015_Dec 2011*].

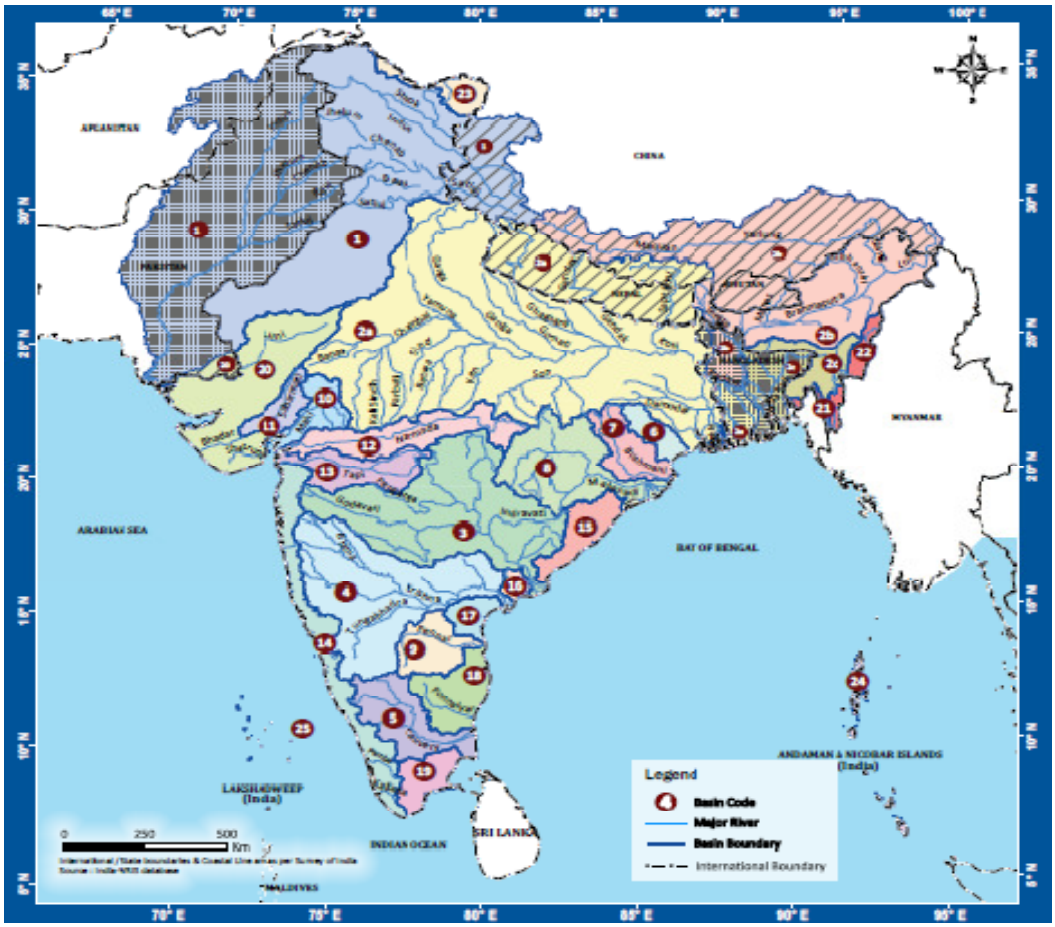

Figure 2.1a: Main River Basins of India: The Ganga River Basin is the yellow region marked as "2a" [*India-WRIS, 2012*].

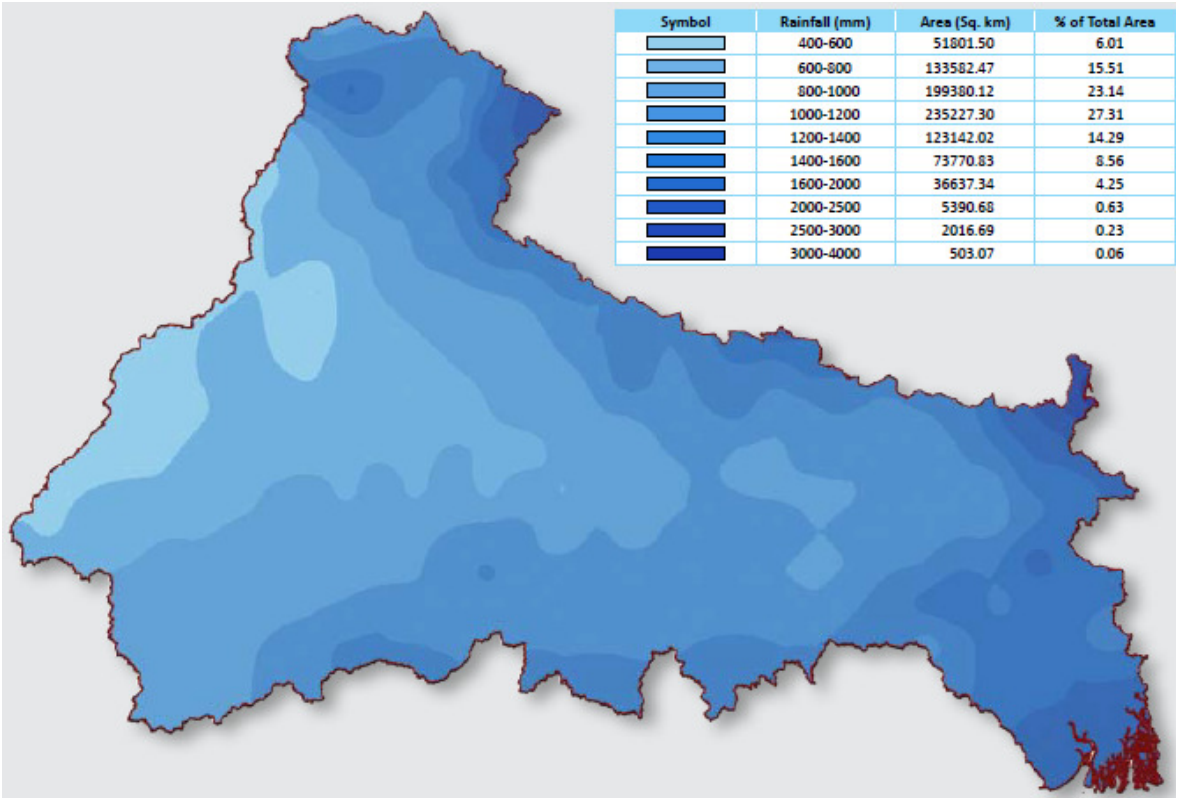

Figure 2.1b: Average Annual Rainfall during 1971–2005 in NRGB" [*India-WRIS, 2012*].

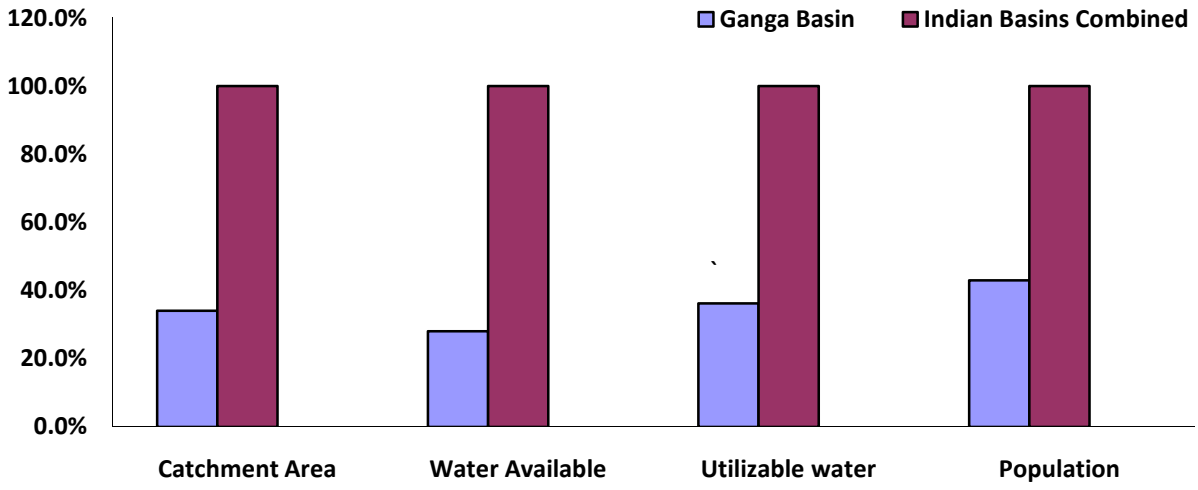

Figure 2.1c: Hydrological Importance of NRGB relative to Indian Basins Combined

2.2. Geology

Geologically, the NRGB is part of a tectonically active foreland basin of the Himalayan mountain range formed by collision of the northeast moving Indian tectonic plate with the Eurasian plate and its subduction under the latter, a process that commenced some twenty five million years ago. The former seabed south of the Himalayas then got gradually filled with sediments eroded from Himalayan rocks. Thus the NRGB – and the Indo-Gangetic plains as a whole – came to consist largely of alluvial plains formed during the Tertiary and Quaternary periods by flood deposits of Himalayan rivers. Alluvial deposits of up to or more

than 1 km thick, interspersed with semi-confining or confining strata, span across much of the basin, constituting large and highly productive multi-aquifer systems (*Figure 2.2*). The aquifers of the NRGB, which extend westward well beyond the basin boundary, are thus a major contributor to India's estimated total ground water potential of 433 cu.km./yr [*CGWB, 2009; CGWB, 2012; CWC, 2010; Wikipedia, 2013*].

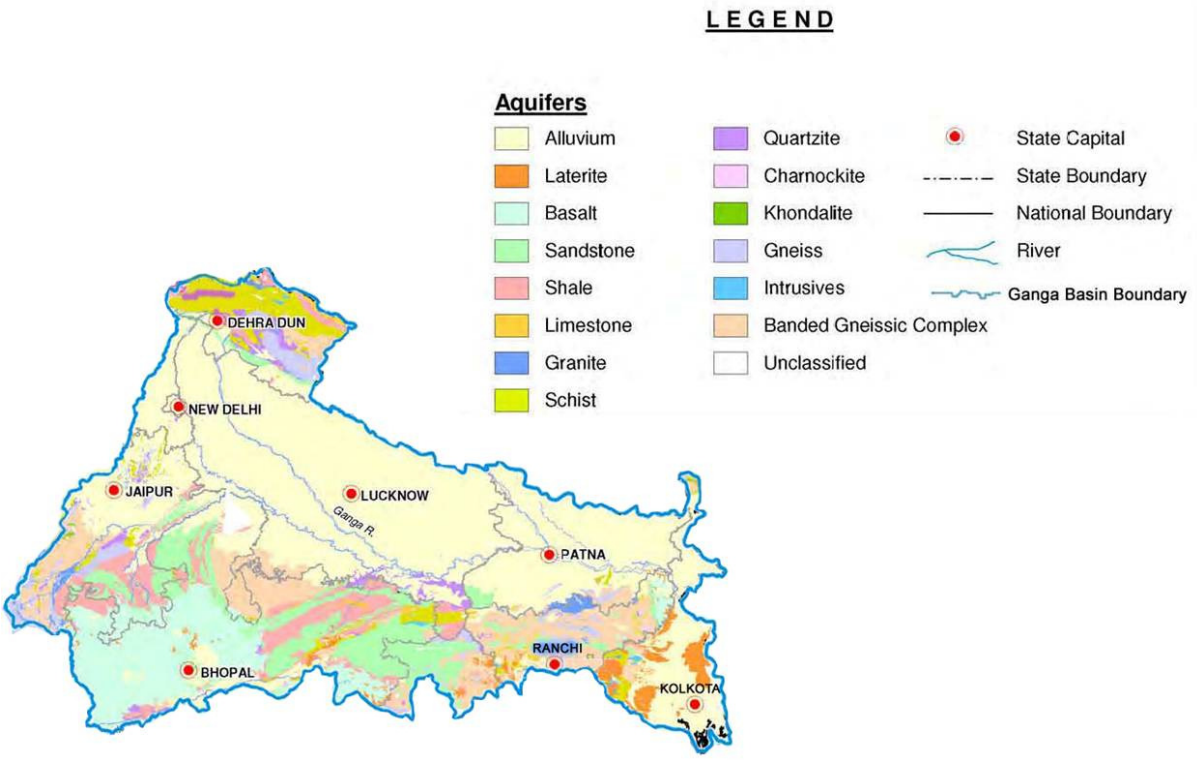

Figure 2.2: Aquifer Systems of NRGB [*Adapted from:* ***CGWB, 2012***]

The rivers in the upper and middle Ganga plains occupy narrow valleys separated by large interfluves. Near the Himalayan front, valley formation and incision were affected by both tectonic and climatic factors, whereas the strongly incised valley formation in the western and southern plains are believed to have been controlled mainly by climatic factors. In contrast, the fluvial morphologies in the lower Ganga plains and the deltaic region were influenced significantly by sea level fluctuations, besides climate and tectonics [*Sinha et al., 2005*]. It may be noted here that the Himalayan rivers of the Ganga River Network are not only water conveyance systems, but also conduits for large amounts of sediment transfer from the Himalayas to the river basin (by flooding) and to the Gangetic delta and the sea. To quote Tandon et al. [*2008*], the "Ganga river system ranks 18th worldwide in terms of its basin area (980,000 km^2) and 2nd in terms of the total suspended load (524 mt/yr)."

2.3. Wetlands

There are many lakes, tanks and marshes in NRGB. Figure 2.3a shows the many surface water bodies of NRGB including manmade reservoirs. Figure 2.3b shows some major fresh water and saline lakes of NRGB. But besides big lakes, NRGB has a large number and variety of wetlands spread across the basin – in the mountainous Himalayan region, the Himalayan terai region, the Gangetic plains, and the coastal deltaic region – which together support a

large and diverse ecological system in different geophysical settings. Several of NRGB's wetlands are home to specialized flora and fauna as well as migratory species, which fulfill crucial ecological and social functions such as nutrient recycling, water purification, flood attenuation, ground water recharge, and buffering of shorelines against erosion, besides providing water, fish, fodder and recreation to society [*Prasad, et al., 2002*].

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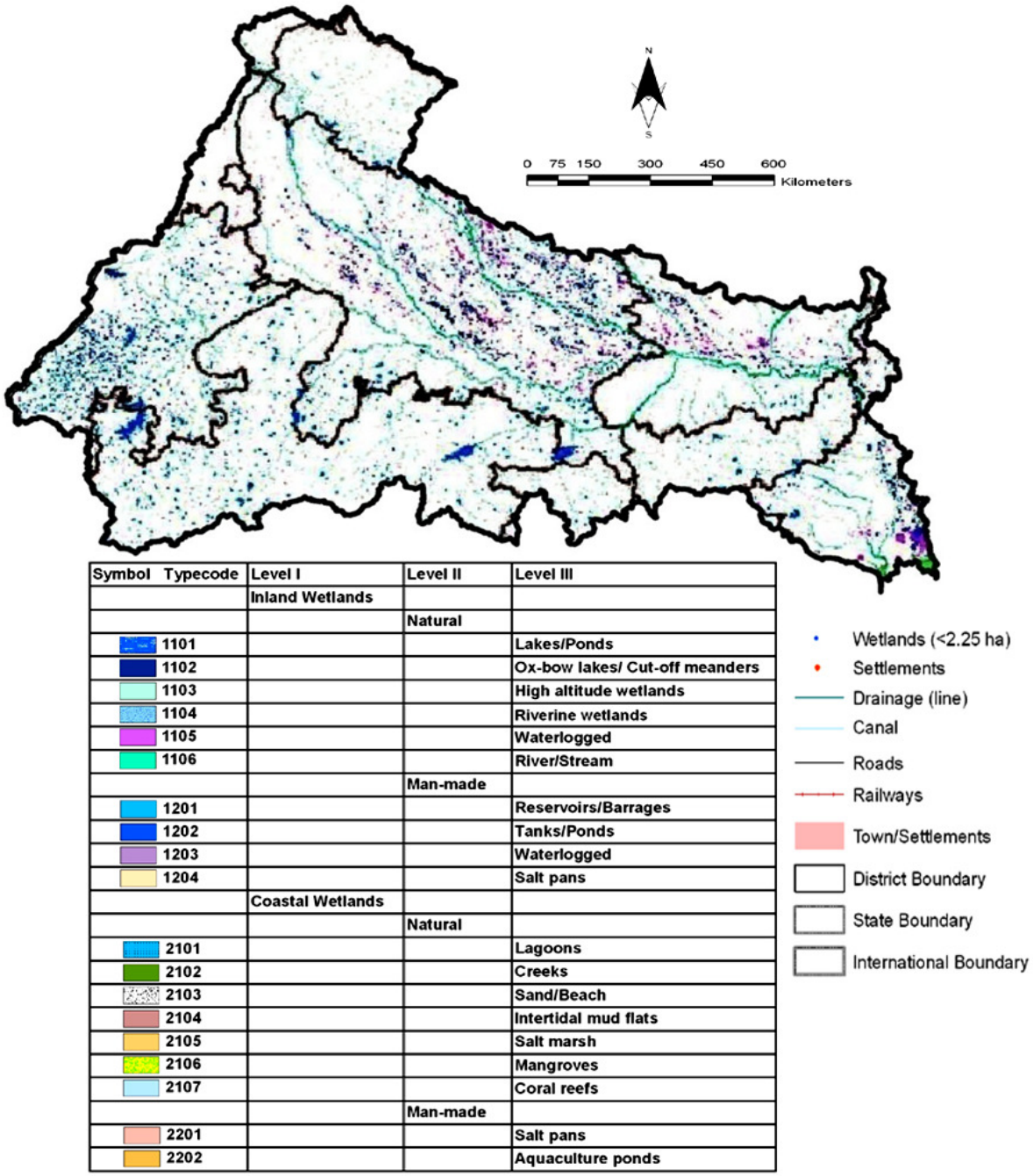


Symbol Typecode	Level I	Level II	Level III
	Inland Wetlands		
		Natural	
1101			Lakes/Ponds
1102			Ox-bow lakes/ Cut-off meanders
1103			High altitude wetlands
1104			Riverine wetlands
1105			Waterlogged
1106			River/Stream
		Man-made	
1201			Reservoirs/Barrages
1202			Tanks/Ponds
1203			Waterlogged
1204			Salt pans
	Coastal Wetlands		
		Natural	
2101			Lagoons
2102			Creeks
2103			Sand/Beach
2104			Intertidal mud flats
2105			Salt marsh
2106			Mangroves
2107			Coral reefs
		Man-made	
2201			Salt pans
2202			Aquaculture ponds

Figure 2.3a: Significant Surface Water Bodies of NRGB [*Adapted from:* ***SAC, 2011*****]**

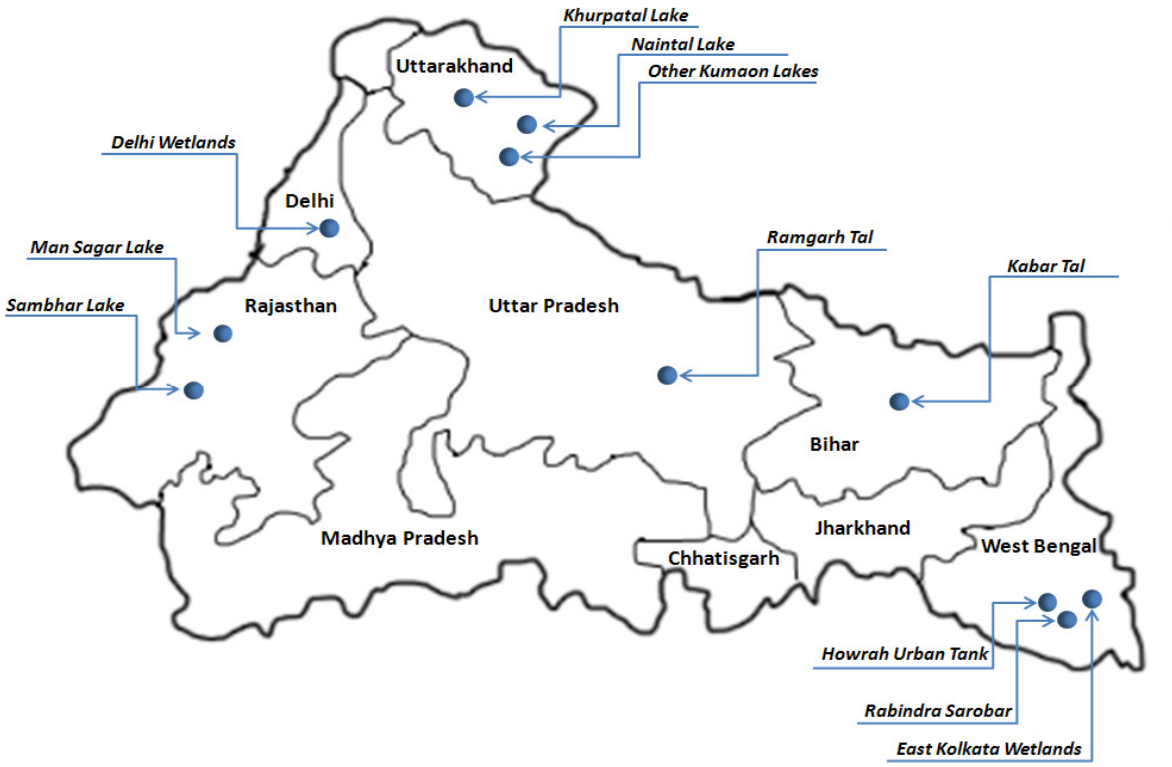


Figure 2.3b: Major Lakes & Wetlands of NRGB [*Adapted from:* ***Rainwaterharvesting, 2013***]

2.4. Geomorphology of National River Ganga

In keeping the primary focus of NRGB on River Ganga, it is essential to delineate the river morphology clearly. River Ganga is defined herein as comprising of six main head-streams originating in the Himalayas, namely the Alaknanda, Dhauli Ganga, Nandakini, Pinder, Mandakini and Bhagirathi rivers starting from their feeding glaciers up to their respective confluences at Vishnu Prayag, Nand Prayag, Karn Prayag, Rudr Prayag, Dev Prayag and Rishikesh (together comprising the Upper Ganga segment), the subsequent main stem of the river downstream from Rishikesh to Varanasi (the Middle Ganga segment) and the final stretch from Varanasi to Ganga Sagar (the Lower Ganga segment). Among these segments, the headstreams are fast-flowing mountainous rivers cutting through deep gorges and narrow valleys, whereas the Middle Ganga stretch meanders through relatively flat plains, with annual floods often covering vast expanses on both sides of the river. The lowermost part of the Lower Ganga segment tends to be braided, especially in the delta region near the Bay of Bengal where sea tides affect the river flow.

Since the most dynamic and vulnerable regions of a river include its active floodplains, a river's active floodplain needs to be included in the defining river space. In fact, the entire river valley (including the active floodplain) is a sensitive geomorphic-ecological river space. Based on remote sensing data and other inputs, the active floodplain of the Middle and Lower Ganga stretches from Rishikesh to Farakka has been mapped as shown in Figure 2.4 [vide *IIT_GRB Thematic Report Code: 005_ Ver 1_Dec 2010*]. Likewise, the valley margins for the same stretches are shown in Figure 2.5, vide *: 021_Dec 2011*. Detailed maps given

in the report show significant diversity of valley widths and geomorphic features in different reaches of the river, which have strong implications for the hydrological regime, water resource management, and ecological health of NRGB.

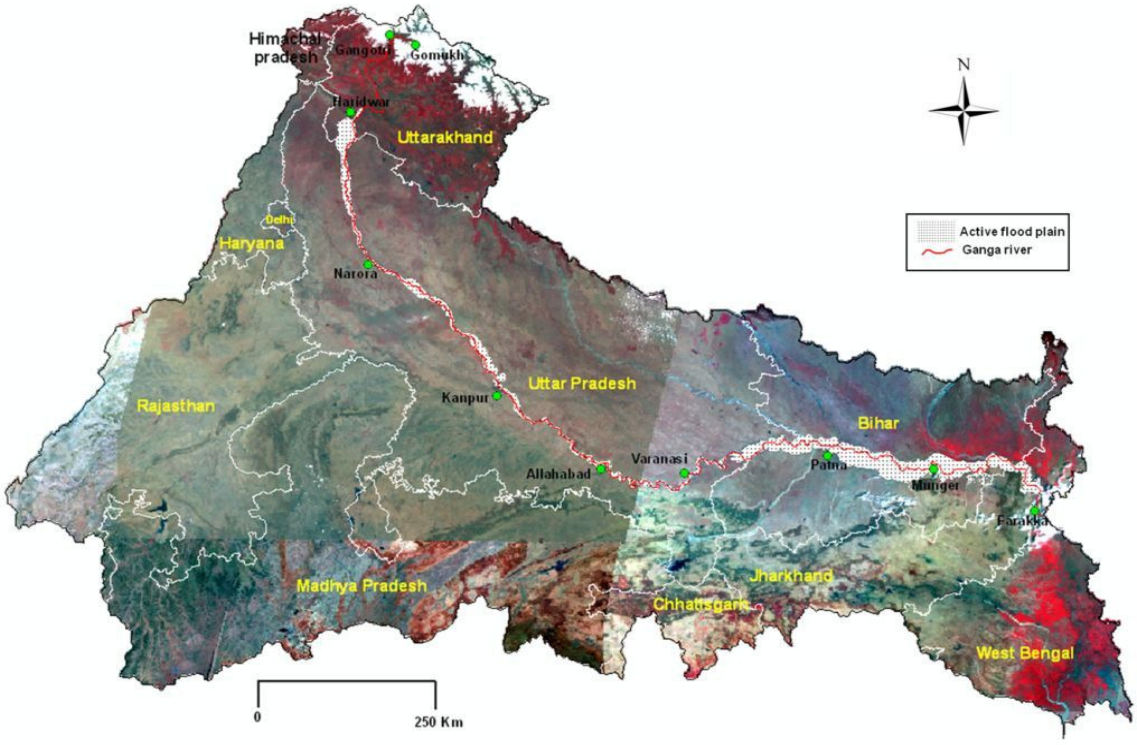


Figure 2.4: Map of Ganga River with its Active Floodplain (*based on AWIFS data*).

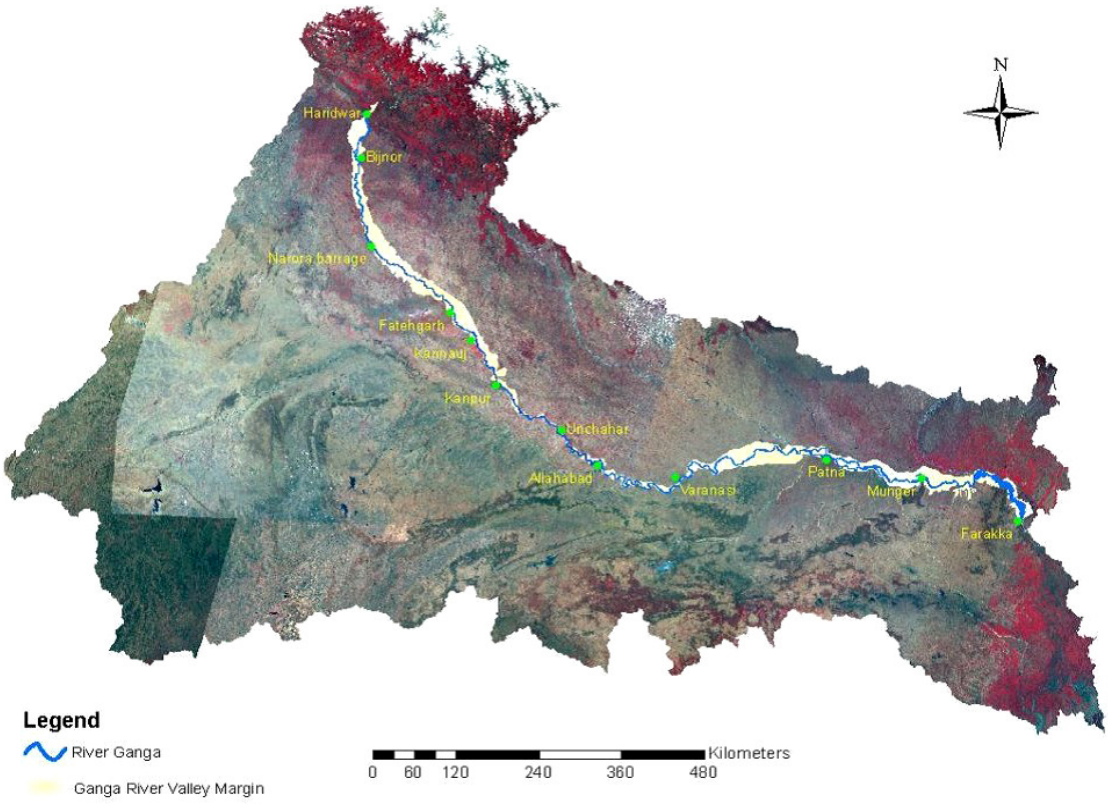


Figure 2.5: Geomorphic Map of Ganga River Valley

2.5. Biodiversity of National River Ganga

The biodiversity of National River Ganga is unique as it synthesizes three very different eco-regions of India situated along climatic gradients, namely the Himalayas, the Gangetic plains and the Deltaic regions [vide *IIT_GRB Thematic Report Codes: 020_Jun 2012 and 027_Jun 2012*]. The distribution of flora and fauna being largely dependent on the substrate, habitat and trophic status, the presence or absence of a particular family, genus or species is indicative of the conditions prevailing in the eco-region. The biodiversity in the Ganga river may be grouped under seven heads, viz.: (i) Phytoplanktons (tiny free-floating living organisms that drift with the water and constitute the main autotrophic base of the food chain in the Ganga ecosystem); (ii) Periphytons (which, together with phytoplanktons, comprise 1176 Taxa of attached and free-floating algal forms); (iii) Zooplanktons (comprising 294 Taxa of largely macroscopic or assemblage of microscopic free-floating animals); (iv) Zoobenthos (comprising 73 families of insects including higher forms that group under rocks and boulders spending part of their life as larvae and those which live and grow on soft substrate); (v) Fish (of 284 species plus 13 Chondrichthye species); (vi) Higher aquatic vertebrates (comprising Reptiles, Amphibians and Mammals that include 13 species of hard and soft turtles, besides the Gangetic dolphin, gharial, crocodile and porpoise); and (vii) Macrophytes (which are higher forms of plants that grow free floating or submerged in water bodies). Among these, periphytons, phytoplanktons and macrophytes are producers while zooplanktons, zoobenthos, fish and higher aquatic vertebrates are consumers of the food produced. Together, these micro- and macro-organisms, through their interplay with the abiotic environment, represent the ecological status of National River Ganga.

3. Philosophy, Vision and Conceptual Framework

3.1. Philosophy

The philosophical premise of this Plan is that the NRGB environment is a common human heritage which – depending on its status – can be either life-enhancing or life-damaging, and that the latter can be a long-term or even permanent feature whereas the life-enhancing prospect tends to be delicately balanced and tenuous. Now, as a common heritage, it is undeniably our common goal that the environment should be life-enhancing; hence we must intervene to salvage the environment whenever it threatens to become harmful. Moreover, if the reasons for environmental changes are only partly known (e.g. when they are caused by complex biotic or earth processes), then suitable interventions may need to be devised experimentally along with efforts to better understand such processes; but, if the environmental degradation is due to unrestrained anthropogenic activities, then the interventions will have to: (i) curtail or regulate such activities, and (ii) introduce additional measures for environmental restoration and strengthening.

The above premise underlying the GRBEMP Recommendations proposed herein should clear the way for judging the merit of the proposals in an unbiased manner. Conventionally, in debates pitting "Environment versus Development", Development is considered in economic terms whereas Environment is not assigned any economic value. To make a meaningful comparison, environmental positives must be considered as common human capital and environmental negatives as common human liabilities, where environmental negatives include both depletion of valuable resources and build-up of wastes, and vice versa for environmental positives. Since environmental positives and negatives have been historically fairly stable, they are often taken for granted, i.e. without considering their economic importance. Their proper economic valuation requires complex and futuristic analysis of an intricate environmental system, which would need a time-span well beyond the timeframe envisioned for preparing this GRBEMP. However, to give an idea of the economic value of the ecosystems of river basins, some estimates for the Murray-Darling Basin in Australia have been given in APPENDIX I.

3.2. Vision

Vision Statement: National River Ganga, which epitomizes the environmental status of the National River Ganga Basin, and around which human civilization flourished over millennia, has been flowing ceaselessly since primeval times. In order to preserve and invigorate National River Ganga, her essential character needs to be grasped in a holistic manner. After extensive research and consultations, the "wholesomeness of National River Ganga", viewed from a dynamic perspective, was determined to be the sanctity of the river system imbibed in four points as stated below. Out of these, the first two points are based on ancient Indian concepts – a testimony to our ancient wisdom, while the latter two points derive from modern scientific knowledge and understanding:

1. **"*Aviral Dhara*" (meaning "Continuous Flow"):** The flow of water, sediments and other natural constituents of River Ganga are continuous and adequate over the entire length of the river throughout the year.
2. **"*Nirmal Dhara*" (meaning "Unpolluted Flow"):** The flow in the Ganga River Network is bereft of manmade pollution; hence the river water quality should not be (significantly) affected by human activities.
3. **Geologic Entity:** The Ganga River System is a heritage of past geological ages, i.e. they are the earth's creations of ancient times, which may not be reparable if damaged.
4. **Ecological Entity:** The Ganga River System is a delicately structured balance between various living species and the physical environment, achieved by nature over thousands of years and vulnerable to irreversible changes.

In the background of escalating impacts of human activities on the NRGB environment, the above four points have guided the formulation of seven important missions of GRBEMP, viz.: "*Aviral Dhara*", "*Nirmal Dhara*", "*Ecological Restoration*", "*Geological Safeguarding*", "*Disaster Management*", "*Sustainable Agriculture*", and "*Environmental Knowledge-Building and Sensitization*". These missions are discussed in the following chapter.

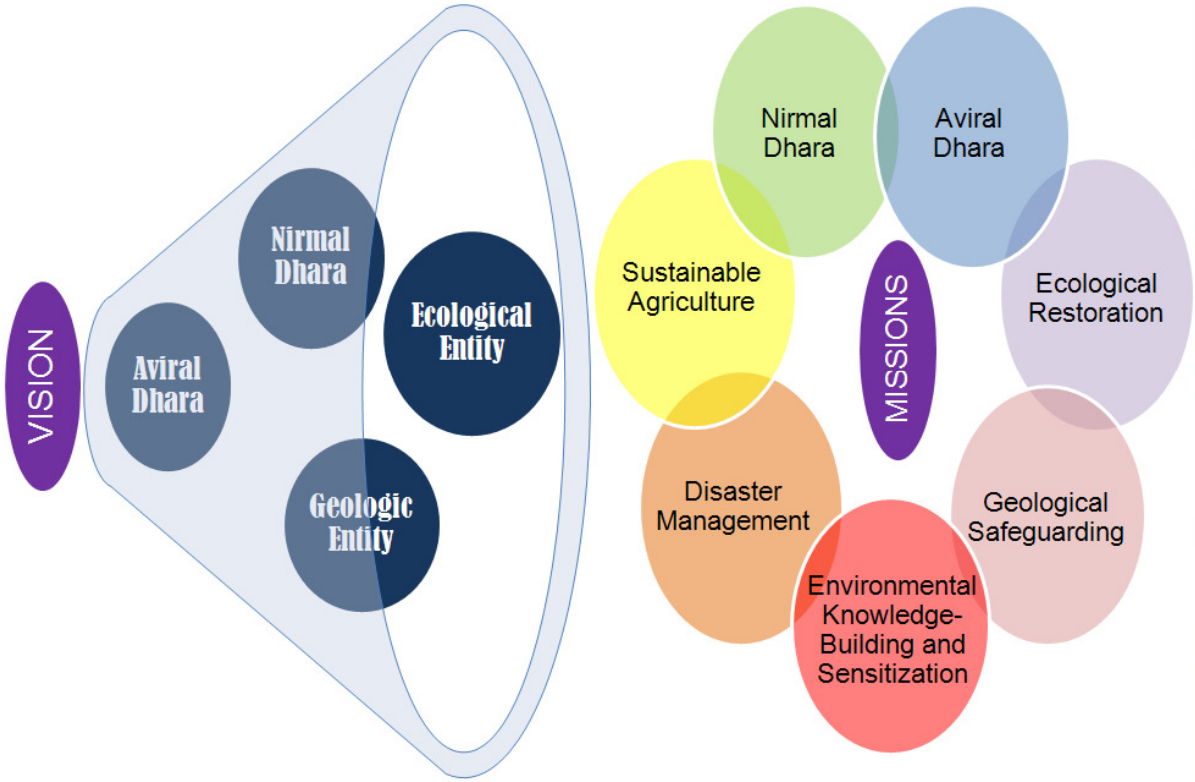


Figure 3.1: GRBEMP Vision and Missions.

3.3. Conceptual Framework

Conceptual Framework: Based on the above vision and the awareness of social needs, the main objectives of GRBEMP are identified as the following**:**

a) Environmental Flows shall be maintained in all rivers and tributaries of Ganga River System to fulfill their geological, ecological, socio-economic and cultural functions.

b) Water quality in all rivers and tributaries of Ganga River System shall be consistent with their governing geological, ecological, socio-economic and cultural functions.

c) Water and other aquatic resources of the Ganga River System shall be used judiciously to enable sustainable development in the entire NRGB.

d) All existing, ongoing and planned anthropogenic activities in NRGB shall be reviewed or scrutinized in a transparent and inclusive manner (with broad consensus of all affected people and stakeholders) for the overall health of NRGB.

With the above objectives in mind, the GRBEMP is formulating policy frameworks (or "Action Plans") with built-in feedback mechanism for a range of anthropogenic activities in NRGB. To fulfill these objectives, the need to set up a permanent nodal agency was also felt to implement the Action Plans and other needed measures in NRGB on a long-term basis. The nodal agency is envisioned as an independent Commission for NRGB proposed to be set up by an Act of Parliament. The basic approach in this framework action plan is**:** Apply modern science and technology in conjunction with traditional wisdom.

पारंपरिक ज्ञान के साथ आधुनिक विज्ञान और नई
प्रौद्योगिकी को प्रयोग मे लाना
ज्ञान धारा + जन ज्ञान

While recognizing the NRGB environment with its diverse features and processes as an integrated whole, the task of analyzing and preparing the GRBEMP was broken up from the whole to the parts into several thematic groups as follows**:**

- Environmental Quality and Pollution (EQP)
- Water Resources Management (WRM)
- Fluvial Geomorphology (FGM)
- Ecology and Biodiversity (ENB)
- Socio-economic and Socio-Cultural (SEC)
- Policy, Law and Governance (PLG)
- Geo-Spatial Database Management (GDM)
- Communication (COM)

In addition, two cross-thematic groups were also set up – one on Environmental Flows (*or E-flows*), and the other on Environmental Valuation. However, it was subsequently realized that the latter theme would require extensive research and primary data collection, which may go well beyond the time frame envisioned for preparing the GRBEMP. Figure 3.2 below shows the work structure relating the Thematic Groups to fulfill the GRBEMP Missions.

Based on these works, the interim conclusions and provisional recommendations (actionable points) of GRBEMP are presented in the next two sections.

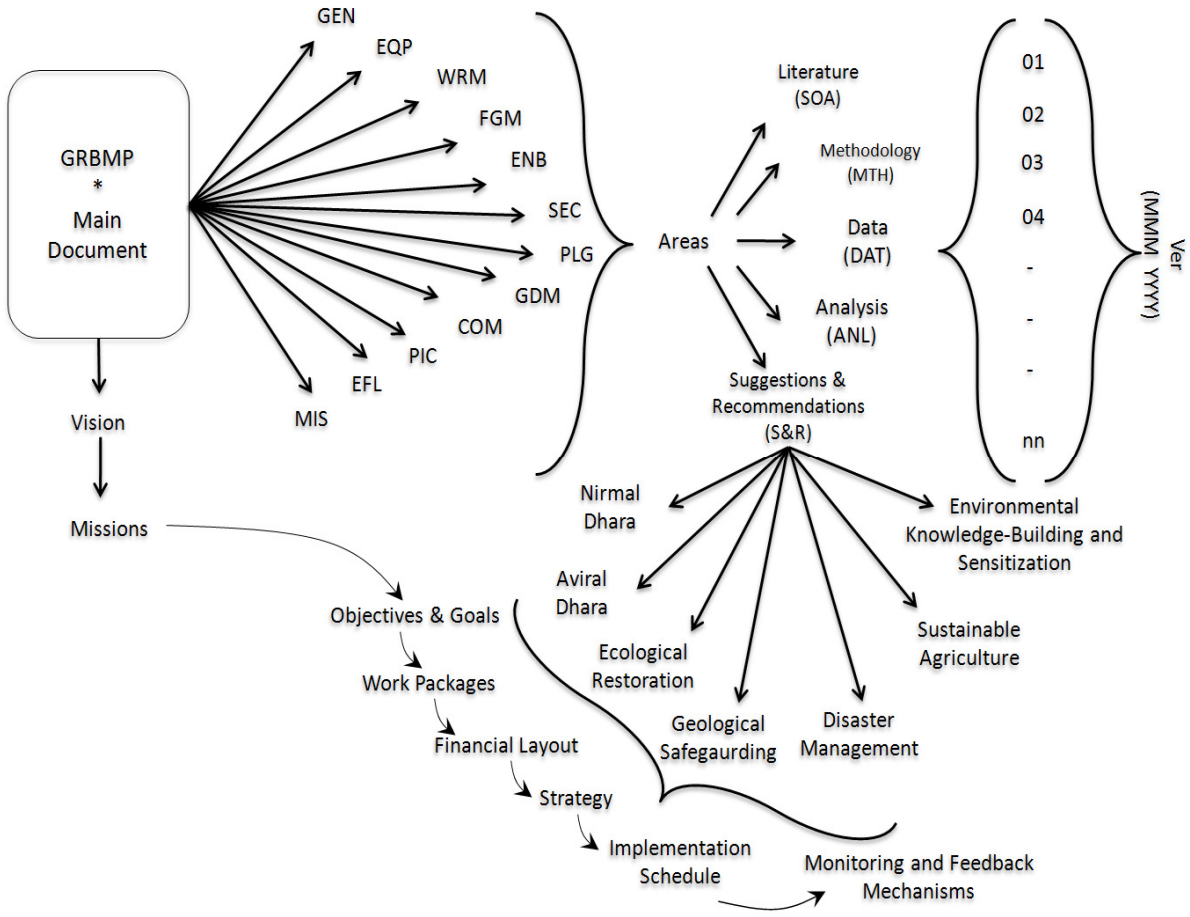


Figure 3.2: Flow Diagram of GRBEMP Work Structure

4. GRBEMP Missions

4.1. Aviral Dhara

For a given geological setting and climatic pattern, alluvial rivers – as characterized by their morphologies, floodplain geometries and fluvial patterns – achieve stability through long-term physical balance between various dynamic parameters such as water flow rates and sediment loads (including seasonal and inter-year variations), terrain gradient, and river influent/effluent rates. "Aviral Dhara" is a consequence of this long-term stability of rivers. Anthropogenic activities have violated this aspect of river integrity in several ways – by erecting obstacles to flow, by significant water withdrawals, by increased disposal of debris in rivers, and by altering the natural water recharge/extraction. Regarding the last point, it may be noted that, since alluvial basins are hydraulically connected by groundwater flow (besides other hydrological connections), water withdrawals/ recharges are not only those directly from/to the rivers but also from/to different regions of the basin. Thus, while longitudinal connectivity in the river network is an essential first step to maintain "Aviral Dhara", having adequate river flows depends much on the basin's overall water status.

Box 4.1

"Damming and flood control can have negative impacts (in rivers), such as declining fish catches, loss of freshwater biodiversity, increases in the frequency and severity of floods, loss of soil nutrients on floodplains, and increases in diseases such as schistosomiasis and malaria. ... On the Mississippi River, the rising frequency and severity of flooding – attributed to local flood control structures – have reduced the river's ability to support native flora and fauna, while a dramatic increase in floods on River Rhine has been attributed to increased urbanization, engineering, and the walling off of the river from its floodplain."

– "Vital Water Graphics" [*UNEP, 2008*]

Dams, barrages and other manmade structures block or constrict rivers, thereby interrupting the flow of water, sediments and aquatic species. While the short-term and local benefits of such structures can be reasonably estimated, the long-term, basin-wide environmental losses in terms of river stability, soil and water fertility, ecological balance, flood events, health effects, and other facets of basin performance are difficult to predict [*UNEP, 2008; WWC, 2000*]. Similar adverse effects are also caused by anthropogenic activities that significantly alter river flows or sediment loads. The UNEP document cited in Box 4.1 discusses some of these aspects in terms of "*river fragmentation*" defined as "the interruption of a river's natural flow by dams, inter-basin transfers or water withdrawal … by man." However, it is not only interruptions or changes in flow rate that cause physical imbalance in a river; the balance may also be easily upset by alterations in sediment load as well as seepage inflow/ outflow and overland inflow rates.

As mentioned earlier, India's (and NRGB's) water resources potential and water use have been evaluated by nodal government agencies under MoWR, GOI. Some relevant data are cited in Tables 4.1A and 4.1B [*CWC, 2000; Jain et al., 2007; ADB, 2009*]:

Table 4.1A: Water Resources Potential (approximate) in River Basins of India

River Basin	Catchment Area (km^2)	Total Water Resource Potential (BCM)	Replenishable Ground Water Potential (BCM)	Utilisable Surface Water Resources (BCM)
Ganga	861452	525	171	250
Total Indian	**3290,000**	**1869**	**433**	**690**

Table 4.1B: Projected Water Demand (in BCM i.e. billion m3)

Sector	Standing Sub-Committee of MoWR			NCIWRD		
Year	***2010***	***2025***	***2050***	***2010***	***2025***	***2050***
Irrigation	688	910	1072	557	611	807
Drinking Water	56	73	102	43	62	111
Industry	12	23	63	37	67	81
Energy	5	15	130	19	33	70
Others	52	72	80	54	70	111
Total	**813**	**1093**	**1447**	**710**	**843**	**1180**

The above data give an indication of the critical status of water resources in India (and in the NRGB), especially when water demands are compared with the water resource potentials. The following points, however, are pertinent with regard to these data:

a) How approximate are the above water resource potentials? Estimates made at different times and/or by different government agencies are often very different from each other [*CWC, 1986*]. While the likely error margins are not indicated in the above documents, the figures have enough room for uncertainty depending on estimation methods and measurement techniques. For instance, *ground water potential* depends on estimating storages and yields of complex aquifer systems spread over large and diverse regions. On the other hand, *surface water resource potentials* are based on river discharges only, and not of other surface water bodies. Independent estimates suggest that the above water resource potentials are overestimated by up to 88%, and the total water resource potential of India may be only 654 BCM instead of 1123 BCM [*UNICEF et al., 2013*].

b) The above water estimates are for very large regions, and spatial variations of water resource potential cannot be gauged from the above data. Such variations are significant in NRGB, considering the diversity in physical and hydrological features of the basin.

c) As seen from Table 4.1A, India's surface water resource potential (1,869 BCM) as well as its "utilizable" part (690 BCM) are significantly greater than the ground water potential (433 BCM). On the other hand, as per recent government estimates, "*more than 90% of the rural and more than 50% of urban water supply is met by ground water … with an*

estimated annual groundwater withdrawal of 221 BCM" [*CGWB, 2012*]. Thus, groundwater usage is purportedly much higher than surface water usage, although surface water potential is much higher than groundwater potential. This differential usage pattern needs to be considered in framing India's water resource policies.

d) The information cited in the above paragraph also shows that India's estimated "water usage" is much less than half (and perhaps as low as one-third) of the estimated "water demand" of 710 BCM or 813 BCM in 2010 (*vide Col.5 and Col.2 of Table 4.1B*), which suggests that India is already under severe water-stress/ water-scarcity. However, this conclusion seems untenable if "water-stress" is based on the premise of per capita water availability being less than 1000 m^3/year [*which seems to be the government norm, whereas the international norm for "water stress" is when a nation's per capita water availability falls below 1700 m^3/yr, vide FAO, 2012; UN-Water, 2013*]. As per government figures of 2006, the per capita water availability was expected to reduce to below 1000 m^3/yr only around 2025 [*ADB, 2009*]. But as per later CWC figures, the per capita water availability in India was 1588 m^3/yr (*which was significantly higher in the Ganga basin at almost 2000 m^3/yr*) in 2010 and is expected to reduce to 1434 m^3/yr in 2025 [*India-WRIS, 2012; CWC, 2010*]. On the other hand, NIH states that India's "utilizable" per capita water availability reduced from 1,100 m^3/yr in 1998 to 938 m^3/yr in 2010, and is expected to further reduce to 814 m^3/yr in 2025 [*NIH, 2013*]. The term "utilizable" is not quantitatively explained in the above documents, and this adds to overall confusion about the significance of the data. While clarity on these data and their interpretations are needed, it is likely that much of the country (including NRGB) is under increasing water-stress, which certainly calls for major changes in how India's (and NRGB's) waters are managed.

e) The projected water demands in Table 4.1B were evidently computed assuming the per capita demand as being invariant over time and not by assessing the demand trend or other factors. But given binding constraints on water availability, the growth in demand must get constrained, implying a need for demand management [*UNICEF*, 2013].

f) The projected water demands are for human use only, and do not give any indication of the environmental needs of the basin. In other words, the water needed for the survival and health of India's (and NRGB's) aquatic system is unstated. From discussions with various agencies, it appears that, generally, no attempt is made to reliably assess this requirement and it is often ignored.

Thus the NRGB's water status needs to be re-examined afresh and in considerably greater detail in order to estimate its true potential and its spatial-temporal effect on river flows. However, notwithstanding errors in the estimates quoted above, it is easily surmised that human water demands have been increasing while dry-season river discharges and ground water levels have been falling in many parts of the NRGB, which implies that the hydrological status of NRGB is shifting relentlessly towards a state of critical imbalance. To overcome this impending crisis, it is imperative therefore that either (i) water availability in

the basin is increased through *increased storage*, or (ii) water demands are controlled through more *efficient water use*. (Or both options are simultaneously pursued.)

4.1.1. Water Storage

Human interventions promote two types of water storages, viz. *concentrated (or centralized) storage*, and *distributed (or decentralized) storage*. Till date, governmental focus has been mainly on "*centralized storage*" facilities in the form of dammed reservoirs on rivers. While such storage systems may have the advantage of economy of scale for capital investment, they often involve significant costs for reservoir operation, transporting water to end-users, human displacements, land inundation, ecological damage, and river mutilation. Moreover, evaporation losses from surface reservoirs are often high, especially in tropical climates like India's, with no safe method having been found to control such losses. As per UNESCO, globally more water evaporates from reservoirs than is used for industrial and domestic needs, vide Figure 4.1, and this trend is likely to continue in the foreseeable future [*UNEP, 2008*].

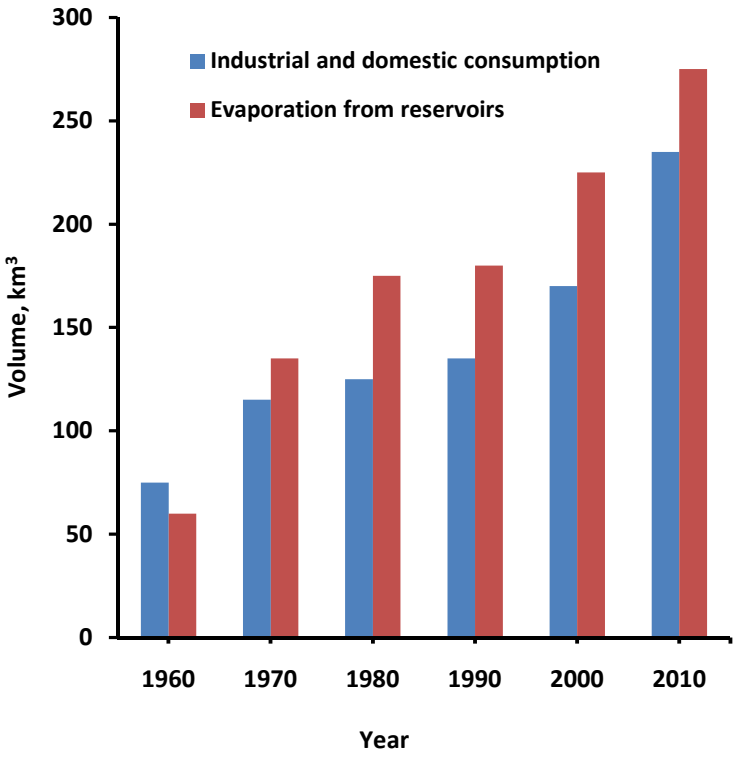


Figure 4.1: Reservoir Evaporation

Notwithstanding the above limitations, dams may fulfill several needs, such as hydropower generation, flood control and navigation, in addition to consumptive water use. Thus, though dams (and other hydraulic structures that fragment, constrict or otherwise mutilate rivers) may be undesirable in free-flowing rivers, their environmental impacts need to be considered in full before adopting or discarding specific projects. Four categories of environmental impacts due to dams (and other hydraulic structures in rivers) have been worked out in the GRBEMP as presented in Table 4.2.

Table 4.2: Criteria for Permissibility of Dams and Other Projects on Rivers

Category	Environmental Impact	Environmental Clearance
I	**MAJOR LONG-TERM, IRREVERSIBLE IMPACTS:** Break in Longitudinal River Connectivity, leading to: (i) loss of habitat of rare or endangered species in river; and/or (ii) disruption in movement of biota along the river length; and/or (iii) disruption in sediment transport in the river. Critical Flow Reductions, leading to: inadequate Environmental Flows needed to maintain river stability and ecological balance. Land Inundation: causing loss of habitat of endangered/ rare terrestrial species living in the areas inundated.	**DEFINITELY "NO"** [*Such a project should be summarily rejected, except in critical national interest and after reviewing at the highest political level.*]
II	**LONG-TERM, IRREVERSIBLE IMPACTS OF LESS IMPORT:** Land Inundation, leading to: (i) loss of terrestrial biodiversity and other ecological changes; and/or (ii) loss of historical, religious and cultural heritage sites. Geological Hazards, such as: (i) seismic hazards; and/or (ii) landslides, land subsidence, etc.	**GENERALLY "NO"**, [*But permissible in exceptional cases after thorough study and review by domain experts*]
III	**POTENTIALLY REVERSIBLE LONG-TERM IMPACTS:** Land Acquisition and Inundation, leading to human dislocation, loss of livelihood, marginalization, etc. Construction Activities, leading to: ecological damage, disruption of local hydrology, human dislocation, loss of livelihood, etc. Inadequate water downstream of project area, leading to: adverse effects on livelihood, tourism (including religious tourism) and recreational activities. Adverse socio-economic impacts: Demographic changes, changes in livelihood patterns, unplanned "developmental activities", tourism and other recreational activities, etc.	**"CONDITIONALLY PERMISSIBLE"** [*subject to:* *(i) a comprehensive socio-economic and environmental impact assessment of the project by an independent agency; and* *(ii) formulation of a Rehabilitation/ Resettlement Plan and an Environmental Management Plan acceptable to all stakeholders*.]
IV	**POTENTIALLY REVERSIBLE SHORT-TERM IMPACTS:** Construction Activities that cause: noise, explosions, degradation of forests and agricultural land, pollution from debris, influx of outsiders, despoiling of nature, etc. Potentially adverse socio-economic impacts: Increase in crime and other social vices, tensions between native population and outsiders, etc.	

The second option of "*distributed water storage*" can be of great advantage in NRGB (see Fig. 4.2). NRGB has a vast groundwater storage capacity which can be annually replenished by capturing runoff (during monsoons and other rainfall periods) and letting it percolate down to the water table through recharge pits, trenches, etc. In addition, distributed surface storages (ponds and tanks) also need to be adopted for their environmental and socio-economic usefulness. Taken up at the level of small or micro-watersheds, these measures have the advantage of decentralized and better management by local government bodies and end-users (rural and urban communities), besides boosting

groundwater levels and river base flows. However, both field-level technical help and relevant data (climatic, topographic, soil, water table, etc.) should be provided to user communities by government agencies.

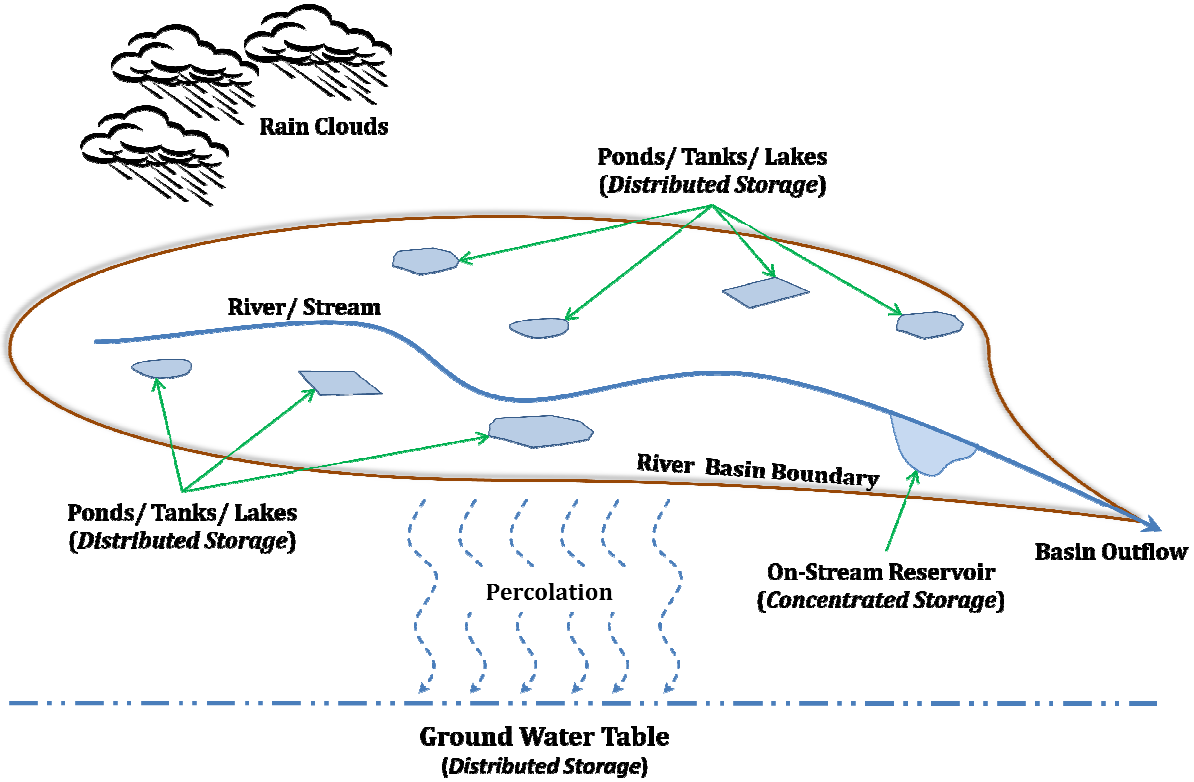


Figure 4.2: Storm-water runoff storage options – Concentrated and Distributed Storages

The "*distributed storage*" concept should also be applied to natural ecosystems of NRGB, especially *wetlands*, *forests* and *grasslands*. Each of these ecosystems contributes significantly to water conservation in the basin, besides providing other vital ecosystem services. As noted by Pegram et al. [*2013*] "*healthy and functioning aquatic ecosystems are fundamental to rivers, in terms of the goods and services that they provide, the cultural and other social activities they support, and their inherent biodiversity value. … Experience shows that once seriously degraded, these systems become difficult and costly to return to healthy conditions. It is therefore critical for basin planning to incorporate an understanding of the ecological limits, thresholds and interconnections of the entire basin water resources.*" In the case of wetlands, Prasad, et al. [*2002*] had emphasized the great need to protect the existing wetlands, adding that "*even a small country like UK could designate 161 wetlands as Ramsar sites, India ... so far managed to delineate a mere six sites till date.*" The number of Ramsar wetlands in India subsequently increased to 25, but hundreds of other wetlands in the country (including many in the NRGB) are in a state of pitiable degeneration [*Dhandekar, 2011*]. *Forest cover* and *grasslands*, too, have reached minuscule proportions in the NRGB except in high altitude regions [*India-WRIS, 2012*]. Overall, the restoration and preservation of wetlands, forests and grasslands, combined with various water and soil conservation measures, is an urgent need in NRGB.

4.1.2. Water Use Efficiency

While water is a renewable resource, the renewal capacity of NRGB is limited by the region's precipitation and various physiographic factors. That our fresh water usage may be nearing the average annual water renewal capacity of the basin may not have been realized by the general population (or even by major water-users), but this is a distinct possibility. Hence, several measures are immediately required to ensure efficient water use, viz.**:**

i) Realistic pricing of fresh water (especially for commercial and affluent domestic consumers) and disincentives for wastage of water.
ii) Techno-economic assistance and incentives for poor and marginal sections (such as those engaged in subsistence agriculture) to improve water-use efficiencies.
iii) Allocation of water rights and entitlements to stakeholders.
iv) Direct reuse of water where possible, e.g. reuse of irrigation return flows.
v) Treatment and recycling/reuse of domestic and industrial wastewaters where feasible.

4.1.3. Policy Focus

In concluding, the foregoing discussions strongly suggest that the government strategy on NRGB's water resources needs some major changes. These may be stated as follows**:**

A) Government agencies usually deal with the water resources of NRGB as independent of other natural resources; but river basin waters are intimately linked with other vital resources of the basin, such as *soil/silt and its nutrients (organic and inorganic)* and *biotic resources*. It is imperative therefore that water resource management in NRGB should be assimilated into a broader framework of natural resource management (or "environmental resource management") instead of the water-only approach.

B) Thus far, governmental emphasis on "development of water resources" has broadly meant extracting increasingly more water and energy from the basin for human use. This emphasis on water and energy abstractions has often lead to the water resource systems themselves being endangered (as evident from many vanishing wetlands and streams). Thus, if "development" and "use" of water resources lead to their extinction, then it is evident that government priority should immediately shift from "*conjunctive use*" of surface and ground water resources to their "*conjunctive preservation*".

C) Many national and international commentators have noted that, in recent decades, large-scale water (especially groundwater) abstractions from the environment are being effected by water-users themselves. Many other aquatic resources are also directly tapped by users. Yet, users are not entrusted with the maintenance of water resource systems, thereby creating a contradiction between ownership and usage. The obvious need to give stakeholders the rights and responsibilities to maintain the water resource systems has been advocated by many agencies/ experts [*e.g. ADB, 2009; Sen, 2009; Thakkar, 2012; UNICEF, et al., 2013*]. It is suggested here that the management of aquatic resources should shift from "*centralized government control*" to "*decentralized stakeholder control*" combined with "*expert guidance and regulation*".

4.1.4. Environmental Flows

Environmental Flows (or E-Flows) are a regime of flow in a river or stream that describes the temporal and spatial variations in quantity and quality of water required for freshwater and estuarine systems to perform their natural ecological functions (including material transport) and support the spiritual, cultural and livelihood activities that depend on them, vide *IIT_GRB Thematic Report Code: 022_GBP_IIT_EFL_SOA_01_Ver 1_Dec 2011*. After reviewing different methods of estimating E-Flows and in consultation with stakeholder and expert groups, the Building Block Method was found to be most suitable for rivers. Based on this method E-Flows were computed for some relevant sites on Alaknanda and Bhagirathi rivers of the Upper Ganga Segment (which is considered to have high hydropower potential) shown in Figure 4.3. The detailed procedure for computing E_Flows are described in a separate Thematic Report by E-Flows Group under preparation, and is briefly stated hereunder. It should be noted here that, the method quantifies only the minimum water flow rates required to sustain the river, and do not specify other requirements. In the absence of specific data, it is recommended that the E-Flows should carry river sediments (suspended load and bed load) in approximately the same proportions as present in virgin flows in the river.

To compute E-Flows at the seven selected sites, the geomorphological features of the respective sites were analysed and the sites were physically surveyed to map the river cross-sections. The virgin river flows at these sites were considered for the period prior to construction of Tehri Dam for which the flow data of Alaknanda and Bhagirathi rivers were available from CWC namely, for the period 1972 to 1982 for Uttarkashi (Lat 30°44'20"N, Long 78°21'23"E) and Devaprayag Upstream (Lat 30°09'00"N, Long 78°35'54"E) and Downstream (Lat 30°08'00"N, Long 78°35'44"E) Stations, and for the period 1977 to 1987 for Rudrapayag (Lat 30°16'24"N, Long 78°21'17"E) and Rishikesh (Lat 30°10'21"N, Long 78°18'30"E) Stations. The flow-discharge curves at the E-Flows sites were then estimated from the virgin flows at the nearest measuring stations.

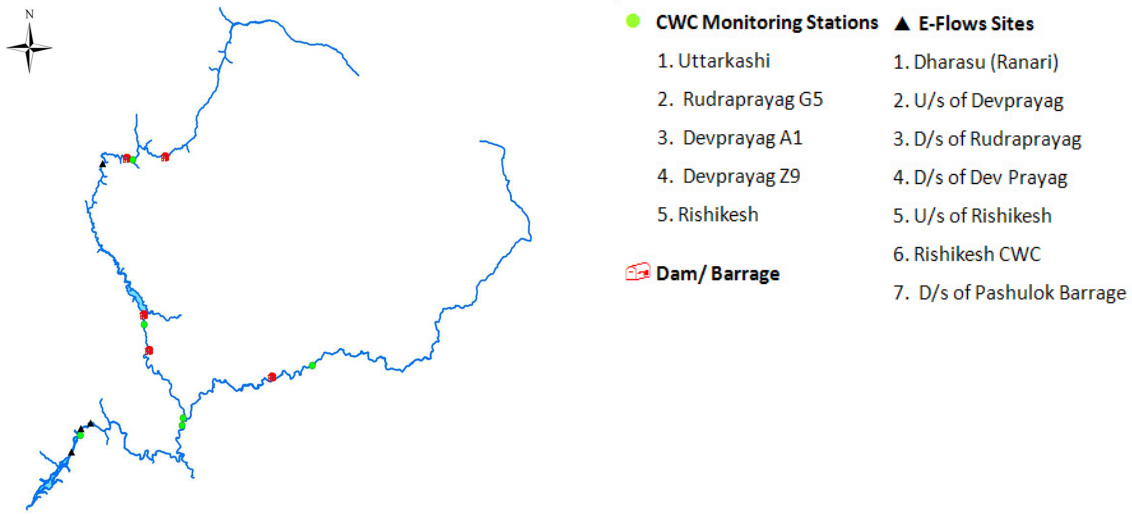
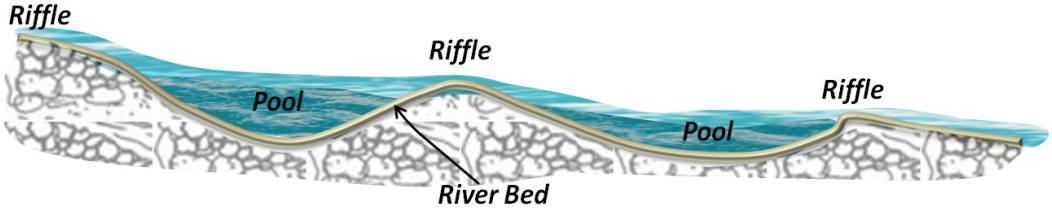
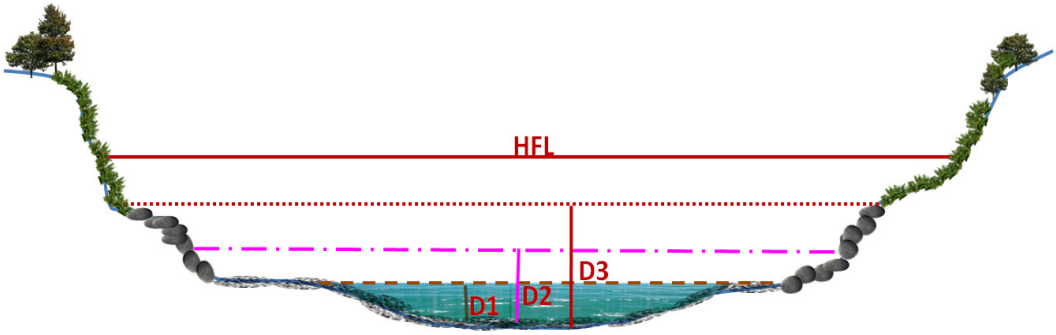


Figure 4.3: Location Map of Flow Monitoring Stations and E-Flows Sites.

E-Flows at the sites selected depend on ecological and geomorphological requirements, the cultural, spiritual and livelihood requirements being within these limits in these rivers. Referring to Figure 4.4, E-Flows corresponding to depth D1 are required during lean periods. For the spawning period of keystone species, E-Flows corresponding to D2 need to be maintained throughout the season, but increased flow corresponding to D3 are needed for minimum 18 days during the monsoon season (preferably distributed over the season). The keystone species in the given river stretches were identified, and the required depths D1 and D2 were determined. Since flow depths at pools are higher than at riffles, hence the critical E-Flows sites were selected at riffle sections. The flows corresponding to D1 and D2 were then read from the stage-discharge curves for the given sites. To define D3, the average virgin flows that were exceeded for 18 days during the monsoon (June to October, but essentially July to September) were determined. This corresponds to average virgin flows having 20% dependability during monsoons. The depth D3 was then read from the stage-discharge curve and checked against the available river depth at the site. The results for the seven different sites are summarized below (excluding quantitative flow data which are not presented for proprietary reasons.)



Riffle and Pool Locations in Longitudinal River Profile



River Cross-Section at E-FlowSite

D1 – Depth of water required for mobility of keystone species during lean period

D2 – Depth of water required for mobility of keystone species during spawning period

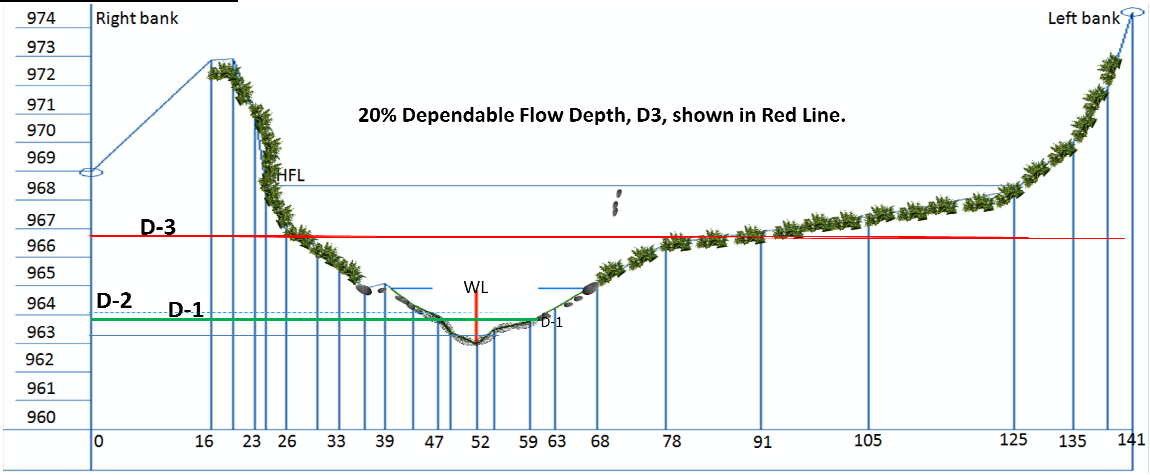
D3 – Depth of water required for mobility of keystone species during spawning period

Figure 4.4: E-Flows Assessment – Conceptual Diagram.

A. E-Flows at Site 1: Dharasu (Ranari): (Lat 30°43'02"N, Long 78°21'17"E).

Geomorphic Attributes: Confined, incised river channel with coarse bed material in degradational regime in Himalayan steep valley.

Cross-Section at Site:



Keystone Species	Required Depths for E_flows		
	D_1 (m)	D_2 (m)	D_3 (m)
Snow Trout *(Schizothorax richardsonii)*	0.5 m	0.8 m	3.41
Golden Mahseer *(Tor putitora)*			

Computed E-Flows as % of Virgin River Flows:

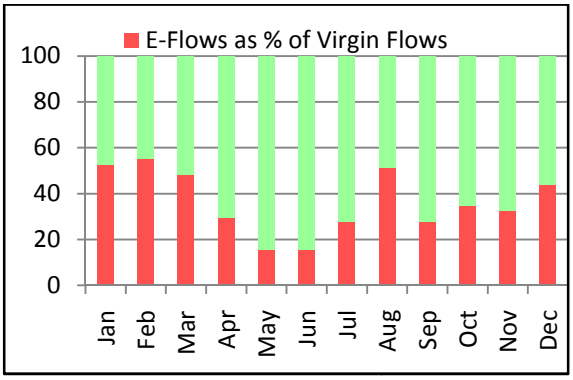


Figure 4.5a: E-Flows as Percentage of Mean Monthly Flows for Dharasu.

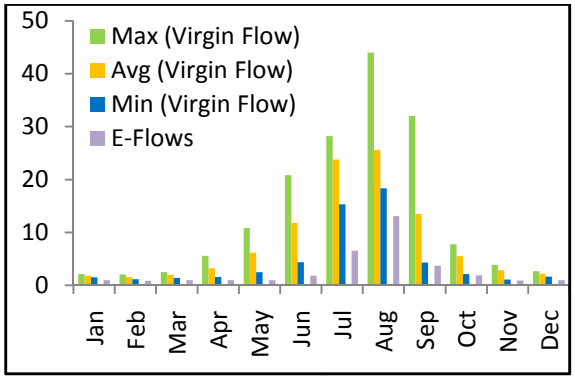


Figure 4.5b: Monthly E-Flows and River Flows as % of Annual Flows for Dharasu.

Table 4.3: Percentage of Virgin River Flow required as E-Flows for Dharasu

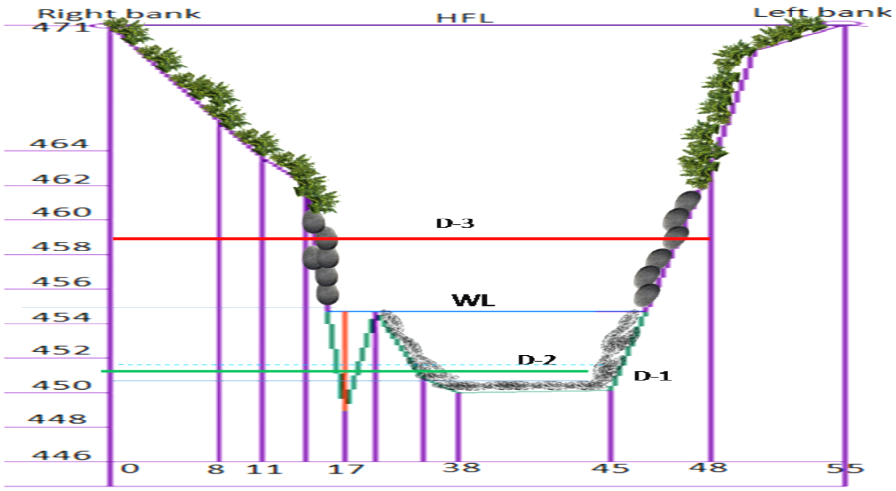
Period of Year (Season)	Wet Period	Dry Period	Annual
E-Flows as percentage of Average Virgin Flow during the period	33.76 %	32.96 %	33.60 %

As seen from the above results, the minimum E-Flows required to maintain river integrity are only about 1/3rd the average virgin flows of the river in both dry and wet seasons. However, this fraction varies over the year and is relatively higher during winter, river flows being minimum in winter. River flows also varied annually, but the required E-Flows are less than the monthly virgin flows even in the driest years, as evident from Figure 4.5b.

B. E-Flows at Site 2: Upstream of Devprayag (Lat 30°09'06"N, Long 78°35'56"E)

Geomorphic Attributes: Confined, incised river channel with coarse bed material in degradational regime in Himalayan steep valley.

Cross-Section at Site:



Keystone Species	Required Depths for E_flows		
	D_1 (m)	D_2 (m)	D_3 (m)
Snow Trout *(Schizothorax richardsonii)*	0.5 m	0.8 m	8.48
Golden Mahseer *(Tor putitora)*			

Computed E-Flows as % of Virgin River Flows:

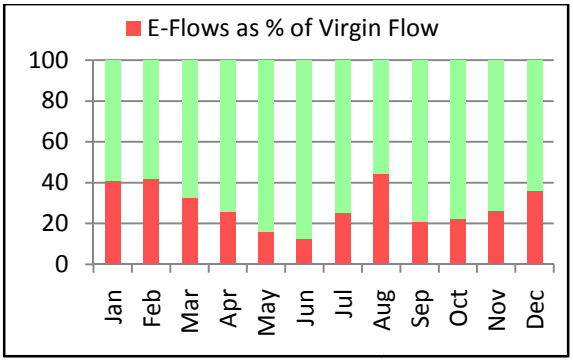


Figure 4.6a: E-Flows as Percentage of Mean Monthly Flows for Devprayag U/s.

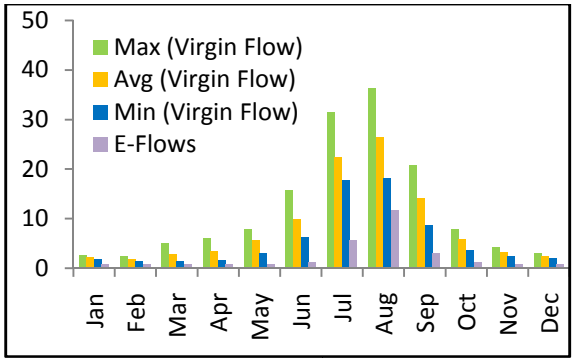


Figure 4.6b: Monthly E-Flows and River Flows as % of Annual Flows for Devprayag U/s.

Table 4.4: Percentage of Virgin River Flow required as E-Flows for U/S of Devprayag

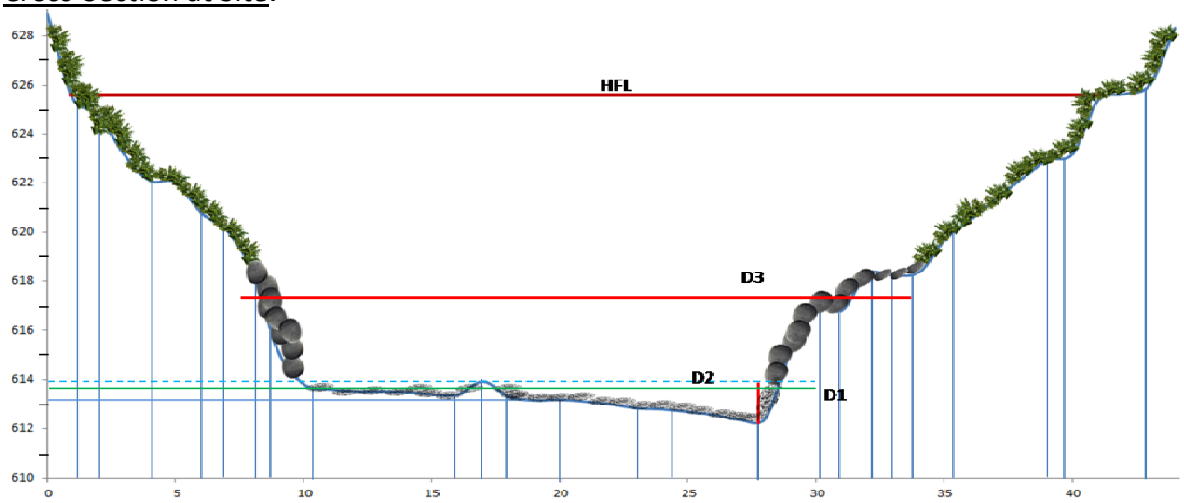
Period of Year (Season)	Wet Period	Dry Period	Annual
E-Flows as percentage of Average Virgin Flow during the period	29.05 %	27.98 %	28.82 %

As seen from the above results, the minimum E-Flows required to maintain river integrity are much less than 1/3rd the average virgin flows of the river in both dry and wet seasons. However, this fraction varies over the year and is relatively higher during winter, river flows being minimum in winter. River flows also varied annually, but the required E-Flows are less than the monthly virgin flows even in the driest years, as evident from Figure 4.6b.

C. E-Flows at Site 3: Downstream of Rudraprayag (Lat & Long same as CWC G5)

Geomorphic Attributes: Confined river channel with coarse bed material in degradational regime in Himalayan bedrock.

Cross-Section at Site:



Keystone Species	Required Depths for E_flows		
	D_1 (m)	D_2 (m)	D_3 (m)
Snow Trout *(Schizothorax richardsonii)*	0.5 m	0.8 m	4.23
Golden Mahseer *(Tor putitora)*			

Computed E-Flows as % of Virgin River Flows:

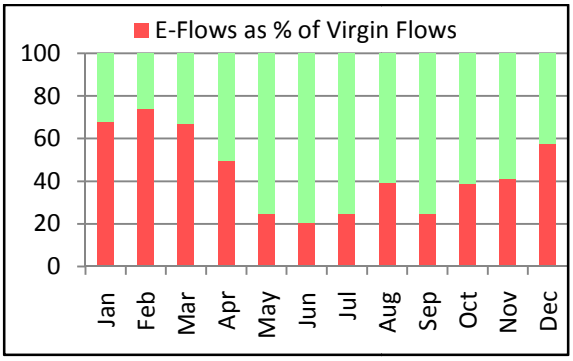


Figure 4.7a: E-Flows as Percentage of Mean Monthly Flows for D/s of Rudraprayag.

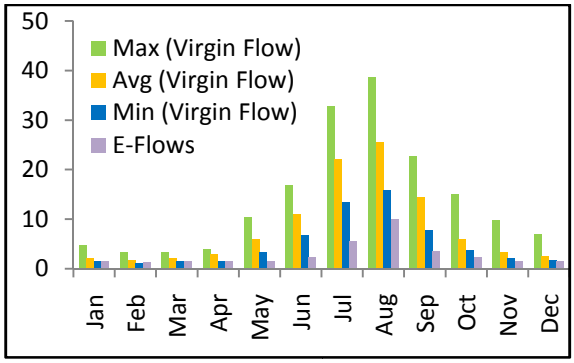


Figure 4.7b: Monthly E-Flows and River Flows as % of Annual Flows for D/s of Rudraprayag.

Table 4.5: Percentage of Virgin River Flow required as E-Flows for D/S of Rudraprayag.

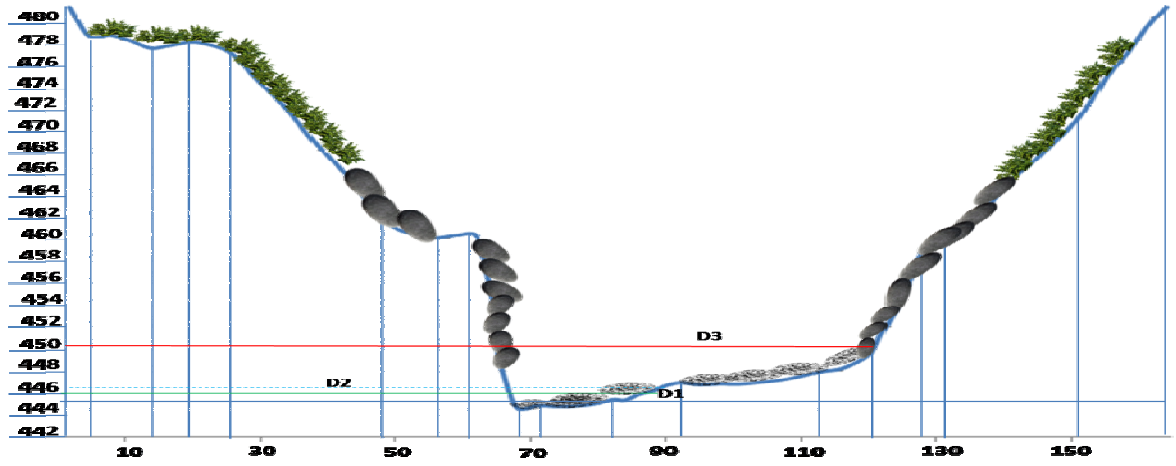
Period of Year (Season)	Wet Period	Dry Period	Annual
E-Flows as percentage of Average Virgin Flow during the period	29.74 %	47.68 %	33.51 %

As seen from the above results, the minimum E-Flows required to maintain river integrity are less than 1/3rd the average virgin flows of the river in the wet period, but nearly half that of the dry period flows, river flows being minimum in winter. River flows also varied annually, but the required E-Flows are generally less than the monthly virgin flows even in the driest years, as evident from Figure 4.7b.

D. E-Flows at Site 4: Downstream of Devprayag (Lat 30°08'27"N, Long 78°35'47"E)

Geomorphic Attributes: Confined, incised river channel with coarse bed material in degradational regime in Himalayan steep valley.

Cross-Section at Site:



Keystone Species	Required Depths for E_flows		
	D_1 (m)	D_2 (m)	D_3 (m)
Snow Trout *(Schizothorax richardsonii)*	0.5 m	0.8 m	4.63
Golden Mahseer *(Tor putitora)*			

Computed E-Flows as % of Virgin River Flows:

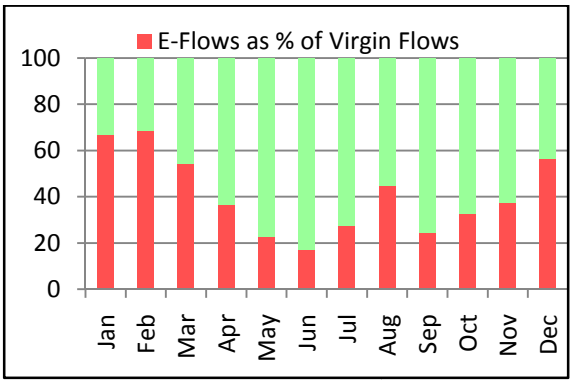


Figure 4.8a: E-Flows as Percentage of Mean Monthly Flows for CWC-Z9.

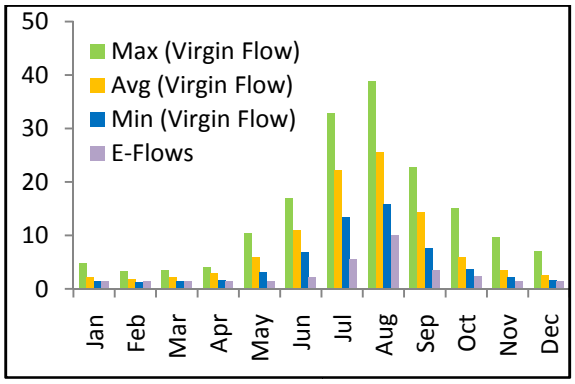


Figure 4.8b: Monthly E-Flows and River Flows as % of Annual Flows for CWC-Z9.

Table 4.6: Percentage of Virgin River Flow required as E-Flows for CWC-Z9.

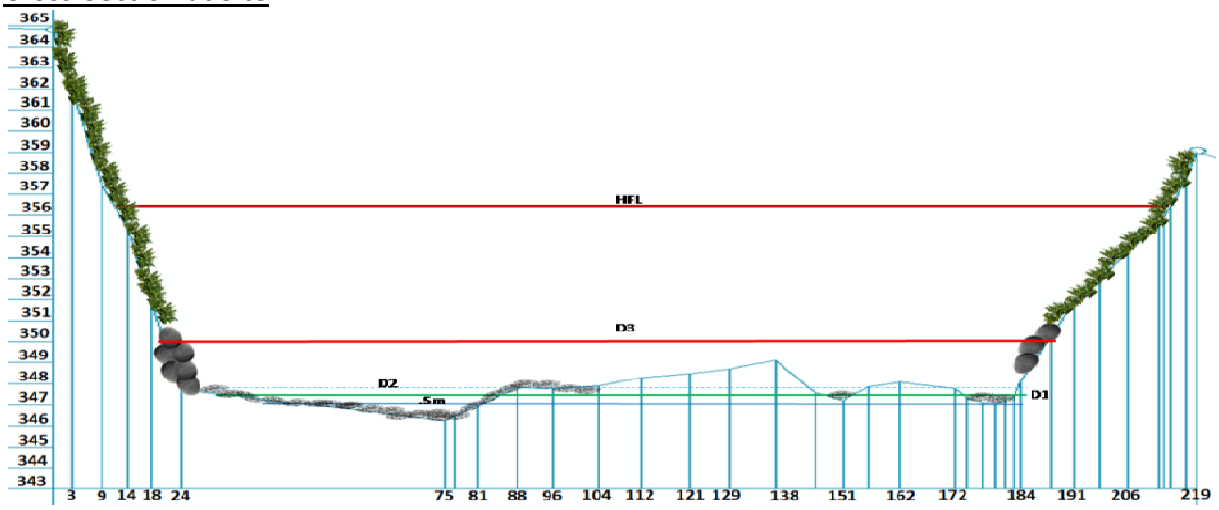
Period of Year (Season)	Wet Period	Dry Period	Annual
E-Flows as percentage of Average Virgin Flow during the period	31.34 %	42.26 %	33.62 %

As seen from the above results, the minimum E-Flows required to maintain river integrity are less than 1/3rd the average virgin flows of the river in the wet period, but more than 40% of the flow during the dry period flows, river flows being minimum in winter. River flows also varied annually, but the required E-Flows are generally less than the monthly virgin flows even in the driest years, as evident from Figure 4.8b.

E. E-Flows at Site 5: Upstream of Rishikesh (Lat 30°08'02"N, Long 78°20'11"E)

Geomorphic Attributes: Partly confined, moderately steep river channel with coarse bed material in aggradational regime in Himalayan bedrock-alluvial transition.

Cross-Section at Site:



Keystone Species	Required Depths for E_flows		
	D_1 (m)	D_2 (m)	D_3 (m)
Golden Mahseer *(Tor putitora)*	0.5 m	0.8 m	2.91

Computed E-Flows as % of Virgin River Flows:

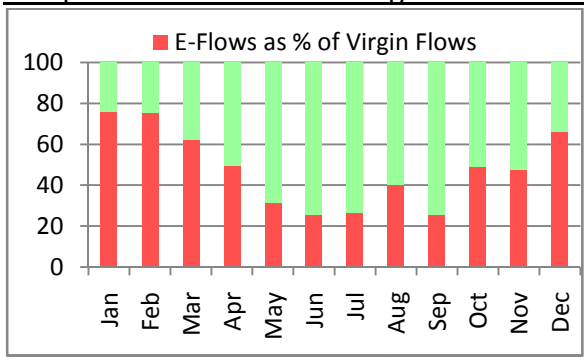


Figure 4.9a: E-Flows as Percentage of Mean Monthly Flows for U/S of Rishikesh.

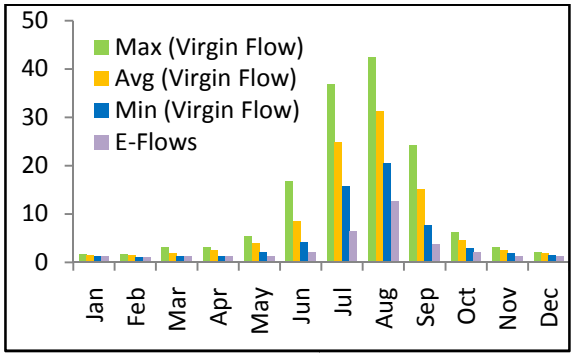


Figure 4.9b: Monthly E-Flows and River Flows as % of Annual Flows for U/S of Rishikesh.

Table 4.7: Percentage of Virgin River Flow required as E-Flows for U/S of Rishikesh

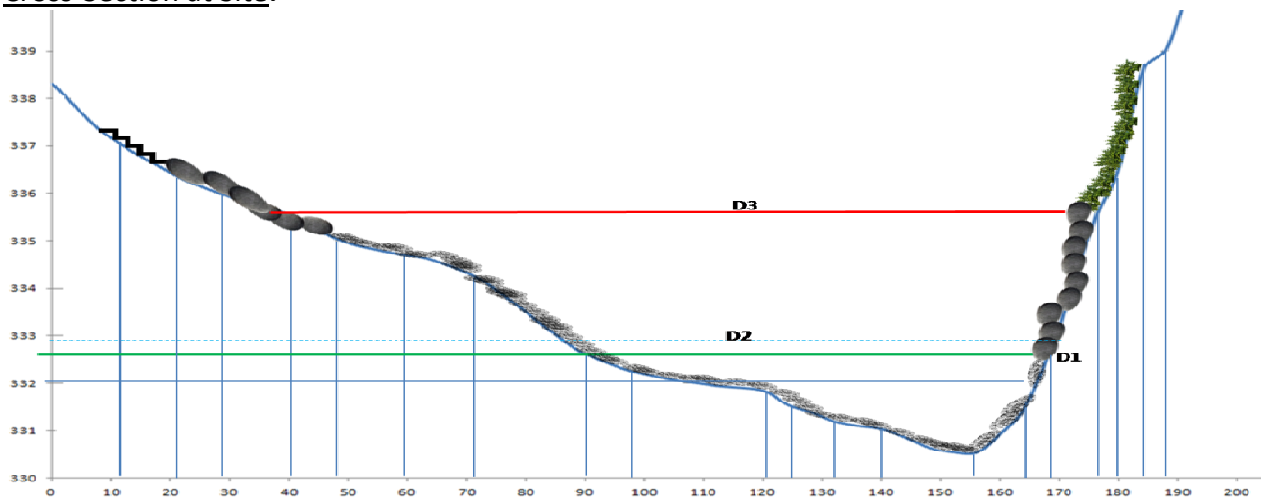
Period of Year (Season)	Wet Period	Dry Period	Annual
E-Flows as percentage of Average Virgin Flow during the period	32.29 %	53.09 %	35.56 %

As seen from the above results, the minimum E-Flows required to maintain river integrity are less than 1/3rd the average virgin flows of the river in the wet period, but more than half that of the dry period flows, , river flows being minimum in winter. River flows also varied annually, but the required E-Flows are generally less than the monthly virgin flows even in the driest years, as evident from Figure 4.9b.

F. E-Flows at Site 6: Rishikesh CWC (Lat & Long same as CWC Site, Rishikesh)

Geomorphic Attributes: Partly confined, transition river channel with coarse bed material in aggradational regime in Himalayan bedrock.

Cross-Section at Site:



Keystone Species	Required Depths for E_flows		
	D_1 (m)	D_2 (m)	D_3 (m)
Golden Mahseer *(Tor putitora)*	0.5 m	0.8 m	3.63

Computed E-Flows as % of Virgin River Flows:

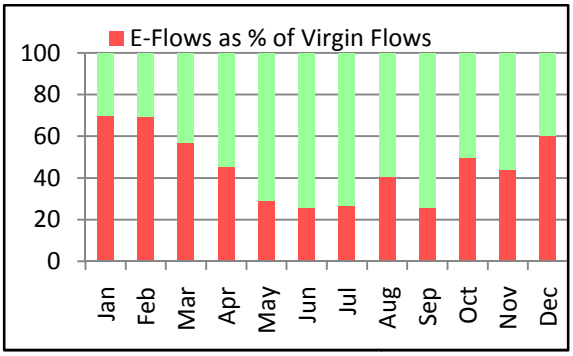


Figure 4.10a: E-Flows as Percentage of Mean Monthly Flows for Rishikesh CWC.

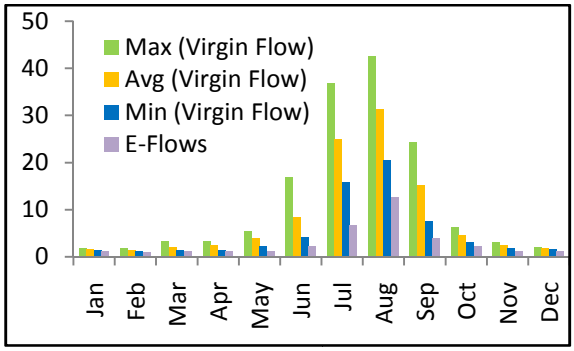


Figure 4.10b: Monthly E-Flows and River Flows as % of Annual Flows for Rishikesh CWC.

Table 4.8: Percentage of Virgin River Flow required as E-Flows for Rishikesh CWC

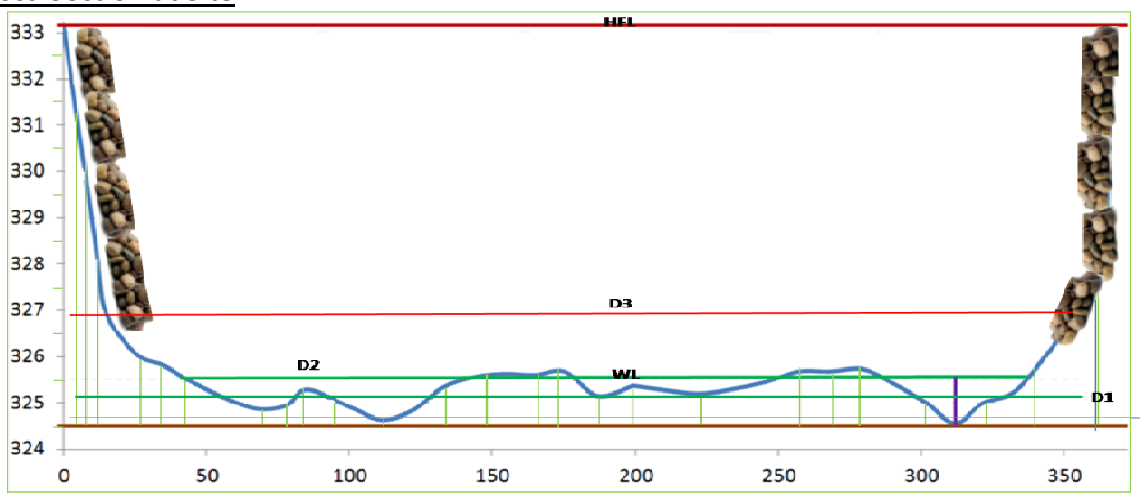
Period of Year (Season)	Wet Period	Dry Period	Annual
E-Flows as percentage of Average Virgin Flow during the period	32.61 %	48.73 %	35.14 %

As seen from the above results, the minimum E-Flows required to maintain river integrity are less than 1/3rd the average virgin flows of the river in the wet period, but nearly half that of the dry period flows, , river flows being minimum in winter. River flows also varied annually, but the required E-Flows are generally less than the monthly virgin flows even in the driest years, as evident from Figure 4.10b.

G. E-Flows at Site 7: Downstream of Pashulok Barrage (Lat 30°04'05"N, Long 78°17'03"E)

Geomorphic Attributes: Partly confined, moderately steep river channel with coarse bed material in aggradational regime in Himalayan bedrock-alluvial transition.

Cross-Section at Site:



Keystone Species	Required Depths for E_flows		
	D_1 (m)	D_2 (m)	D_3 (m)
Golden Mahseer *(Tor putitora)*	0.5 m	0.8 m	2.04

Computed E-Flows as % of Virgin River Flows:

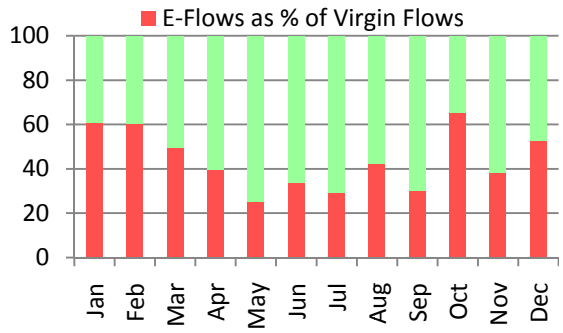


Figure 4.11a: E-Flows as Percentage of Mean Monthly Flows for Pashulok Barrage D/s.

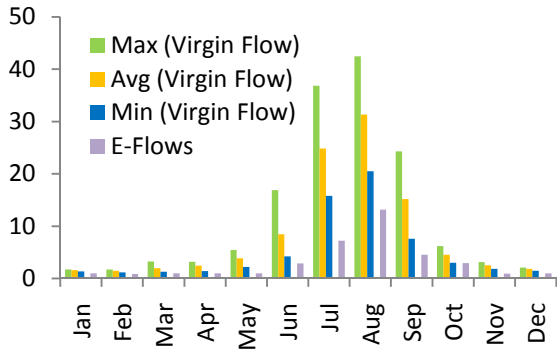


Figure 4.11b: Monthly E-Flows and River Flows as % of Annual Flows for Pashulok Barrage D/s.

Table 4.9: Percentage of Virgin River Flow required as E-Flows for Pashulok Barrage D/s

Period of Year (Season)	Wet Period	Dry Period	Annual
E-Flows as percentage of Average Virgin Flow during the period	36.45 %	42.50 %	37.40 %

As seen from the above results, the minimum E-Flows required to maintain river integrity are slightly more than 1/3rd the average virgin flows of the river in the wet period, but more than 40% of the dry period, river flows being minimum in winter. River flows also varied annually, but the required E-Flows are generally less than the monthly virgin flows even in the driest years, as evident from Figure 4.11b.

4.2. Nirmal Dhara

Ganga river's water quality had been acclaimed in ancient times. Its life-giving and healing qualities are evident from the following description in Rajanirghanta (~300 AD) meaning "The qualities of Ganga water are: *Coolness, sweetness, transparency, high tonic property, wholesomeness, potability, ability to remove evils, ability to resuscitate from swoon caused by dehydration, digestive property and ability to retain wisdom*":

अस्या जलस्य गुणाः शीतत्वम्, स्वादुत्वम, स्वछत्वम, अत्यन्तरुच्यत्वम्, पथ्तत्वम्, पावनत्वम्, पापहारित्वम्, तृष्णामोहध्वंसत्वम्, दीपनत्वम्, प्रज्ञाधारित्वंच, इति राजनिर्घण्टः

The properties of Ganga river's waters quoted above are remarkable, to say the least. However, in present times the river water quality is abysmal, posing a grave environmental threat to the region. The change in water quality may have been occurring over many centuries. Ancient scriptures had cautioned against misusing the Ganga river. For instance, the following edict in Sanskrit prohibited thirteen types of human actions, viz.: *defecation*; *ablutions*; *discharge of wastewater*; *throwing of used floral offerings*; *rubbing of filth*; *body shampooing*; *frolicking*; *acceptance of donations*; *obscenity*; *offering of inappropriate praises or even hymns in a incorrect way*; *discharging of garments*; *bathing and, in particular, swimming across*.

गंगां पुण्यजलां प्राप्य त्रयोदश विवर्जयेत्। शौचमाचमनं सेकं निर्माल्यं मलघर्षणम्।
गात्रसंवाहनं क्रीड़ां प्रतिग्रहमथोरतिम्। अन्यतीर्थरतिंचैवः अन्यतीर्थ प्रशंसनम्।
वस्त्रत्यागमथाघातं सन्तारंच विशेषतः ॥

ब्रह्माण्डपुराण (८०० ई०)

It is possible that such strictures got diluted over time. But, the environmental significance of many of these precautions is obvious to the modern mind. And, what is equally significant, they convey a sense of deep respect for National River Ganga.

The present-day deterioration in water quality is largely due to anthropogenic wastes entering and polluting the river network in various ways, and it is imperative that the original quality water is restored as much as possible. In attempting this, we already have the example of the Thames river cleanup in UK. To quote the "World Water Vision" [*WWC, 2000*], "*The industrial revolution turned the Thames into a stinking, black health hazard as it ran through London in the late 19th century. Major investments in wastewater treatment and cleaner production have gradually restored its recreational and environmental value. … (Hence) there is a critical need to integrate water and environmental management*." In other words, "Aviral Dhara" must be combined with "Nirmal Dhara", Geologic and Ecological concepts to salvage the National River Ganga.

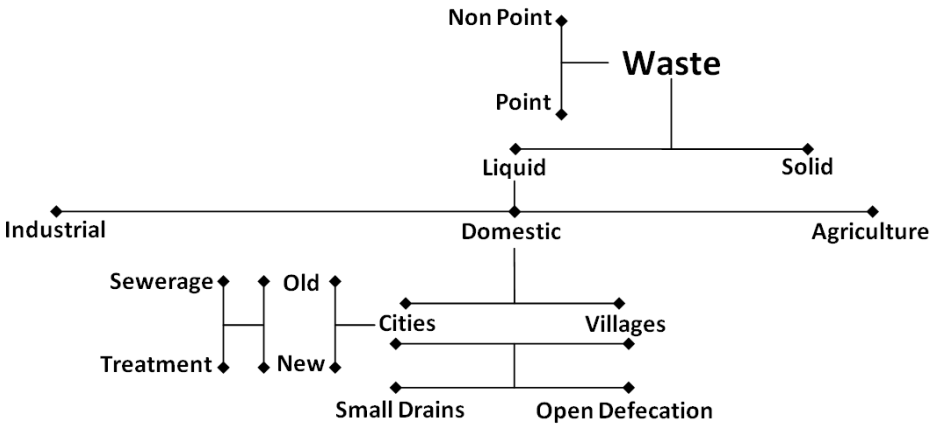


Figure 4.12: Anthropogenic Waste Generation in NRGB

The main approach in this plan for "Nirmal Dhara" mission has been to identify the type of polluting wastes, their sources of generation (point and non-point sources), and the techno-economic feasibility of collecting and treating them for their safe environmental discharge and/or possible recycle or reuse. Figure 4.3 illustrates the main identification results and the tasks. Among point sources, urban and industrial wastewaters are the major source of pollution, needing immediate remediation. Non-point sources need a different approach for their mitigation, and this problem can be taken up subsequently.

The relevant findings of the "Nirmal Dhara" mission are presented in the following reports**:** (i) "Guidelines for Implementation of Sewage Collection, Diversion, Pumping, Treatment, and Reuse (Sewage CDPTR) Infrastructure in Class I Towns" [*IIT_GRB Thematic Report Code: 004_GBP_IIT_EQP_S&R_03_Ver 1_Dec 2010*]; (ii) "Guidelines for the Preparation of Urban River Management Plan (URMP) for all Class I Towns in Ganga River Basin" [*IIT_GRB Thematic Report Code*: *002_GBP_IIT_EQP_S&R_01_Ver 1_Dec 2010*]; (iii) "Pulp and Paper Industries in Ganga River Basin: Achieving Zero Liquid Discharge" [*IIT_GRB Thematic Report: 014_GBP_IIT_EQP_S&R_04_Ver 1_Dec 2011*]; (iv) "Review of Wastewater Reuse Projects Worldwide" [*IIT_GRB Thematic Report: 012_GBP_IIT_EQP_SOA_01_Ver 1_Dec 2011*].

4.2.1. ZLD and Reusable Water from Domestic Wastewaters

In consideration of the magnitudes of domestic wastewater generation from different urban locales, urban settlements have been divided into Class I Towns (having population over 100,000) and Class II Towns (having population between 50,000 to 100,000). For Class I towns of NRGB, the following main steps concerning sewage CDPTR infrastructure for medium to long term (over the next 25 years) are recommended**:**

1. Complete stoppage of the discharge of sewage, either treated or un-treated, from Class I towns into any river of the NRGB.
2. All sewage generated in Class I towns of NRGB must be collected and treated up to tertiary level. Guidelines for tertiary treatment have been specified in *IIT_GRB Thematic Report: 003_GBP_IIT_EQP_S&R_02*, the recommended treated effluent standards being: BOD < 10 mg/L; SS < 5 mg/L; fully nitrified effluent; P < 0.5 mg/L; FC < 230/100 mL.

3. The tertiary treated water should be reused for various non-potable purposes, such as industrial, irrigation, horticultural, and non-contact/non-potable domestic use. Unused treated water may be utilized for groundwater recharge but only via surface storages and subsequent infiltration and percolation through soil.
4. The unit cost of the above tertiary treatment was worked out for Year 2010 price levels at approx. Rs.10/- per m^3 (or 1 paisa/litre). This cost should be borne by the users of treated water, while the cost of fresh water should be at least 50% higher (considering the minimum cost of full treatment of such wastewaters in the natural environment.) These costs should be chargeable from water-users – especially urban and commercial users – thereby ensuring economic use of water and safety of the environment. The water pricing mechanism may be periodically reviewed.

The above proposals are essential to overcome the declining state of urban wastewater management in NRGB. Although much money and effort has been spent in Ganga Action Plan over the past few decades, the overall achievement has been limited. And, yet, the same approach has persisted over the years, leading to general disillusionment and cynicism. This attitudinal blockade is illustrated in Figure 4.4. But such despondency and cynicism can be easily overcome if water is considered as a "resource" rather than as "dirt". By adequately treating wastewater and re-using it instead of dumping the untreated or partially treated wastewater to sully the environment, urban wastewater treatment can achieve "Zero Liquid Discharge" (or ZLD) and recover the value of water as a "resource".

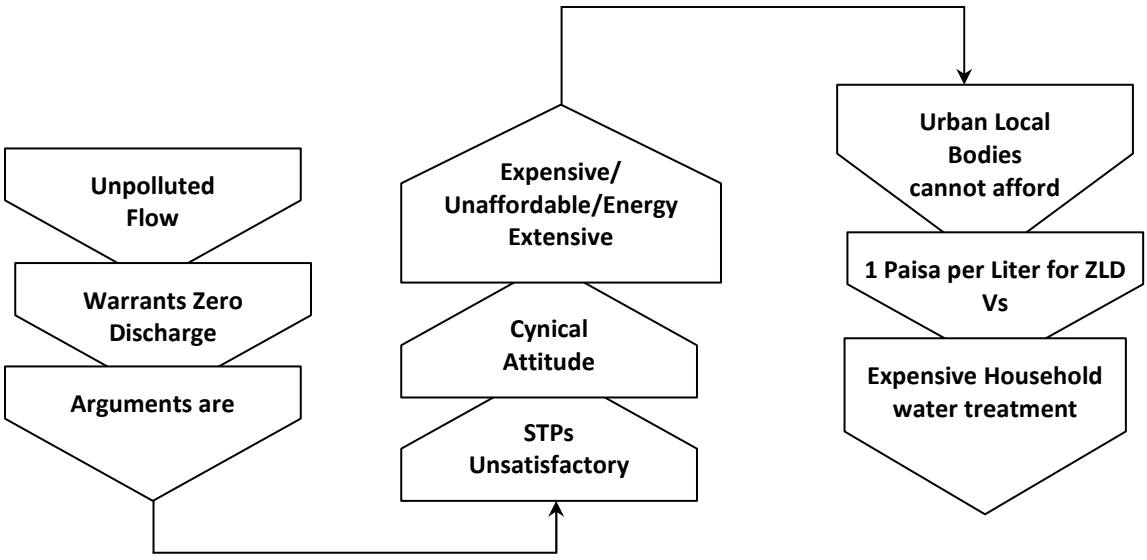


Figure 4.13: Urban Wastewater Treatment for Reuse

4.2.2. Additional Recommendations for Actions on Sewage Treatment

To implement the above concept effectively, it is envisaged that the conversion of urban sewage to usable (and saleable) water should be effected by independent agencies contracted to supply and operate the required wastewater treatment systems for prolonged

periods. Such agencies (service providers) should be paid for the actual quantity of usable quality water produced, and not for merely providing or running the treatment facilities. The following steps have been formulated to fulfill this task in urban centers**:**

1. All new sewage treatment plants and their pumping stations should be constructed and managed by the same agency, adopting the DBFO (Design–Build–Finance–Operate) Model as per *IIT_GRB Thematic Report Code 003_GBP_IIT_EQP_S&R_02_Ver 1_Dec 2010*.
2. The sewage pumping and treatment infrastructure should be built in a modular fashion such that the pumping and treatment capacity is approximately the same as the actual sewage collected/available.
3. All new sewage treatment plants sanctioned in NRGB require treatment up to tertiary level (as specified in *IIT_GRB Thematic Report Code 003_GBP_IIT_EQP_S&R_02_Ver 1_Dec 2010*) and should be funded by the DBFO model.
4. As per the proposed DBFO Model, payments will be made to the service provider in annuities spread over the contract period during the operation and maintenance phase of the project. The payments will be linked to the actual amount of treated sewage (of specified quality) produced by the service provider.
5. All necessary clearances, permissions, etc. for funding of sewage pumping stations and treatment plants using the DBFO model should be obtained from NGRBA.
6. The process of empanelment of qualified/reputed service providers interested in construction, operation and maintenance of sewage treatment plants for usable water quality production through the DBFO route should be started soon.

4.2.3. Recommendations for Actions on Urban River Management Plan (URMP) for all Class I Towns

A URMP should have 'actionable' items to ensure that the riverbank in the town is cleaned, developed and beautified such that it is easily accessible to the citizens as a public space suitable for various spiritual, religious, recreational, socio-cultural and other outdoor activities. Furthermore, 'actionable' items to ensure prevention of discharge of treated or untreated sewage into the river (either directly or indirectly) and 'actionable items' to ensure that treated sewage is reused/ recycled should be a part of the URMP.

Important Points

1. Each Class I town of NRGB must prepare an URMP within the next 6–12 months.
2. An expert standing committee must be set up for vetting and approving the URMPs.
3. Only those project proposals (DPRs) prepared on the basis of 'actionable' items in URMPs shall be eligible for funding in future.

4.2.4. ZLD and Reusable Water from Industrial Wastewaters

Effluents generated by industries are widely varying in nature, depending on the industry's products, raw materials used, processing technologies adopted, etc. While some industrial wastewaters can be adequately treated for reuse very economically, others have dissolved impurities that are more expensive or difficult to remove. Nonetheless, these impurities (and other recalcitrant pollutants) are hazardous, and their removal is essential for reuse or

environmental disposal of the treated water. But once the wastewater is treated up to the level of safe environmental discharge, there is little point in discarding the water rather than reusing it (after some further tertiary treatment, if needed).

An attempt has been made in the GRBEMP to assess technology options and work out the indicative costs of the required effluent treatment for different types of industries. Since the treatment level needed may be different for different industry types, the focus has been on those effluent-generating industries with high pollution potential that have a significant presence in the NRGB. These include *Tanneries*, *Pulp and Paper Industries*, *Distilleries* and *Textile and Dyeing Units*. At present, the work for *Pulp and Paper Industries* has been completed, while the others are in progress.

Pulp and paper Industries, particularly agro-based ones, are major polluters of rivers, e.g. of Rivers Ramganga and Kali which lead to pollution of River Ganga in its middle stretch. The results of existing effluent treatment practices have been highly unsatisfactory so far, and National River Ganga continues to get polluted. The prevailing discharge standards are based on the premise that the background river water quality is almost pristine and at least 10 times dilution water is available in the river. However, these conditions are not met in many rivers including National River Ganga except during the monsoons. By adopting the Zero Liquid Discharge criterion (*full treatment and reuse of wastewater*), not only will the river water quality be saved from further deterioration, but groundwater abstractions will also reduce significantly, enabling higher base flows in rivers during dry seasons.

The technology options and costs of treatment have been worked out for different types of Pulp and Paper Manufacturing units, and presented in the *IIT_GRB Thematic Report Code*: 014_GBP_IIT_EQP_S&R_04_Ver 1_Dec 2011. The analysis of costs for tertiary treatment shows that if these costs are absorbed in production, then the production costs for RCF-based manufacturing processes will increase by about 4–6%, whereas for agro-based manufacturing the cost increase is in the range of 17–19%. In order to avoid grave pollution of the aquatic environment, however, the ZLD standard is imperative; in other words, the additional cost of tertiary treatment needs to be absorbed in the production cost (hence, borne by manufacturers, consumers and/or the government).

4.3. Ecological Restoration

The ecological balance in the Ganga river network has been critically affected in recent times, with major indicator species (including fishes and dolphins) having dwindled or disappeared from many river stretches in recent history. In order to assess the ecological status of the Ganga river network, historical changes in the biodiversity of the river system need to be known. However, historical data being scarce, only some recent changes in biodiversity can be identified. They include the disappearance or reduction of several indicator species in various stretches of the river such as Dolphins, and the Trout, Indian Major Carp and Hilsa fishes. As given in relevant GRBEMP Thematic Reports on the flora and fauna of the Ganga River System [*IIT_GRB Thematic Report Codes:*

020_GBP_IIT_ENB_DAT_01_Ver 1_Dec 2011; 025_GBP_IIT_ENB_DAT_02_Ver 1_ Jun 2012; 026_GBP_IIT_ENB_DAT_03_Ver 1_Jun 2012, 027_GBP_IIT_ENB_DAT_04_Ver 1_ Jun 2012; *028_GBP_IIT_ENB_DAT_05_Ver 1_ Jun 2012; 029_GBP_IIT_ENB_DAT_06_Ver 1_ Jun 2012; 029_GBP_IIT_ENB_DAT_07_Ver 1_ Jun 2012*], the following important reasons are of significance**:** break in longitudinal connectivity of rivers due to dams or barrages (*such as the Maneri Bhali, Pashulok, Bhimgauda and Farakka barrages and the Tehri and Koteshwar dams*) affecting the mobility of aquatic species, abstraction of large amounts of water into canals in the middle Ganga stretch, pollution of river waters through urban and rural discharges, bio-magnification of toxic compounds, habitat degradation, over-fishing/over-exploitation of species, introduction of exotic species (*such as Chinese Carp and Tilapia*) and loss of spawning, feeding and nursery grounds. These reasons indicate that the primary requirement for restoring the ecological status depends largely on adherence to the principles of "Aviral Dhara" and "Nirmal Dhara". Additionally, protection of spawning and breeding grounds of native species, variability in flow regimes, and elimination of competing exotic species from the river network are needed [*Poff, 1997*].

On the basis of fragmentary data obtained from secondary sources, the present ecological scenario for four stretches of the main Ganga river are presented in Table 4.10. The parameters which are conspicuous by their presence and absence have been examined. And, though no historical data are available for comparison, reasonable desired levels of the main river species are indicated in the table.

Table 4.10: Biological Profile of National River Ganga

River stretch	Algal ratio D* G* BG*	Specific Zoobenthos	Fish Families/ RET species	Carps/ Cat fishes/ All Fish taxa	Characteristic fish species	Higher vertebrates
Upper Ganga UG1 (Gangotri to Gangnani)	100:6:0 (33, 2, 0) Total: 36 Other: 1	Plecoptera, Tricoptera, Ephemeroptera, Diptera	NIL [However, sighting of a few brown trout *Salmo trutta fario* have been reported.]			No vertebrates
UG2 (Gangnani to Devprayag)	100:17:5 (123, 21, 6) Total: 151 Other: 1	Plecoptera, Tricoptera, Ephemeroptera, Diptera, Coleoptera	4/ 14	(23/6/35)	Snow Trout (*Schizothorax richardsonii*)	No vertebrates
UG3 (Devprayag to Haridwar)	100:14:13 (95, 13, 12) Total: 123 Other: 3	Tricoptera, Ephemeroptera, Diptera, Odonata	12/ 8	(25/7/42)	Golden Mahseer (*Tor putitora*)	No vertebrates
Middle Ganga MG1-MG3 (Haridwar to Fatehgarh)	100:36:15 (100, 36, 15) Total: 154 Other: 3	Tricoptera, Ephemeroptera, Diptera, Odonata	25/ 15	(46/14/109)	Indian Major carps, Catfishes	Soft and hard Turtles, Ghariyal & Gangetic Dolphins

Table continued to next page … … … …

… … … … Table continued from previous page

River stretch	Algal ratio D* G* BG*	Specific Zoobenthos	Fish Families/ RET species	Carps/ Cat fishes/ All Fish taxa	Characteristic fish species	Higher vertebrates
MG4-MG5 (Fatehgarh to Varanasi)	100:67:36 (149,100,54) Total: 322 Other: 119	Tricoptera, Coleoptera	24/ 12	(34/28/92)	Indian Major Carps, Catfishes	Gangetic Dolphins, Turtles
Lower Ganga LGA (Varanasi-Farakka)	100:118:105 (81, 96, 85) Total: 285 Other: 23	Tricoptera, Ephemeroptera, Diptera, Coleoptera, Annelids & Mollusca	35/ 16	(41/31/121)	Indian Major carps, Catfishes	Dolphins, Turtles
LGB (Farakka-Ganga Sagar)	100:161:220 (127, 205, 279) Total: 652 Other: 41	Thysanura, Collembola, Annelids, Mollusca & Echinoderms	37/ 12	(16/27/172)	IMC, Catfishes, Hilsa, Polynems paradiseus, Liza parsia, Harpodon neherus	Turtles, Ghariyal, Gangetic Dolphins, Porpoise, Crocodile

Note: D* G* BG*= Diatoms, Green algae, Blue-Green algae.

4.4. Geological Safeguarding

Modern anthropogenic ventures can threaten geological formations supporting the river basin in new ways. Notable among these are underground explosions, excavations, tunneling, mining and rock fracturing. Likewise, over-withdrawal of ground water from confined/ semi-confined aquifers may create unbearable overburden pressures, causing the aquifer matrix to (partially) collapse with consequent land subsidence. Another potential threat is due to large reservoirs. Operation of such reservoirs – involving their filling up during high flows and emptying during lean periods – produces significant variations in soil water pressures, which build up additional cyclical stress patterns.

Geomorphological features of rivers and wetlands are more vulnerable than the underlying geologic strata to both natural and manmade stresses. While natural phenomena such as wind, storms, cloudbursts, seismic pressures, landslides and avalanches may not be controllable, various land-use practices that are potentially geo-sensitive need to be checked. These include land-uses that significantly affect the physical properties of catchments such as denudation/ deforestation and construction activities on fragile slopes and in floodplains, agricultural tillage and consequent soil erosion, sand mining from river beds, embankments for flood control and river bank modifications for other purposes.

It should be kept in mind that disruptions in existing geological features of a basin can be due to natural earth processes, which may get compounded by anthropogenic threat factors indicated above, together increasing the geological damage potential. Thus geological monitoring of earth processes in sensitive areas is essential. For example, Himalayan tributaries of the Middle Ganga segment – such as the Kosi and Gandak rivers – are known to be highly dynamic, i.e. with significant tendency to shift their courses. With regular

monitoring of the dynamism of these rivers, timely checks can be imposed on destabilizing anthropogenic activities along with precautions against impending fluvial changes.

Thus assessment and/or implementation of underground safety measures (to maintain the geological integrity), land-use practices (to protect the geo-morphological features of rivers, lakes and wetlands), and continuous geological monitoring (to forecast impending geological events) are therefore essential for geologic housekeeping of NRGB. These aspects need to be analyzed in greater detail subsequently.

4.5. Disaster Management

The Ganga river network is capable of extensive damage to life and property by floods and water-borne diseases in many areas of the basin. It is of prime concern that such damages are controlled. While these issues need to be worked out in further detail, a brief summary of the mission's direction is given below.

In the Upper Ganga segment floods occur mainly as flash floods due to cloud-bursts and heavy rains, sometimes accompanied by landslides leading to damming up of rivers and later dam-bursts that pose grave flood risks. The subsequent Ganga plains, particularly the eastern parts, are prone to more widespread flooding [*Tandon et al. 2008*] and are among the worst flood-affected regions in the world. The floods occur not only due to heavy rains but also due to various geomorphic, neotectonic and fluvial processes. While these processes are not fully understood, floods may be seen as natural phenomena that cannot be entirely prevented. On the flip side, floods clear excess deposits and sandbars from rivers. Besides, floods carry valuable nutrient-rich silt to flood-plains, which otherwise may not reach the land except in unplanned ways (e.g. see Box 4.1). Hence, what can be mainly done regarding floods is to curb their impact and minimize the damages caused (without resorting to short-sighted flood control measures that interfere with river processes). The emphasis should be on strengthening natural ecosystems (such as forests and wetlands) and land-use control (slope stabilization,

Box 4.1

For Maharashtra farmers, drought has its uses!
by Rahul Wadke; Mumbai, April 29, 2012

The severe drought in Maharashtra is proving to be a blessing in disguise for farmers in the State. Dried-up rivers, lakes and ponds are giving the farmers access to nutrient rich silt, which usually settle at the bottom of these water bodies. Silt is a fine granular material derived from rocks and soil. ... It is spread over the farms for enhancing soil fertility. Farmers have to dig up the silt and cart it away to their farm. However, the process of transporting the silt is expensive. Banks, sensing a business opportunity, have decided to offer loans of up to Rs 1 lakh for every 2.5 acre of farmland. …

Progressive farmer and founder member of Organic Farmers' Association of India, Jayant Barve, said that silt can enhance the farm yield by a factor of ten. However, in the first year of application, it does not replace the chemical fertilisers. From the second year onwards, the benefits can be reaped. The valuable manure can be used for any kind of crop, he said.

– News Item in Hindu Businessline

[Accessed on 08-5-13 from: http://www.thehindubusinessline.com/news/states/for-maharashtra-farmers-drought-has-its-uses-after-all/article4667146.ece?ref=wl_industry-and-economy.]

removal of permanent structures from floodplains, etc.) Simultaneously, early warning and evacuation systems, along with disaster mitigation provisions must be kept readily available.

Water-borne diseases are common in the NRGB, as in other tropical parts of the world. However, when rivers, wetlands, and other components of NRGB's aquatic system become a major source of disease and disorder among human beings (and/or livestock), it is often due to water quality degradation by anthropogenic causes. Thus, once again, by focusing on Aviral Dhara and Nirmal Dhara, problems related to water-borne diseases can be largely overcome. Until then, basic hygiene precautions among the population and emergency healthcare services to prevent the outbreak of epidemics are essential.

4.6. Sustainable Agriculture

India is a largely agricultural country, with most of her arable land (more than 60% of the country's landmass) being used for agriculture. This is unlike many other large, agriculturally productive countries, much of whose arable land may be pastures. For instance, the United States, which has more arable land than any other nation (and about 44–45% of her landmass), uses more than half of her arable land for livestock grazing [*World Bank, 2013; US-EPA, 2013*]. In NRGB most of the arable land lies in fertile alluvial plains with high annual rainfall, and it has been mainly deployed for agriculture since long. With developments in large-scale canal irrigation during British rule, increasingly more arable land was brought under cultivation. Consequently, agriculture is the prime sectoral user of water in India, accounting for more than 80% of her water use. Hence water resource depletion in India and in NRGB may be significantly attributed to agricultural use, calling for efficient irrigation practices. Simultaneously, agriculture is also a potentially major source of water pollution. These two aspects underline the unsustainability of modern agricultural activity in NRGB.

The major growth of agriculture in NRGB in the last few decades and its impact on the aquatic environment have been surveyed in accompanying Thematic Reports**:** *Report Code: 015_GBP_IIT_SEC_ANL_01_Ver 1_Dec 2011* and *Report Code: 013_GBP_IIT_EQP_SOA_02_ Ver 1_Dec 2011*]. The basic conclusions of these reports are recounted below.

There has been a tremendous growth in agriculture in the past 40 to 50 years, with agricultural output per district of NRGB increasing almost two to three fold from Rs. 1.97 billion during 1962-65 to Rs. 5.24 billion during 2003-06 at 1990-93 prices. Simultaneously, despite considerable farm mechanisation since the 1980s, the average number of male agricultural workers employed per 10 hectares of Net Sown Area in NRGB also increased steadily from 11 during the period 1962-65 to around 26 during the period 2003-06. The total irrigated areas in NRGB also increased steadily, and the estimated irrigation water use was more than 65 BCM in 2008. With the increasing use of tube-wells in recent times, much of the present irrigation water use in NRGB may be from groundwater.

Agriculture (along with animal husbandry, aquaculture, etc.) can also be a major source of contaminant discharge. Apart from traditional agro-residues, animal refuse and eroded soil, modern chemical fertilizers and pesticides can be significant pollutant contributors to water

sources through surface runoff and percolation through soil [*Misra and Mani, 1994*]. Pollutants from fertilizers are mainly as nitrates, phosphates, and sometimes heavy metals such as lead and cadmium. Pesticides have a wider range of polluting chemicals, which may be highly toxic, chemically stable, and/or biomagnifying through the food chain. But pesticides are used not only in agriculture; they are also used extensively for grain storage. In any case, the actual usage data being scarce, only some general conclusions can be drawn about fertilizers, and little about pesticides. From 1962-65, when the average level of fertilizer consumption was 1,700 MT per district in NRGB, the fertilizer consumption grew tremendously to 102,600 MT during 2003-06. It may be surmised that unless the usage is efficient, these can significantly pollutie both surface and ground waters.

Overall, the main recommendations of efficient water use given under Mission "Aviral Dhara" should apply for agriculture, along with realistic pricing of energy use and promotion of organic farming and of bio-fertilizers and bio-pesticides instead of chemical fertilizers and pesticides. Other measures frequently recommended by various agencies also need to be pursued, such as rain-fed farming, changes in cropping patterns and systems of crop intensification [*Thakkar, 2012; UNICEF, 2013*].

4.7. Environmental Knowledge-Building and Sensitization

The primary goal of an effective environmental plan for the NRGB is to ensure the environmental health of the river basin as a whole, and of the Ganga River Network in particular. To achieve this, one must take account of the diverse developmental pressures on NRGB's environment, which need in-depth understanding of relevant natural processes and their linkages. Such understanding is directly dependent on building a comprehensive bank of environmental data to enable meaningful analyses, thereby making it possible to arrive at quantitative environmental indicators with some degree of certainty. The importance of such a knowledge storehouse has been repeatedly stressed by various agencies and experts, such as India's "National Water Policy – 2002 (*section on "Information System" for water-related data*)" [*MoWR, 2002*], "Comprehensive Mission Document on National Water Mission – 2011 (*section on "Comprehensive Water Data Base in Public Domain"*)" [*MoWR, 2011*], World Bank Report on "India's Water Economy" [*Briscoe and Malik, 2006, pp 51–52*], WWC's "Better Water Resource Management" [*Sadoff and Muller, 2009*], SANDRP's "Water Sector Options for India in Changing Climate" [*Thakkar, 2012*], United Nations' "Water Security and the Global Agenda, 2013" (*Box 8, page 25*) [*UN Water Task Force, 2013*], UNICEF's "Water in India: Situation and Prospects" [*UNICEF, 2013*], etc.

While there is considerable data collection by national and state agencies focussing on specific themes (such as water resources, forest resources, agriculture or industry), environmental assessment requires the integration of disparate themes into a cohesive whole. In other words, environmental planning and management must combine diverse fields such as *water resources, land resources* and *biological resources* with *river dynamics, geological phenomena* and *atmospheric processes* as well as *traditional wisdom* – the experiential essence of generations of people who lived in NRGB. Thus, the environmental

data bank must be a multi-dimensional archive based on regularly collected environmental data, intermittent monitoring data, as well as individual observations and interpretations covering a wide and eclectic data field. In recent times, some water-related and other data have been published by the government and/or are available on websites. However, as discussed under Mission "Aviral Dhara", some of the estimated data need clarifications, while primary data are seldom available. Until such data are brought together and made easily available to users, environmental planning and monitoring of the NRGB can only be a fickle endeavour.

The above data bank along with relevant environmental reports should be accessible to all citizens for two important reasons, namely**:** (i) to inform and sensitize the populace about NRGB's environment, and (ii) to enable stakeholder and community participation in comprehensive environmental management of NRGB. In this context, it should be emphasized that the importance of environmental knowledge in sensitizing people is crucial. Just as good road sense depends on familiarity with traffic rules, knowledge of "environmental rules" (or environmental processes) is essential for true environmental sense. Moreover, since environmental parameters need basin-wide monitoring, and environmental issues are always open to fresh insights, much can be gained from sensitizing people and motivating them to participate in the environmental upkeep of NRGB. This can be achieved by complementing the environmental data bank with target-specific educational material and programmes on NRGB's environment for community education and sensitization.

5. Recommendations of Interim GRBEMP

5.1. Principles of Usage of Water in National River Ganga Basin

(1) The usage of water shall be posterior to nature and ecology.

(2) The usage of water for society shall have sequential priority from 'basic human needs' to 'livelihoods' to 'developmental activities'.

(3) Within each priority, water usage shall be institutionalized on the principles of equity, resource conservation and protection.

5.2. Prohibition of Environmentally Ruinous Activities in NRGB

S No	Activity Prohibited	Explanatory Note
1.	Engineered diversion and/or storage of water in any river unless E-flows are maintained in the immediate downstream of the diversion/storage.	*"E–Flows" are the flow regimes needed to maintain the ecological integrity of a river and the goods and services provided by it. It is computed by the Building Block Method or other standard holistic methods.*
2.	Discontinuity in flow in any river due to engineered diversion/ storage in the river.	*This measure conforms to the "Continuous Flow" ("Aviral Dhara") criterion of Vision.*
3.*	Discharge of sewage (either treated or untreated) from Class I towns, either directly or indirectly, into any river.	*This measure conforms to Unpolluted Flow ("Nirmal Dhara") criterion, since even treated sewage as per existing norms carries significant disease-causing pathogens [IIT_GRB Thematic Report Code: 003_GBP_ IIT_ EQP_S&R_02_Ver 1_Dec 2010]*
4.*	Discharge of industrial effluents (either treated or untreated) from any large or medium industry or cluster of small industries, directly or indirectly, into any river.	*This measure conforms to the "Unpolluted Flow" ("Nirmal Dhara") criterion, since even treated effluents often contain significant amounts of recalcitrant, slow-degrading pollutants.*
5.**	Direct injection of sewage or industrial effluents (either treated or untreated) into the subsurface.	*This measure fulfills the "Unpolluted Flow" criterion by protecting groundwater from pathogens and recalcitrant pollutants.*
6.	Disposal of un-burnt or partially burnt corpses and carcasses of animals in any river or riverbank or natural water body.	*These measures conform to the "Unpolluted Flow" ("Nirmal Dhara") criterion by protecting rivers and water bodies from significant pollution sources.*
7.	Defecation and dumping of municipal or industrial solid wastes or sludge in any river, riverbank, active floodplain of river, or natural water body.	
8.	Construction of new permanent structures for residential, commercial or industrial use in the active flood plain of any river.	*This action conforms to the Vision criterion of geological and ecological integrity of river space.*

* Measures 3 and 4 are intended to curtail the present practice of discharging "treated" wastewater into rivers, since these wastewaters are only partially treated, and are therefore polluting. If they are fully treated, then they can be readily reused or used for other purposes instead of consuming fresh water. Thus, complete treatment of the wastewater serves a dual purpose of preventing pollution and saving on fresh water usage. The technological and financial viabilities of complete treatment have been explained in Sections 4.2.1 and 4.2.2.

** Measure 5 envisages that, if treated wastewaters seep through the soil into the water table, they can be purified by slow filtration and biochemical processes in the soil but not if they are sent directly into groundwater. Hence, the treated wastewater should be held in an unlined water body to allow for seepage into the soil. Moreover, the ponds/lagoons into which treated wastewater is discharged should be in an accessible place for ready inspection or monitoring at any time.

5.3. Restriction of Environmentally Harmful Activities in National River Ganga Basin

The following anthropogenic activities are potentially damaging for the NRGB environment. Their allowance, prohibition or regulation should be based on their actual environmental impacts assessed in specific situations as also their social and economic implications.

1. Discharge of sewage (either treated or untreated) from Class II Towns and smaller towns and villages, directly or indirectly, into rivers.
2. Disposal of industrial/ municipal solid wastes and sludge (from treatment of sewage or effluents) to be restricted everywhere except in secure landfill/ hazardous-waste sites.
3. Discharge of industrial effluents (either treated or untreated) from small scale industrial units into rivers.
4. Disposal and/or discharge of mining and construction debris in any river flood plain, river bank or in the river itself.
5. Construction of bridges and associated roads, jetties, ghats, ports and permanent hydraulic structures (*for water storage, diversion or control, or channelization*) in rivers.
6. Withdrawal of ground water by electric/diesel operated shallow or deep tube wells.
7. Sand mining, dredging, stone crushing, sediment removal, and mining of other materials from river beds.
8. Agricultural activities in river beds and active flood plains of rivers.
9. Commercial fishing or aquaculture in rivers.
10. Ritual immersion of idols, and floral and other offerings in rivers.
11. Washing of clothes, vehicles, etc. in rivers.
12. Deforestation of hill slopes, notified forests and other sensitive areas.
13. Hazardous or harmful emissions that can directly or indirectly affect terrestrial waters (such as sulfur/ nitrous oxides, pulverized fuel ash or 'fly ash', etc).
14. Use of chemical fertilizers and pesticides in agriculture, horticulture, aquaculture, animal husbandry, forestry, etc.
15. Use of pharmaceutical, cosmetic, personal care and other products of domestic or institutional consumption that contribute harmful pollutants in natural waters.

16. Any activity that can lead to geologically disruptive phenomena such as heightened seismic activity, ground subsidence, slope instabilities, landslides, and leaching/ erosion of contaminants into water bodies.
17. Cattle grazing on semi-barren hill slopes or in over-grazed areas.

5.4. Promotion of Environmentally Beneficial Activities in National River Ganga Basin

The following activities and interventions shall be promoted through both public and private mobilization to improve and invigorate the NRGB environment.

1. Reuse and/or recycle of domestic and industrial wastewaters (after due treatment) and use of products derived from sewage sludge, with appropriate mechanism for commercial use/ reuse wherever possible. Such mechanism may include higher pricing for fresh water over recycled water and for chemical fertilizers over organic fertilizers.
2. Development of much-needed pollution-controlling infrastructure, such as sanitation, sewerage and sewage treatment facilities for residential areas, industrial effluent treatment plants, and secure solid waste and hazardous waste landfill sites.
3. Facilities for environmentally safe cremation/burial of corpses and disposal of animal carcasses.
4. Ground water recharge with unpolluted water (*including use of kharif canals, paleo-channels, 'nalas', check dams, unlined ponds and lagoons, etc.*) to raise groundwater levels where needed and enhance river base flows.
5. Higher efficiencies in irrigation water use (through appropriate irrigation techniques, rationalization of cropping patterns, recycling of return flows, etc.) for agriculture, horticulture and fodder cultivation.
6. Higher efficiencies in institutional, commercial, industrial, domestic, municipal and community water uses through minimization of losses, wastage control and provision of adequate water treatment facilities.
7. Afforestation/ grassland development of degraded forests/ grasslands, wastelands and denuded hill slopes (for control of surface runoff and soil erosion, slope stabilization and enhanced groundwater recharge).
8. Appropriate measures for flood mitigation in floodplains.
9. Protection of breeding areas and natural habitats of indigenous and migratory species (including fishes, birds, reptiles, amphibians and mammals), and preventing the spread of exotic species in rivers and water bodies.
10. Eco-friendly tourism, pilgrimage and recreational activities in rivers and riverbanks.
11. Removal of slum clusters and other human encroachments from active flood plains of rivers, and the use of the flood plains for development of water-recharge structures and ecological parks.
12. Use of bio-fertilizers and bio-pesticides (in place of chemical fertilizers and pesticides) in agriculture, horticulture, aquaculture, forestry, etc., to protect groundwater from agricultural pollutants.

13. Regular collection, compilation and dissemination of environmental data of NRGB (including hydrological, geological, meteorological, land-use and pollution data) and maintenance of a historical database in public domain for ready access by any person/ agency.
14. Continuous ground-level monitoring through competent non-profit/ for-profit agencies of: (i) NRGB's environmental status, and (ii) implementation of Prohibited, Restricted and Promoted Activities.
15. Conducting regular environmental education programs – through competent non-profit/ for-profit agencies and institutions – for: (i) public awareness of NRGB's environmental problems and their remediation, and (ii) developing a healthy civic sense of environmental proprieties.
16. Periodic review of "GRBEMP Action Plans and Their Implementation" with feedback from all concerned individuals and agencies including rural and urban local bodies.

Note: Measures 13, 14 and 15 are not intended to duplicate the works being done by specific government departments. Rather, they are aimed at enabling comprehensive environmental management of the NRGB by: (i) pooling the knowledge and efforts of government, private sector, academia, experts and common people, and (ii) environmental capacity building through the spread of scientific understanding and technical competence in both formal and informal sectors of society.

5.5. Implementation Mechanism

As evident from the above, a long-term program for implementation, monitoring, review and evaluation of environmental problems and interventions pertinent to NRGB are needed. Since these measures cover a wide variety of activities involving continuous monitoring and feedback from diverse sources, institutions and individuals, an independent agency is essential to conduct these activities in a coordinated manner. It is therefore proposed that a nodal agency, tentatively termed "National River Ganga Basin Management Commission" (NRGBMC), with adequate resources and authority be set up to ensure the environmental health of NRGB. The NRGBMC is proposed to be set up by an Act of Parliament (refer Appendix III for the tentative draft of a Bill based on a separate GRBEMP Thematic Report by PLG Group under preparation). The NRGBMC should comprise Legal Luminaries, Technical Experts, Government Functionaries and Civil Society Members.

The main task of the NRGBMC may be summarily stated as follows:

(1) The NRGBMC should take all measures necessary for the environmental conservation and development of National River Ganga Basin in a transparent and inclusive manner.

(2) Such measures shall include the following:

- **(a)** Ensuring that E-flows are maintained in all rivers of the Ganga River Network at different locations and in different seasons.
- **(b)** Protecting the geology and ecology of the National River Ganga Basin.
- **(c)** Using of floodplains in appropriate manner, and after ensuring Environmental Impact Assessment for approval of major projects in flood plains.

(d) Ensuring both short-term and long-term measures for conservation and improvement of aquatic resources in National River Ganga Basin.

(e) Monitoring, review and dissemination of the National River Ganga Basin's environmental status in the public domain.

Note**:** All actionable measures of the GRBEMP may not be implementable at one go, and the monitoring and review of environmental actions have to be a continuous process. The Technical Reports, Database and Action Plans of this GRBEMP (under finalization) can be taken as a starting point for the proposed NRGBMC.

5.6. Legislation for NRGBMC

The need for a new legislation and the constitutional provisions enabling the establishment of NRGBMC have been discussed in IIT_GRB Thematic Report Code: 011_GBP_IIT_PLG_DAT_01_Ver 1_Dec 2011 titled "Mapping of Legislations Applicable to the Ganga River Basin". Some of its conclusions are briefly recounted below as background to the proposed legislation.

5.6.1. Comprehensive Legislation on Management of NRGB

India has failed to develop its water resources through integrated river basin development, and inter-State conflicts over rivers have become common. But the Constitution has provisions enabling the Union to regulate interstate rivers in public interest. The Constitution gives full control over waters of a river to a State (List II entry 17), but the State's rights are subject to any law made by Parliament for the regulation and development of interstate rivers to the extent the control of the Union is declared by Parliament by law to be expedient in public interest (List I entry 56). This means that Parliament can make a law taking over the regulation, development and management of an interstate river for the common benefit of the States in national interest. The prevailing condition of National River Ganga warrants the immediate attention of law-makers for such a law.

For enacting the proposed law, it is important to locate subject matters in List II which may be seen as being in conflict with entry 56 of List I. Article 246 (1) confers exclusive jurisdiction on the centre to enact laws on subject matters enlisted in List I, whereas clause 2 of Article 246 grants such exclusivity to the states to enact law on subject matters enlisted in List II. Now Entry 56 of List I provides for "regulation and development of inter-state river and river valleys to the extent to which such regulation and development under the control of Union is declared by Parliament by law to be expedient in the public interest." Thus, the matter of regulation and development of interstate rivers may not be in conflict with the legislative power of the states if the law refrains from impinging on matters within the competence of state legislatures.

The provisions of various existing legislations (enacted by the centre and states) indirectly affecting rivers and river basins relate to subjects on water, sanitation, irrigation, agriculture, pollution, fishing, ecology and biodiversity, environment, etc. Under most of these legislations, Authorities perform the necessary functions stated under the law, but

interestingly no authorities are entitled to play a role in prevention of river pollution. In fact, no concerted effort has been made till date on the legislative front against exploitation of rivers in various ways. Many issues concerning river management do not fall within the present legislative frame, such as maintenance of environmental flows, protection of a river basin's ecology and biodiversity, maintenance of ground water table, consolidated plans for diversion of river waters in different stretches, discharge of sewage, obstructions to river flows and loss of connectivity, use of floodplains and active floodplains, etc. It is desirable, therefore, to adopt an integrated river basin management plan approach that focuses on maintenance and restoration of wholesomeness of rivers of the Ganga basin. Accordingly, the proposed Ganga River Basin Management Act should aim to prohibit and regulate activities that affect the wholesomeness of rivers, and establish authorities or institutions to regulate the activities thereon.

5.6.2. Objective of NRGBMC

The NRGBMC is intended to serve as a custodian of National River Ganga Basin (NRGB) and work for its upkeep and improvement on the premise that health of National River Ganga is a key indicator of the health of NRGB as a whole.

5.6.3. Envisaged Functions of NRGBMC

The Commission is envisaged to fulfil the following functions**:**

Information and Communication

- Procure primary and secondary data (both environment-related data as well as socio-economic, cultural, developmental and other data of NRGB) from government and non-government data collection agencies, and pre-process the data for possible errors and inconsistencies.
- Compile the above data along with those obtained by NRGBMC itself through environmental monitoring, and process them to obtain suitable representations in the form of maps, charts, parametric values, etc.
- Compile all useful environmental reports obtained from various sources in easily usable formats.
- Store all data and reports (soft- and hard-copies) in easily retrievable systems and make them accessible to all interested users.

Environmental Monitoring and Impact Assessments:

- Conduct regular field measurements of environment–related data in NRGB for such information that are not regularly collected or available from other agencies. The data may be procured through the Wing's in-house facilities and through outsourced works to technical and non-technical organizations and individuals (such as local governance bodies, schools, colleges, NGOs, community organizations, etc.)
- Conduct random field measurements of environment–related data of NRGB for specific or sporadic needs (such as to cross-check existing data or fill up gaps in data).

The data may be procured through the Wing's in-house facilities and through outsourced works as above.

- Pre-process all data collected for subsequent archiving and use.
- Conduct Environmental Impact Assessments of on-going and future developmental and infrastructural projects in NRGB as and when the need arises.
- Monitor developmental and infrastructural projects in NRGB for which EIA or preliminary environmental approval was granted by Commission.
- Assist the NRGBMC, if required, in field measurements and monitoring that may be needed for investigation purposes.

Research, Policy, and Governance

- Procure and evaluate available research reports on river basins for their pertinence to the NRGB environment.
- Identify major research needs for NRGB, for communicating to the government.
- Conduct need-based applied research as may be possible by NRGBMC.
- Conduct economic, sociological and cultural analyses pertinent to NRGBMC data bank as well as other information procured from government or other sources.
- Review the impacts of anthropogenic activities in NRGB from time to time.
- Review governmental Policies and Plans (existing and under consideration) and frame suitable Policies and Plans to ensure that the environmental needs of NRGB are met.
- Provide scientific explanations and clarifications for various recommendations given as and when required by the government or other regulatory bodies.
- Formulate good governance guidelines.

Advocacy and Sensitization

- Promote overall awareness of NRGB's environment and how NRGBMC's measures help in safeguarding and restoring it.
- Educate stakeholders (from rural communities to school students and urban interest groups) on comprehensive understanding of complex environmental processes and their interaction with anthropogenic activities. This will involve preparing special educational material, training of field educators, and conducting regular educational programs and feedback from various types of stakeholders.
- Conduct advanced interactive programmes with stakeholders and experts through Seminars, Workshops, etc.
- Conduct special campaigns to sensitize and motivate people to participate in improving the health of NRGB.

Investigation:

To investigate

- Issues regarding non-implementation of measures relating to specified prohibition, restriction, conservation and promotion of activities.
- Non-compliance of policy decisions and guidelines issued by NRGBMC for environmental preservation of the National River Ganga Basin.
- Continuance of existing practices in contravention of the provisions of the Act.

5.6.4. NRGB Fund Generated by NRGBMC

The NRGBMC must be empowered to**:** (i) impose penalties/ damages on individuals and agencies for any violation of its norms and guidelines on restrictions and prohibitions of environmentally harmful activities in the NRGB, and (ii) reward individuals and agencies who contribute exceptionally to the health of NRGB either by their reformative actions or by their watchdog/ investigative actions in conformity with NRGBMC's goals and guidelines. All penalties and damages should be deposited in a specific fund with the Central Government. The said fund should be utilized by the Government on the recommendation and consent of the NRGBMC for environmental improvement of NRGB and to reward individuals and agencies who have made exceptional contributions for the health of NRGB.

Glossary of Technical Terms

The following technical terms have been used in this document. They may be defined as follows (in a simplified manner where possible for ease of understanding)**:**

(a) "**Active Flood Plain**" is the area on the two sides of a river that gets inundated by a flood having a mean recurrence interval of 2.33 years.

(b) "**Afforestation**" is the planting of trees to restore or re-establish forest cover.

(c) "**Aviral Dhara**" or "**Continuous Flow**" (in a river or stream) means continuity of flow in both time and space, including connectivity of flow throughout the river.

(d) "**Basin**" means the entire catchment (*of a water body or water course*) including the soil, water, vegetation and other natural resources in the area.

(e) "**Catchment**" (or "**Drainage Basin**") is the entire land area whose runoff from rain, snow or ice drains into a water body or a water course (before the water course joins another river or discharges into a water body.)

(f) "**Connectivity**" (of a river) means continuity of flow in the three directions, viz. longitudinal connectivity (along the length of the river), lateral connectivity (across the width of river), and vertical connectivity (below the water surface in vertical direction).

(g) "**Deforestation**" means removal or reduction of forest cover, especially when caused by anthropogenic activities.

(h) "**Degraded Forest**" means a forest having loss or reduction of native forest cover and**/** or vegetation density.

(i) "**Direct Injection**" (of water) means injection or introduction (of water) directly into subsurface waters through natural or artificial crevices, faults, channels or conduits without the natural passage through porous soil strata.

(j) "**Ecological Park**" is a protected area for conservation of native, endangered species.

(k) "**Ecology**" is the totality of relations between organisms and their environment. It includes the composition, distribution, amount, number and changing states of organisms within and among ecosystems.

(l) "**Ecosystem**" is a community of organisms and their physical environment, considered to function together as a unit, and characterized by a flow of energy that leads to trophic (or nutritional) structure and material cycling.

(m) "**E-flows**" means Environmental Flows (*defined later*);

(n) "**Embankment**" is a raised wall of earth, stone or other material to hold back water within a water body or water course; it includes levees constructed on either side of a river as a flood protection measure.

(o) "**Engineered Diversion**" means a structure or device constructed or installed to transfer (part of) the river water into a canal or other engineering structure.

(p) "**Environmental Flows**" are the regime of flows required to maintain the ecological integrity of a river and the goods and services provided by it, computed by Building Block Method (or other standard holistic methods).

(q) "**Flood**" means the overflowing of water from a water course or water body that inundates normally dry land.

(r) "**Flood Plain**" is the land area susceptible to inundation by flood waters.

(s) "**Flood Routing Channel**" is a channel designed to carry the excess water of a water course during high flows.

(t) "**Geologic Entity**" is an entity formed by ancient earth processes over geologic ages (hence over long periods of time, usually millions of years).

(u) "**Ground Water Recharge**" is replenishment (in part or wholly) of water depleted from ground water reservoirs.

(v) "**Hydrologic Cycle**" is the natural cyclic movement of water on earth (from oceans to the atmosphere by evaporation, then onto land by rain and snow, and back to the oceans by flow through rivers).

(w) "**Irrigation Return Flow**" means the returning of unused water from irrigation applications to the water source from which they were taken. The source is usually a natural water course, water body or groundwater.

(x) "**National River Ganga**" is the entire length of six head-streams in the state of Uttarakhand namely, Rivers Alaknanda, Dhauli Ganga, Nandakini, Pinder, Mandakani and Bhagirathi (starting from their originating glaciers up to their respective confluences at Vishnu Prayag, NandPrayag, KarnPrayag, Rudrprayag and Dev Prayag) as also the main stem of the river thereafter up to Ganga Sagar.

(y) "**Nirmal Dhara**" or "**Un-polluted Flow**" means flow in a river or stream that is not (significantly) polluted by anthropogenic activities.

(z) "**Paleo-Channel**" is the remnant of an extinct river or stream that got filled with sediments deposited in later periods.

(aa) "**Water Body**" (or "**Surface Water Body**") is a depression on land or a lowland area that usually holds water or remains saturated through most of the year, such as a lake, tank, pond, marsh or swamp.

(bb) "**Water Course**" (or "**Surface Water Course**") is an overland channel (natural or manmade) through which water flows such as a river, stream, rivulet ("nala") or canal.

(cc) "**Watershed**" is same as Drainage Basin. [*Note*: The term "**watershed**" is also used to mean a "drainage divide" as per British usage, i.e. it is a ridge of high land dividing two areas that are drained by different rivers or water bodies]

Abbreviations and Acronyms

1.	ADB	:	Asian Development Bank.
2.	BCM	:	Billion Cubic Metres.
3.	BOD	:	Biochemical Oxygen Demand.
4.	CDPTR	:	Collection, Diversion, Pumping, Treatment and Reuse
5.	CGWB	:	Central Ground Water Board.
6.	COD	:	Chemical Oxygen Demand.
7.	CWC	:	Central Water Commission.
8.	DBVO	:	Design–Build–Finance–Operate.
9.	DPR	:	Detailed Project Report.
10.	FAO	:	Food and Agricultural Organization.
11.	FC	:	Fecal Coliform.
12.	GRBEMP	:	Ganga River Basin Environment Management Plan.
13.	MoEF	:	Ministry of Environment and Forests.
14.	MoWR	:	Ministry of Water Resources.
15.	NCIWRD	:	National Commission on Integrated Water Resources Development.
16.	NGRBA	:	National Ganga River Basin Authority.
17.	NRGB	:	National River Ganga Basin.
18.	NRGBMC	:	National River Ganga Basin Management Commission.
19.	NIH	:	National Institute of Hydrology (India).
20.	P	:	Phosphorous.
21.	RCF	:	Re-Cycled Fibre.
22.	SS	:	Suspended Solids.
23.	SANDRP	:	South Asia Network on Dams, Rivers & People.
24.	UN	:	United Nations.
25.	UNEP	:	United Nations Environment Programme.
26.	UNESCO	:	United Nations Environmental, Social and Cultural Organization.
27.	UNICEF	:	United Nations Children's Fund.
28.	ULB	:	Urban Local Body.
29.	URMP	:	Urban Renewal Management Plan.
30.	USEPA	:	United States Environmental Protection Agency.
31.	WWC	:	World Water Council.
32.	ZLD	:	Zero Liquid Discharge.

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List of IIT GRBEMP Thematic Reports

S No	Report Code	Description
1	000_GBP_IIT_GEN_VD_April_2012	Documentation of Vision, Conceptual Framework and Guiding Principles
2	001_GBP_IIT_GEN_DAT_01_Ver 1_Dec 2010	River Ganga at a Glance: Identification of Issues and Priority Actions for Restoration
3	002_GBP_IIT_EQP_S&R_01_Ver 1_Dec 2010	Guidelines for the Preparation of Urban River Management Plan (URMP) for Class I Towns in Ganga River Basin
4	003_GBP_IIT_EQP_S&R_02_Ver 1_Dec 2010	Sewage Treatment in Class I Towns: Recommendation and Guidelines
5	004_GBP_IIT_EQP_S&R_03_Ver 1_Dec 2010	Guidelines for Implementation of Sewage Collection, Diversion, Pumping, Treatment, and Reuse (Sewage CDPTR) Infrastructure in Class I Towns
6	005_GBP_IIT_FGM_DAT_01_Ver 1_Dec 2010	Active Floodplain Mapping: Defining the River Space
7	006_GBP_IIT_GEN_ANL_01_Ver 1_Dec 2011	Strength, Weakness, Opportunity and Threat (SWOT) Analysis of Ganga Action Plan (GAP)
8	007_GBP_IIT_PLG_ANL_01_Ver 1_Dec 2011	Assessment of Public Consultation Process for Environmental Clearance of Hydropower Projects in Upper Ganga Segment
9	008_GBP_IIT_PLG_ANL_02_Ver 1_Dec 2011	Mapping of Policy Instruments and Governance Agencies for Environmental Clearance of Hydropower Projects in Upper Ganga Segment
10	009_GBP_IIT_PLG_ANL_02_Ver 1_Dec 2011	Policy and Governance: Perspective and Analytical Framework for Management of Urban Sewage
11	010_GBP_IIT_PLG_ANL_02_Ver 1_Dec 2011	Prevention of River Pollution by Urban Sewage: Recommendations from Policy and Governance Perspective based on a Model Case Study
12	011_GBP_IIT_PLG_DAT_01_Ver 1_Dec 2011	Mapping of Legislations Applicable to the Ganga River Basin
13	012_GBP_IIT_EQP_SOA_01_Ver 1_Dec 2011	Review of Wastewater Reuse Projects Worldwide: Collation of Selected International Case Studies and Experiences
14	013_GBP_IIT_EQP_SOA_02_Ver 1_Dec 2011	Emerging Contaminants in Ganga River Basin with Special Emphasis on Pesticides
15	014_GBP_IIT_EQP_S&R_04_Ver 1_Dec 2011	Pulp and Paper Industries in Ganga River Basin: Achieving Zero Liquid Discharge
16	015_GBP_IIT_SEC_ANL_01_Ver 1_Dec 2011	Agriculture in the Ganga River Basin: An Overview
17	016_GBP_IIT_SEC_ANL_02_Ver 1_Dec 2011	Trends in Agriculture and Agriculture Practices in Upper Ganga Basin (Uttarakhand)
18	017_GBP_IIT_SEC_ANL_03_Ver 1_Dec 2011	Trends in Agriculture and Agriculture Practices in Middle Ganga Basin (Uttar Pradesh)
19	018_GBP_IIT_SEC_ANL_04_Ver 1_Dec 2011	Trends in Agriculture and Agriculture Practices in Lower Ganga Basin (Bihar)
20	019_GBP_IIT_SEC_ANL_05_Ver 1_Dec 2011	Trends in Agriculture and Agriculture Practices in Upper Ganga Basin (West Bengal)

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S No	Report Code	Description
21	020_GBP_IIT_ENB_DAT_01_Ver_Dec2011	Floral and Faunal Diversity of Upper Ganga
22	021_GBP_IIT_FGM_DAT_02_Ver 1_Dec 2011	Delineation of Valley Margin and Geomorphic Mapping along the Ganga River Basin and the Yamuna Sub-basin
23	022_GBP_IIT_EFL_SOA_01_Ver 1_Dec 2011	Environmental Flows: State-of-the-Art with special reference to Rivers in the Ganga River Basin
24	023_GBP_IIT_EQP_ANL_01_Ver 1_June 2012	Water Quality in the Ganga River and Efficacy of Sewage Treatment Processes in Coliform Removal: A Case for Adopting Tertiary Treatment
25	024_GBP_IIT_ENB_DAT_02_Ver 1_Sep 2012	The Status of Sundari (H. fomes) an indicators species in the Sunderbans
26	025_GBP_IIT_ENB_DAT_02_Ver 1_Jun 2012	Floral and Faunal Diversity of Middle Ganga
27	026_GBP_IIT_ENB_DAT_03_Ver 1_Jun 2012	Floral and Faunal Diversity of Lower Ganga: Part A – Varanasi to Farakka
28	027_GBP_IIT_ENB_DAT_04_Ver 1_Jun 2012	Floral and Faunal Diversity of Lower Ganga: Part B – Farakka to Ganga Sagar
29	028_GBP_IIT_ENB_DAT_05_Ver 1_Jun 2012	Status of Higher Aquatic Vertebrates in the Ganga River, India
30	029_GBP_IIT_ENB_DAT_07_Ver_Jun 2012	Hilsa : An assessment in lower Ganga river basin, India
31	030_GBP_IIT_ENB_DAT_08_Ver 1_Jun 2012	Status of Fish and Fisheries of River Ganga
32	031_GBP_IIT_ENB_DAT_09_Ver 1_Jun 2012	Wetlands
33	032_GBP_IIT_ENB_DAT_10_Ver 1_Jun 2012	Riparian Floral Diversity in Ganga River Basin
34	033_GBP_IIT_ENB_DAT_11_Ver_Jun 2012	Floral and Fauna Diversity in Alaknanda River
35	034_GBP_IIT_ENB_DAT_12_Ver 1_Jun 2012	Floral and Faunal Diversity in Yamuna River
36	035_GBP_IIT_ENB_DAT_13_Ver 1_Jun 2012	Floral and Faunal Diversity in Ramganga River

Appendix I

Environmental Valuation: Examples from Murray-Darling Basin

Economic Value of Ramsar-listed Wetlands in the Murray-Darling Basin, Australia.

The annual revenue generated in the Murray Darling Basin (MDB) was of the order of $15 billion in 2006. The basin is home to about 30,000 wetlands (including 16 Ramsar-listed sites spread over 630,000 hectares). A detailed analysis of one of the Ramsar sites – the Hattah Lakes – by ACF (Australian Conservation Foundation) in 2010 showed that it generates large annual revenue from ecosystem services (such as water filtration, flood control, water storage, and habitat provision for insect predators and pollinators), besides tourism and recreation. Extending the result to all 16 Ramsar wetlands of the basin, ACF estimated the total ecosystem benefits of the 16 wetlands at $2.1 billion as follows:

Ecosystem service		**$/hectare/yr**
Water filtration:	Includes retention, removal and transformation of excessive nutrients and sediment (representing the avoided cost of investment in a water filtration plant that would be required were the wetland not to exist.)	$2,900
Flood Control:	Controls excessive flows of water during flood events, thus avoiding downstream damage.	$204
Water Storage:	Water is stored within a wetland in times of high water flows and future flows are regulated and balanced out through drier times, reducing investment in additional weirs.	$14
Habitat Provision:	Habitat for birds and animals that provide insect predation and pollination services to surrounding farms.	$217
Other:	Carbon storage and groundwater recharge.	(*Not Valued*)
	TOTAL VALUE PER HECTARE:	$3,335
	AREA IN HECTARES OF RAMSAR WETLANDS:	630,000
	TOTAL VALUE OF ECOSYSTEM SERVICES (per annum):	**$2.1 billion p.a.**

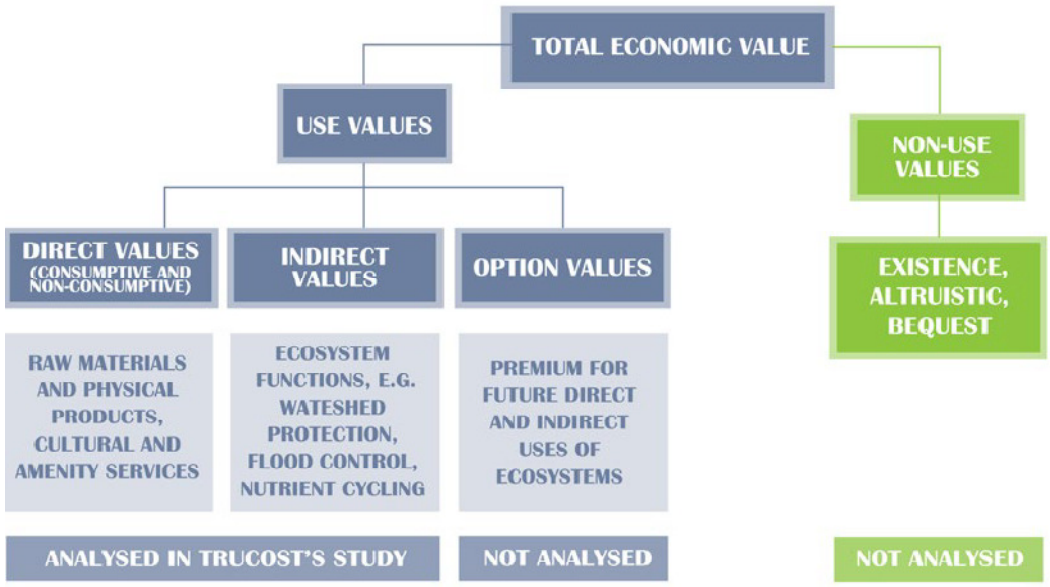
Clearly, without the MDB wetlands and rivers, the great productive base of our agrarian economy would not exist. Without water stored, filtered and delivered through our rivers and wetlands, rural towns could not have drinking water, irrigators could not grow their crops and pastoralists could not water their animals. [*Adapted from: O'Connor, 2010.*]

Economic Value of Yarra Valley Water supplied to Melbourne, Australia.

The Murray-Darling Basin (MDB) is the catchment for Murray and Darling rivers and their many tributaries, covering over one million km^2 or 14% of Australia, and generating one-third of Australia's food supply and 39% of national income from agriculture. The MDB Authority consulted on a MDB Plan that aims to restore the system to a state that enables it to avoid lasting damage to rivers, wetlands, forests and soils. The plan provides an integrated and strategic framework that includes sustainable diversion limits to restore regular flows, thereby improving the capacity of rivers and floodplains to provide

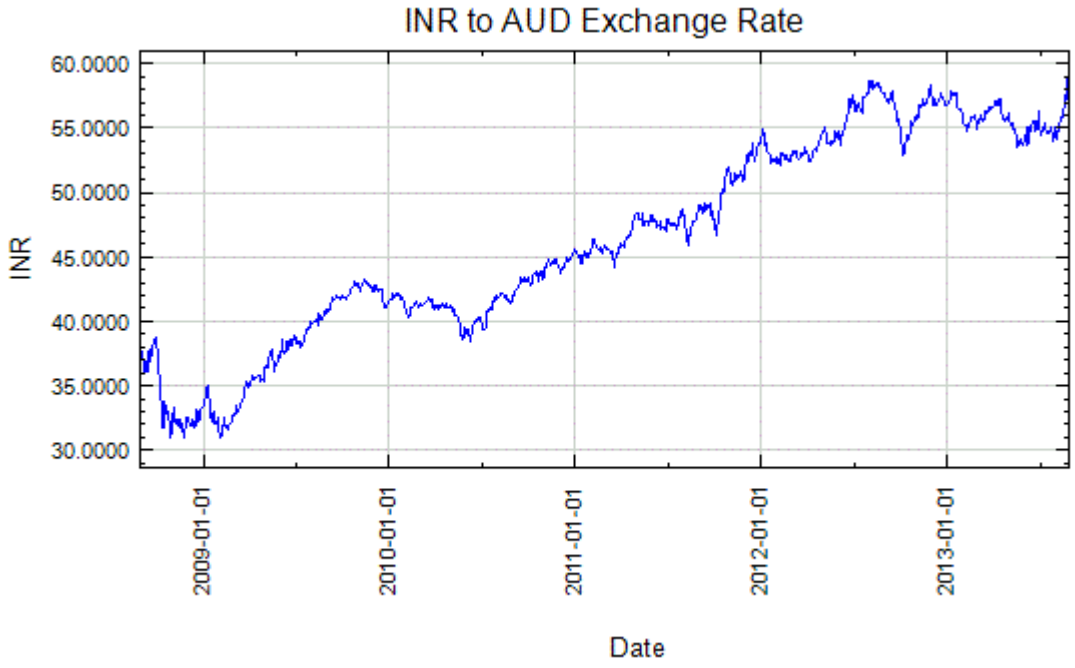
"ecosystem services" such as increased carbon and nutrient recycling; groundwater replenishment; significant reduction in the economic losses associated with algal blooms and salinity; and growth in recreation and tourism industries generated by healthy rivers.

The Yarra River catchment (in MDB) covers over 4,000 km^2 and supplies around 70% of Melbourne's drinking water in 2011-12. Some 4,771,000 m^3 of water were released in the Yarra River in 2011-12 to improve the habitat for aquatic animals; support fish species; increase flood tolerant vegetation; maintain the shape of the river channel; and avoid a decline in water quality. Yarra Valley Water (YVW) commissioned Trucost Plc to estimate the "value of water". Trucost analysed the total value of water in the region to enable YVW to continue to provide sustainable and economically-efficient water management … rather than incurring the costs of damages later. In its analysis, Trucost included the UN System of Environmental-Economic Accounting for Water as a conceptual framework to highlight the Total Economic Value (recommended by FAO) based on different types of uses drawn from them, as depicted below. The study estimated the direct and indirect use values of water abstracted and distributed by YVW. Option and non-use values were not included in valuations due to limitations in quantifying them. Values were calculated in Australian Dollars (AUD) and adjusted for inflation to 2012 prices [*1 AUD ≈ Rs. 52 to 58/- in 2012, as per the chart quoted after this article*].



Key findings**:** The analysis revealed that the indirect use value of water required to supply Melbourne amounts to an estimated AUD5.85/m^3 (as against the domestic and commercial supply price of AUD1.90–1.91/m^3). Variability in water scarcity over time contributed to wide fluctuations in indirect use values year on year. The value of water to Melbourne ranged from AUD1.66/m^3 in 2010-11, when water was relatively abundant, to AUD8.97/m^3 in the most water-scarce year analysed. The hydrological function had the highest indirect use value of the ecosystem functions analysed (AUD4.85/m^3); of this, groundwater recharge had a far more significant value than freshwater replenishment (because of limited groundwater availability in the Yarra valley.) [*Adapted from: van Ast, 2013.*]

Indian Rupee (INR) to Australian Dollar (AUD) exchange rates. [*Accessed 27-8-13 from: http://www.indexmundi.com/xrates/graph.aspx?c1=INR&c2=AUD&days=1825*]



Source: United States Federal Reserve Bank of New York

Appendix II

Summaries of IIT_GRBEMP Thematic Reports

001_GBP_IIT_GEN_DAT_01_Ver 1_Dec 2010

River Ganga at a Glance: Identification of Issues and Priority Actions for Restoration

River Ganga's origin and subsequent course in the plains are described. The Ganga River System is reviewed in three distinct fluvial segments. The Upper Ganga Segment from Gaumukh to Haridwar is described and essential environmental actions needed are defined, especially with regard to the effect of hydropower projects and tourism on the river ecosystem. In the Middle Ganga Segment up to Varanasi, the chief environmental measures needed are found to be complete stoppage of discharge of industrial and domestic wastewaters (and hence their recycling), and the creation of a dolphin protection zone below Garmukhteswar. The Lower Ganga Segment up to Ganga Sagar needs similar pollution control measures as in Middle Ganga, besides detailed hydrological and geo-morphological studies to deal with the high silt loads.

002_GBP_IIT_EQP_S&R_01_Ver 1_Dec 2010

Guidelines for the Preparation of Urban River Management Plan (URMP) for Class I Towns in Ganga River Basin

Most Class I Towns of Ganga River Basin (GRB) are located near River Ganga or its tributaries, and their sewage, solid wastes, riverbank encroachments, etc. harm the rivers. Hence URMPs (Urban Renewal Management Plans) are needed for all Class I Towns of GRB over a 25-year planning horizon for wastewater management and riverbank protection. The URMPs, to be prepared immediately by individual towns, should include actionable items such as removal of encroachments and beautification of riverbanks, banning/ restriction of undesirable activities, sewage collection and diversion, pumping and treatment, and storage, transport and reuse of treated sewage and sludge. The URMPs should be implemented after approval by an expert committee of NGRBA, and funding for various work packages should be made available through NGRBA by different ministries. Unlike other city development plans the URMPs will be river-centric and not city-centric, thereby preventing adverse urban impacts on rivers.

003_GBP_IIT_EQP_S&R_02_Ver 1_Dec 2010

Sewage Treatment in Class I Towns: Recommendation and Guidelines

Urban sewage is a major point source of pollution and also a source of recycled water. Adequate sewage treatment for reuse – either in centralized STPs (Sewage Treatment Plants) or small decentralized STPs – will minimize fresh water withdrawals. The costs, process quality, reliability, environmental factors, land requirements, etc. of different sewage treatment processes are compared. The treatment chain is considered in three stages – Preliminary Treatment, Primary and Secondary Treatment, and Tertiary Treatment.

Technological options for the second stage treatment are considered, and for eight different treatment processes the unit treatment costs and footprint area of treatment plant are derived. A decision matrix table of costs and different treatment parameters is presented. Technological options for sludge management, flow measurement, and bio-assay tests (of treated effluent) are explained. The importance of reusing the treated water, and thereby enabling zero liquid discharge from treatment plants into the environment, is emphasized.

004_GBP_IIT_EQP_S&R_03_Ver 1_Dec 2010

Guidelines for Implementation of Sewage Collection, Diversion, Pumping, Treatment, and Reuse (Sewage CDPTR) Infrastructure in Class I Towns

Currently, sewer networks and pumping facilities are absent or partial, treatment plants malfunctioning or inadequate, and sludge disposal improper. ULBs (Urban Local Bodies) responsible for operating these facilities have different concerns besides financial and other constraints. The Sewage CDPTR Infrastructure for all Class I Towns of Ganga River Basin (GRB) needed are**:** (i) complete stoppage of sewage discharge into rivers, (ii) sewage treatment up to tertiary level, and (iii) reuse of treated sewage water for non-contact/ non-potable purposes. Thus, all new Sewage Treatment Plants must treat up to tertiary level and existing plants upgraded to this level. All Sewage CDPTR Infrastructure should be funded by central and state governments and executed through private-public partnership adopting a DBFO (Design-Build-Finance-Operate) Model, wherein a ULB may contract a service provider for 5–15 years with annual payments against service rendered. Public monitoring of such facilities through independent NGOs, CSOs, etc. is required.

005_GBP_IIT_FGM_DAT_01_Ver 1_Dec 2010

Active Floodplain Mapping: Defining the River Space

The "valley" and "active floodplain" of a river defines the space that it occupies for performing its natural functions. "Floodplain" is an area that is inundated during flood. "Valley" is a wider topographic low occupied by the river and its floodpalin over a longer time. Standard hydrological criteria of defining "active floodplain" is the 2.33 year return flood. Floodplain is ecologically most sensitive and supports a wide variety of vegetation and life forms; its complete preservation is one of the prime indicators of good river health.

Landsat 4-5 TM (30 m resolution), ***IRS P6 AWIFS*** (56 m), ***SRTM*** data were processed in Arc GIS to generate critical parameters for identifying floodpain and valley; and were validated by cross consultation of *MODIS* and *Google Earth* flood times images.

In a basin scale, active floodplain of Ganga River can be divided into four stretches:

a. Hardiwar-Narora: As the river leaves its mountainous reaches it creates a wider (~ 28 km) floodplain that narrows (~10 km) downstream; reduces to ~5 km near the Narora barrage;
b. Narora-Kanpur: Widens (~28 km) again after its confluence with Ramganga, reduces to ~15 km upstream of Kanpur and narrowest (~1 km) downstream of Kanpur.

c. Kanpur-Buxar: Generally narrow; increasing to ~7.5 km near Allhabad; continues unchanged downstream
d. Buxar-Farakka: Floodplain is widest (~42 km) downstream of Munger; near Farakka it is ~26 km

006_GBP_IIT_GEN_ANL_01_Ver 1_Dec 2011

Strength, Weakness, Opportunity and Threat (SWOT) Analysis of Ganga Action Plan (GAP)

This report is primarily aimed at presenting an analysis of the strengths, weaknesses, opportunities and threats (SWOT) of Ganga Action Plans (GAP I and GAP II) and is primarily based on the secondary data collected and literature review. The objective of this report is to consolidate—in a systematic manner—the available knowledge and insights in order to understand nuances and complexity involved in design, implementation and monitoring aspects of the Ganga Action Plan (GAP). Several issues such as delays in implementation of the program, confusion over funding, technological issues, operation and maintenance of the assets do not only indicate typical governance failures but also clarify the gaps in policy and program design. These gaps also highlight the weakness in program planning/implementation/monitoring/evaluation, center-state coordination, state-ULB coordination, etc. The issues such as multiplicity of institutions, especially at the local level and their conflicting/overlapping roles place the need for a deeper institutional analysis. Opaque implementation and low levels of citizen's participation pose broader challenges for the future design and intervention and demand greater transparency. It is equally important to nuance this as problems with respect of to Ganga according to its three important stretches viz., the upper, middle and lower stretches of its flow in order to design the future course of action. Each of its stretch is characterized by different types of problems, having different physical conditions as well as dynamics created by distinct political economy.

007_GBP_IIT_PLG_ANL_01_Ver 1_Dec 2011

Assessment of Public Consultation Process for Environmental Clearance of Hydropower Projects in Upper Ganga Segment

After analyzing the governance structure in the earlier report (Report Code: 010_GBP_IIT_PLG_ANL_02_Ver 1_Dec 2011), this report focuses on a specific aspect of governance – the Public Hearing and Consultation (PC) process which is mandatory for hydropower projects (HPPs) to ensure transparency, accountability and participation in the environmental clearance process. PC is an important vehicle in democratic environmental decision making by developing an arena where the views and suggestions of public are incorporated. Eight case studies of HPPs sampled for rivers Bhagirathi and Alaknanda were undertaken to understand the issues in PC. There is no claim of representativeness of these samples since it forma only a small proportion of the HPPs in the region. However, the in-depth case studies illustrated issues in the microcosm, which is indicative of the macro issues. Understanding the inadequacies and serious lacunae in the process, detailed analysis is given in the report. Some important recommendations are summarised below:

1. The public consultation process must be mandatory even for projects of less than 25 MW;
2. Should ensure informed (all aspects of the project written in local language to be circulated) participation in gramsabhas with adequate time for interested people to express their concerns and the must be recorded in the report
3. Implementation of transparency related provisions by making it mandatory for the PC panel to be constituted a day before the meeting and oversee all such provisions;
4. Before the final EC decision, EAC should inform people about how their concerns and suggestions are incorporated in the EC recommendations by making necessary provision to strengthen each of the stakeholder's right to challenge the EAC decision.
5. The Secretary, MoEF will be responsible for ensuring preparation and timely submission of such compliance reports (in a prescribed format) and its dissemination to local people through the offices of DM and DJ, and also through the MoEF websites.

008_GBP_IIT_PLG_ANL_02_Ver 1_Dec 2011

Mapping of Policy Instruments and Governance Agencies for Environmental Clearance of Hydropower Projects in Upper Ganga Segment

While acknowledging the need for hydropower generation, the process of according environmental clearances to hydropower projects on the basis of EIA studies is an essential tool for safeguarding the ecological integrity and resulting livelihoods in the Upper Ganga basin. Though the State has taken stringent provisions to make the EIA-EC practice mandatory for hydropower projects, various stakeholders (especially from civil society organisations) have expressed grievances about the lacunae in policy instruments and performance of governing agencies leading to violations in practice. The objective of this report is to systematically map the institutional structure (PIs and GAs) for environmental governance in India and to suggest suitable changes to it. The following are the major recommendations of this report:

1. Pre-environmental clearance based on EIA studies is to be made mandatory for projects of all capacity/types including micro-mini- projects and small-medium-large projects whether run-off-the river or otherwise. All of these project types are likely to cause significant impact on local environment which must be studied.
2. An independent authority having required technical competence and supported financially by a consortium of developers is to be established through MoEF. Such an agency should design and conduct feasibility studies and location specific EIAs, if not cumulative impact assessments under the regulation of MoEF. This proposition differs from the consultancy services development mandate of the government and hence, its merits and demerits are needed to be discussed in detail.
3. Independent professionals having required competence in their respective subjects and adequate environmental credentials should be appointed as EAC members and must be provided with adequate secretarial support to thoroughly appraise and

evaluate findings of feasibility studies and EIAs, and to recommend for a clearance through a public proceeding.

4. To ensure transparency and accountability in the environmental clearance decision making process, it should be made mandatory for the concerned agencies to give speaking justifications of their decisions and to share the proceedings in public domain.
5. An independent authority should be established to monitor violations during post clearance construction activities and ensure proactive compliances from the developers.

009_GBP_IIT_PLG_ANL_02_Ver 1_Dec 2011

Policy and Governance: Perspective and Analytical Framework for Management of Urban Sewage

After the analysis of GAP (Report Code: 006_GBP_IIT_GEN_ANL_01_Ver 1_Dec 2011), an urgent need was felt to evolve and articulate a systematic, comprehensive, conceptually sound, and internally consistent perspective—and an analytical framework based on it—that is focused on the policies and governance. The 'Policy and Governance Perspective' and the analytical framework developed in this report are built on the foundation of some clearly defined basic concepts and terms. It also presents a conceptual schema—called as the 'Governance Grid'—which takes a comprehensive view of governance of an entire sector. The perspective then presents a comprehensive and conceptually coherent schema of the actual process of governance as it generally unfolds in reality. The schema begins with the ground-level problems in any sector and helps the analyst identify the core governance maladies of different types in the sector. To address these maladies, the analyst then can evolve recommendations for appropriate changes in—or creation of new—policy instruments and / or governing agencies. The perspective prompts an argument that such core governance maladies cannot be cured by technical, financial, or managerial 'fixes'. It also makes a note that all governance problems cannot be addressed using the policy and institutional 'fixes' either, as they cannot resolve such problems rooted in the 'political bottom-line'. In other words, the problems rooted in the adverse balance of political-economic powers acting against the goals set for the governance of the sector can be resolved only through political action by the sections of society supporting the goals set for governance.

010_GBP_IIT_PLG_ANL_02_Ver 1_Dec 2011

Prevention of River Pollution by Urban Sewage: Recommendations from Policy and Governance Perspective based on a Model Case Study

This report presents an analysis of the ground-level situation of the sewage conveyance and treatment systems in the Kanpur city in Uttar Pradesh. The objective is to bring out important policy and governance related lacunas in the sector, causing continued release of partially treated or untreated sewage and faecal-matter in the river Ganga. This report

broadly follows the template presented in the report titled: Policy and Governance Perspective and Analytical Framework (009_GBP_IIT_PLG_ANL_03_Ver 1_Dec 2011) and begins with the background information on the city of Kanpur with the focus on the activities of the Ganga Action Plan (GAP) executed in two phases (GAP I and GAP II) in the city. The findings focus on different deficiencies in the performance of the sewage system in the city of Kanpur with the analysis of various Policy Instruments (PIs) and lacunas in the Governing Agencies (GAs). The major observation is the proposed weakening of the UP Jal Nigam (UPJN), the para-statal agency currently entirely responsible for carrying out the task related to sanitation. The proposal to shift most of these functions to ULBs through 74th Constitutional amendment act and in parallel encouraging private participation raises a number of questions like huge capacity gaps in ULBs to undertake such functions. The resistance from UPJN for the shift could also affect the smooth functioning of the future pollution abatement activities. The regulatory functions of SPCB are currently severely limited by political interference and resource constraints. It has been evident from the efforts hitherto that sufficient level of experimentation has not taken place for decentralized and in-situ sewage disposal techniques. There is a great need to incentivize such techniques as well as their production and market development if such experiments are to become successful. Such new techniques and practices could be used in the rapidly developing peri-urban areas of large urban agglomerations such as Kanpur as well as to smaller cities which do not have centralized systems for sewage collection, conveyance, treatment, and disposal/reuse. Incentivizing market development for recycling and reuse is another equally important area, especially for cities that are having centralized systems. The shortage of freshwater increasingly faced by the industries in many part of the country which have adequate financial strength to raise finance for undertaking reuse or purchasing treated sewage for industrial use. This potential need to be assessed and pilots should be undertaken at appropriate locations, especially in industrial towns after conducting feasibility assessment of such pilots. However the larger question is whether all the sewage could be absorbed by this mode which again brings in the question of a variety of modes of disposal in the place of currently imagined centralized systems. Small towns would continue to face the financial crisis; even after successful introduction of reforms, primarily because of the smaller sizes of their local economies, which are almost stagnated. Such towns would need continued state support. More case studies are required to be undertaken in the framework of this report to identify the amendments and revisions in GAs and PIs, which would be needed to address these lacunas and distortions. This, in effect, would help us improve the governance of urban sanitation (or sewage) sector in different states along the banks of river Ganga and her tributaries.

011_GBP_IIT_PLG_DAT_01_Ver 1_Dec 2011

Mapping of Legislations Applicable to the Ganga River Basin

Using the Law as an instrument of the River Basin Management has never been within the agenda of state and central legislative authorities; possibly, because it was thought that river is a natural resource and could be exploited to the extent one wants and that river will restore its system back in the natural process.

Because of the above underline thought, there are several legislations [Acts], regulations, rules, order and by-laws enacted/frame, which either pertain to the activities within river basin or have incidental impact over the same. Most of these legislations were enacted to achieve certain specific goals wherein river basin management was never a prime objective. But certain provision of these legislations has been used to regulate the activities on the river bed i.e., water navigation; control pollution, establishment of burning ghat and water sharing etc.

No concerted efforts have been made till date in legislative front against the exploitation of river. Many issues concerning river management didn't fail within the present legislative frame; some of these are maintenance of e-flow; protection of basin's ecology & species; issues relating to the maintenance of ground water in nearby basin area; consolidated plans for diversion of the river water in different stages of rivers; discharge of sewage; obstructions on the river bed; use of floodplain & constructions on it; matter regarding the amount of river water usage; the activities allowed within the river bed etc.

012_GBP_IIT_EQP_SOA_01_Ver 1_Dec 2011

Review of Wastewater Reuse Projects Worldwide: Collation of Selected International Case Studies and Experiences

Unlike most of the river basins worldwide, the practice of treated wastewater reuse is underdeveloped in the Ganga River Basin owing to mist of apprehensions as a result of misconceptions, lack of knowledge and public perception, unclear policies and lack of institutional capabilities. The report presents and reviews some selected case studies of operating wastewater reuse installations worldwide and their associated environmental and public health impacts, economics, community and public perception and participation in order to introduce new ideas and exchange experience for promotion of wastewater reuse in the Ganga River Basin. The plethora of successful case studies suggest that treated wastewater reuse is a plausible option as part of integrated water resources management in the Ganga River Basin. On following the case studies, the zero discharge municipality/city concept by integrating the reuse of highly reclaimed wastewater adopting tertiary-level advanced treatment for non-potable non-human contact uses, seasonal storage in surface reservoir for groundwater recharge and irrigation is recommended as part of the river basin management plan. Water quality standard or guidelines pertaining to wastewater reuse for each beneficial uses must be developed. Moreover, the risk involved, if any must be assessed for treated wastewater reuse schemes before implementation.

013_GBP_IIT_EQP_SOA_02_Ver 1_Dec 2011

Emerging Contaminants in Ganga River Basin with Special Emphasis on Pesticides

Pesticide contamination poses significant risks to the environment and non-target organisms include beneficial soil microorganisms, insects, plants, fish, birds and humans. A limited number of studies have been conducted in the last three decades in Ganga river basin where pesticide concentrations have been monitored in various environmental media. In general, total DDT and total HCH concentrations have been reported at significant concentrations by most researchers. Major findings are:

- Water: Pesticide levels in water samples from the Ganga River basin ranged from non-detectable to a maximum total pesticide concentration of 13.1 micro-g/L in the city of Varanasi. Only four of the fifteen studies reviewed here showed total pesticide concentrations higher than the permissible levels of 1 micro-g/L.
- Sediments: Pesticide levels in sediments ranged from 0.05 ng/g to 240 ng/g.
- Fish: Significant and high pesticide levels have been reported in fish tissue with maximum total DDT concentration of 7.5 micro-g/g in cat fish and maximum total HCH concentration of 3.5 micro-g/g in cat fish. These results indicate that pesticides like DDT and HCH bioaccumulate to significant levels in fish tissue. Health risks associated with these levels of pesticides in food need to be examined in greater detail.

In order to control water pollution by these substances, domestic and industrial wastes (both solid and liquid) should not be discharged/dumped into water bodies without proper treatment.Further, constant monitoring and analysis of the most commonly used pesticides in all environmental media is essential for a comprehensive risk assessment.

014_GBP_IIT_EQP_S&R_04_Ver 1_Dec 2011

Pulp and Paper Industries in Ganga River Basin: Achieving Zero Liquid Discharge

Pulp and Paper Mills, particularly agro-based ones, are a major source of pollution in Ganga river. These mills also consume considerable fresh water. The need for reduced water consumption through improved manufacturing processes and reuse of wastewater are highlighted. Benchmark water consumption figures are indicated for different type of mills. Feasibility of CETPs in place of individual ETPs was examined and found to be generally non-advantageous. For base year 2010, the costs of tertiary treatment needed to produce industry-grade water was worked out for different types of industries. It was found that for complete water recycling, the production costs could increase by about 17–19% for agro-based industries and by 4–6% for RCF-based industries. Practical means for achieving the Zero Liquid Discharge target can be accomplished through a dedicated service provider operating the wastewater treatment and recycling facilities on Design, Build and Operate model.

015_GBP_IIT_SEC_ANL_01_Ver 1_Dec 2011

Agriculture in the Ganga River Basin: An Overview

This report examines the trends in: agriculture land-use and cropping patterns; size of land holdings; crop-diversification; sources of irrigation and status of ground water; use of fertilizers, pesticides, and other inputs; and agricultural production and productivity. For this purpose, the entire basin is divided into three stretches, namely, Upper Ganga Basin (Uttarakhand), Middle Ganga Basin (Uttar Pradesh) and Lower Ganga Basin (Bihar and West Bengal). The study finds that agricultural production in the basin has increased tremendously during last four decades, albeit at varying rates across the states. Net sown area (NSA has declined over time due to growing industrialization and urbanization, while gross irrigated area (GIA) and the uses of other inputs like fertilizer and modern agricultural equipments have increased over the period. Increase in irrigation facilities has resulted into adoption of more water intensive cropping pattern. Although there is a good network of canals, especially in Uttar Pradesh, nevertheless ground water has been the key sources of irrigation in the basin. For instance, it shares 73% of GIA in Uttar Pradesh and Uttarakhand (combined), 59% in West Bengal and 49% in Bihar and Jharkhand (combined). Chemicalization of agriculture has also increased over the period in the basin. West Bengal seems to have registered a tremendous growth in the use of chemical fertilizers from the level of only 5 kg/hectare during 1962-65 to a level of 226 kg/hectare during 2003-06. Uttar Pradesh also followed, more or less, the same level of growth throughout the period with a level of only 4 kg/hectare during 1962-65 to 205 kg/hectare during 2003-06. Comparatively, Bihar has registered a modest growth in the fertilizer consumption. Such an intensive use of fertilizer may lead to disposal of high levels of nitrogen and phosphorus as part of the agricultural runoff into surface water bodies.

016_GBP_IIT_SEC_ANL_02_Ver 1_Dec 2011

Trends in Agriculture and Agriculture Practices in Upper Ganga Basin (Uttarakhand)

This report examines the trends in agriculture and agriculture practices in Uttarakhand and their implications for the Ganga River basin. The study, among others, focuses on land use and cropping pattern, size of land holdings, input use, including irrigation and chemical fertilizers, crop diversification, production and profitability. It is observed that although, the Ganga and its tributaries flow across Uttarakhand, the use of river water in the agriculture is largely confined to the plain areas because possibility of development of irrigation system and adoption of modern input-intensive agriculture in hilly areas is quite limited due to physical, environmental and economic reasons. The study finds that net sown area (NSA) has declined in the recent years due to increasing land demand for non-agricultural uses, particularly for industrialization and urbanization. Further, increasing marginalization of land holdings may pose great threat to the sustainability and economic viability of the agriculture. In the plain areas, cropping pattern is limited to only three water intensive crops—sugarcane, wheat and rice. Huge quantity of water could be saved by changing the cropping pattern from these crops to the less water consuming crops. It is also observed

that the use chemical fertilizer in agriculture, especially in plain areas has increased significantly. The study suggests that in order to maintain *aviral* and *nirmal dhara* in the Ganga River, a two-fold strategy is to be adopted: First, the government policy should be oriented towards making agriculture ecologically as well as economical sustainable which could be done through incentivizing the farmers to adopt alternative farming system, such as organic farming. Second, modern farm technology such as laser land leveling and water saving technology may be promoted for increasing the water use efficiency in agriculture. In order to improve the livelihood of farmers of hill regions, hill agriculture is to be diversified from traditional crops to high value and low volume products. Primary processing of these products can be done in the village itself and secondary and tertiary processing may be done in the industrial clusters.

017_GBP_IIT_SEC_ANL_03_Ver 1_Dec 2011

Trends in Agriculture and Agriculture Practices in Middle Ganga Basin (Uttar Pradesh)

This study examines land-use pattern, occupational structure, size of land holdings, cropping pattern, crop-wise production and yield, area under different sources of irrigation, irrigation intensity, cropping intensity, use of chemical fertilizer and pesticides, status of groundwater utilization, trends in value of agricultural output, costs and returns from major crops and agricultural profitability in Middle Ganga Basin (Uttar Pradesh) which is divided into five regions—North Upper Ganga Plains (NUGP), South Upper Ganga Plains (SUGP), Central region (CR), Southern region (SR) and Eastern Region (ER). The study finds that paddy, wheat, and sugarcane together shared 68.8 percent of total GCA, 83 percent of total GIA and 75 percent of chemical fertilizers consumption in the state. Out of these three crops, sugarcane and wheat continued to generate profits to the growers over the period, while paddy did not consistently provide profits to them. The study reveals that the existing cropping pattern and agricultural practices are economically and ecologically unsustainable. The excessive use of chemical fertilizers and pesticides degrade soil and water and become the major non-point source of pollution of river water. Exponential growth of tube-wells in the basin has seriously depleted the ground water tables and consequently the quality of water. The study suggests that there is strong need to the change the existing agricultural practices and to encourage the farmers to adopt sustainable agricultural practices. Rice-wheat-sugarcane system of farming would not be environmentally sustainable for a longer period. Price signals and market conditions are main determinants of diversification which can be influenced through appropriate agricultural price policy. Alternative agricultural practices (such as organic farming) are not only required to generate more income and employment in the rural areas on sustainable basis but also for improving river health and consequently health of human, animals, and plants. In order to encourage farmers to adopt organic farming, their net farm income may be insured at least for three years either though providing subsidized inputs or through direct transfer of subsidies. This transfer could be much lower than the environmental and health costs that the society bears due to chemicalization of agriculture and pollution of rivers. The government may introduce a

water credit system to encourage the farmers to make efficient use of irrigation water. Irrigation literacy of farmers should be improved through electronic and print media to optimize the water use in agriculture. Information database comprising information on rainfall, groundwater recharge and utilization, water demand for difference purposes, land use pattern, cropping intensity and cropping pattern, customary water rights, irrigation system and practices, etc. may be collected annually and made available on-line.

018_GBP_IIT_SEC_ANL_04_Ver 1_Dec 2011

Trends in Agriculture and Agriculture Practices in Lower Ganga Basin (Bihar)

State of Agriculture in Bihar: Implications for the Ganga River Basin

Bihar has been an agrarian economy with 90 percent of its population living in rural areas. The current report mainly examines the status of the agriculture in the bank and non bank districts of Bihar in order to see the impact of Ganga on agriculture. The study finds that over the years, the area sown more than once has shown declining trend in Bihar, even the cropping intensity is also on declining phase. The current fallow land has increased and net sown area has declined in non-bank districts. The marginal holdings (less than one ha) account for 89.5 percent of the total land holdings in Bihar in 2005-06. Another alarming finding is that average size of marginal holding is 0.24 ha in Bihar in 2005-06. Tube-well has emerged as the most dominating source of irrigation in Bihar. In 2005-06, Tube-wells irrigated 64.72 percent of the net irrigated area and 66.94 percent of the gross irrigated area. Consumption of chemical fertilizers has increased substantially in Bihar agriculture over the time period. The rise in consumption has been more in case of bank districts. The area under rice cultivation has declined gradually over the years, but the area under wheat is showing rising trend. Among the non-food grain crops, sugarcane and banana have shown increase in area as well as production over the years. Looking at the cost and returns in major crops in Bihar, sugarcane, wheat and masur are found to be the profitable crops for farmers in Bihar whereas maize and paddy are not profitable for the farmers. The human and animal absorption in agriculture is declining which has implications for employment and use of animal waste as input in agriculture.

019_GBP_IIT_SEC_ANL_05_Ver 1_Dec 2011

Trends in Agriculture and Agriculture Practices in Lower Ganga Basin (West Bengal)

The study tries to examine the nature and pattern of agricultural activities in West Bengal and their implications for the Ganga River basin. The broad objectives of the study are to examine (a) the agricultural land use and land holding patterns in the state; (b) the trend of growth of agricultural output according to major crops; (c) the sources of inputs used in agriculture with special reference to water and fertilizers. It is observed that over the years, with rise in population in the state, cropping intensity is on the rise and it is higher in the river-bank districts. Rise in cropping intensity without proper crop diversification may lead to unsustainable use of agricultural land indicating greater demand for fertilizers, pesticides and insecticides, water etc. Average operational holding in the state has decreased

significantly over time and considerable portions of farmers are turned out to be marginal farmers. There has been a significant increase agriculture production in the state, thanks to the introduction of high-yielding boro rice cultivation, enabling farmers to grow multiple crops in a year. Amongst the traditional crops, the fertilizer consumption in rice and potato cultivation is very high. There is thus a need to introduce crop diversification, which would economize the use of all resources including chemical fertilizers. Over time, there has been increase in the use of surface and ground water, thereby creating serious implications in terms of ground water depletion and river ecosystem.

020_GBP_IIT_ENB_DAT_01_Ver_Dec 2011

Floral and Faunal Diversity of Upper Ganga

The Central Himalaya in the Uttarakhand offers unique topographical, climatic and environmental features. The diversity of life was reviewed in the upper stretch of river Ganga, Gangotri to Haridwar (294 km). This stretch was divided into three sub-stretches viz., Gangotri to Gangnani (36.9 km) (UG-1), Gangnani to Devprayag (152.76 km) (UG-2) and Devprayag to Haridwar (89.24 km) (UG-3) based on differences in physical, chemical, and biotic attributes. The biotic components of the system are represented by of phytoplankton, periphyton, zooplankton and vertebrate population essentially consisting of fish.

The biotic component in the UG-1 stretch is represented by total 20 taxa of phytoplankton (Bacillariophyceae 17 sp.; Chlorophyceae 02 sp.; Xanthophyceae 01 sp.), 16 taxa of periphyton (Bacillariophyceae 16 taxa) and 25 taxa of zoobenthos (Ephemeroptera 06 sp.; Trichoptera 02 sp.; Diptera 10 sp.; Plecoptera 05 sp.; Coleoptera 02 sp.) as the dominant group. Zooplankton and fish are generally absent in the stretch while some workers reported brown Trout (*Salmo trutto fario*) in the stretch.

In UG-2 stretch the biota consist of 49 taxa of phytoplankton (Bacillariophyceae 28 sp.; Chlorophyceae 16 sp.; Cyanophyceae 04 sp.; Xanthophyceae 01 sp.), 119 taxa of periphyton (Bacillariophyceae 104 sp.; Chlorophyceae 11 sp.; Cyanophyceae 04 sp.), 30 taxa of zoobenthos (Ephemeroptera 8 sp.; Trichoptera 5 sp.; Diptera 8 sp.; Coleoptera 4 sp.; Hemiptera 1 sp.; Odonata 1 sp.; Plecoptera 3 sp.) and 36 taxa of fish (Cyprinidae 23 sp.; Balitoridae 6 sp.; Sisoridae 6 sp.; Schilbeidae 1 sp.). The most characteristic fish of this sub-stretch is Trout (*Schizothorax* sp. and *Schizothoraichthys* sp.). *Schizothorax richardsonii* is selected as a keystone species of this sub-stretch. Zooplankton is not conspicuous except the occasional presence of ciliates viz. *Colpidium* and *Paramecium* sp.

The biota in UG-3 stretch constituted 72 taxa of periphyton (Bacillariophyceae 61 sp.; Cyanophyceae 6 sp.; Chlorophyceae 5 sp.), 77 taxa of phytoplankton (Bacillariophyceae 52 sp.; Cyanophyceae 10 sp.; Chlorophyceae 12 sp.; Xanthophyceae 1 sp.; Euglenophyceae 2 sp.), 14 taxa of zoobenthos (Ephemeroptera 3 sp.; Trichoptera 2 sp.; Diptera 4 sp.; Coleoptera 3 sp.; Odonata 2 sp.; presence of Plecoptera sp.) and 42 taxa of fish. Cyprinidae is the most dominant family while the most critical species is *Tor* sp., which is restricted in the upper region of Rishikesh. This species is known to migrate against water current up to

the river Nayar, where it is known to spawn and rear. Mahseer is not spotted now downstream of Rishikesh barrage. Nematodes and Molluscs also showed the presence in form of zoobenthos in both UG-2 and UG-3 stretch. Zooplankton in UG-3 is scanty consisting of ciliates.

021_GBP_IIT_FGM_DAT_02_Ver 1_Dec 2011

Delineation of Valley Margin and Geomorphic Mapping along the Ganga River Basin and the Yamuna Sub-basin

Maps of valley margin and geomorphic features within the channel belt and active floodplain of Ganga River is presented. **Valleys margins** mark the water divide for the river; lateral hydrological connectivity and recharge of the basin takes place only within the valley margin. The **geomorphic features** within the valley are direct reflection of the hydrological processes operative within the channel and the adjacent floodplain and provide the physical infrastructure of the ecological functions for the River. The satellite images and SRTM is the data source.

Valley width is not uniform and based on valley width, its orientation and position of the river within the valley (symmetrical, left/right margin) the river has been divided into 7 stretches. Maximum valley width varies from 11 to 39 km, while the minimum is 1 to13 km.

22 geomorphic elements have been mapped from Gomukh to Farakka. These include 6 types of in-channel bars, 4 types of secondary/floodplain channels, and 12 types of floodplain features including variety of abandoned bars, levees, floodplain lakes.

River remains narrow confined by Himalayan hills up to **Haridwar**; downstream of Haridwar it widens as it enters the plain and forms a braided stretch on a piedmont fan. Downstream of **Narora** the valley is wide with abandoned braid bars, but channel flow is very narrow due to Narora barrage. Ater **Fategarh** major tributaries join the river and it is incised at places. Between **Kanpur** and **Allahabad** the river is straight with abundant bars. South of **Dalamau** it becomes more stable, meandering. The sinuous course continues beyond **Varanasi** till Gomti and Gaghghara joins and Ganga starts braiding with large stabilised alluvial islands. Joining of large sediment-carrying tributaries (Gandak, Kosi, Mahananda) continues to feed Ganga and the river is characterised by numerous in-channel and abundant braid bars till **Farakka**.

022_GBP_IIT_EFL_SOA_01_Ver 1_Dec 2011

Environmental Flows: State-of-the-Art with special reference to Rivers in the Ganga River Basin

This report explained the concept of E-Flows and its rationale. If further did a thorough review of E-Flows work at a global level and also its relevance for Indian conditions, with special reference to Ganga river system. The concept of Environmental Flows (E-Flows) is defined in this repost, i.e.

"A regime of flow in a river or stream that describes the temporal and spatial variation in quantity and quality of water required for freshwater as well as estuarine systems to perform their natural ecological functions (including sediment transport) and support the spiritual, cultural and livelihood activities that depend on these ecosystems"

A comparative account of various set of E-Flows Assessment (EFA) methodologies has been tabulated to provide comprehensive information about EFA methodologies.

The report also reviewed various initiatives for assessment of E-Flows across the country. The notable among those ones included, the work of WQAA (Water Quality Assessment Authority, Ministry of Water Resources, Government of India) and the study on E-Flows assessment of Upper Ganga by WWF-India (World Wide Fund for Nature – India) and its partners.

The report took a concerted view that for assessment of E-Flows for Ganga river system, the Building Block Methodology (BBM) is the most appropriate methodology. The BBM is one of the holistic set of methodologies and is known for being flexible to accommodate critical local aspects, plus, this methodology works well in data-rich and data-deficient conditions.

023_GBP_IIT_EQP_ANL_01_Ver 1_June 2012

Water Quality in the Ganga River and Efficacy of Sewage Treatment Processes in Coliform Removal: A Case for Adopting Tertiary Treatment

Various intervention and treatment schemes under the Ganga Action Plan (GAP) have been implemented over the last few decades for abatement of pollution and maintaining the river water quality. The report is aimed at analyzing water quality trend of the entire course of the Ganga River since the implementation of GAP and critically reviewing the efficacy of secondary-level sewage treatment technologies in removing microbial pollution and the performance of commonly adopted techniques for disinfection of secondarily-treated effluent. Water quality trend analysis suggests that the river is subjected to severely increasing microbial pollution despite insignificantly higher organic pollution. Lean river flow during most periods in a year due to prevailing climatic and monsoon characteristics in the basin further aggravate the situation. Secondary-level sewage treatment techniques adopted under GAP primarily target reduction in organic pollution and maintaining aesthetics, whereas the reduction in coliforms has been purely incidental. Present paradigm of wastewater treatment employing primary and secondary treatment is vastly ineffective and thereby disinfection of secondarily-treated effluent is bound to be unsatisfactory. The comprehensive analysis presented in the report suggests a case for adopting tertiary-level wastewater treatment with multiple-barrier disinfection approach employing ozonation followed by UV-treatment and/or chlorination in the Ganga River Basin.

024_GBP_IIT_ENB_DAT_02_Ver 1_Sep 2012

The Status of Sundari (H. fomes) an indicators species in the Sunderbans

The Sundarbans area of Hooghly Matlah estuary of the Ganga basin has assumed the name from the forests of Sundari (*Heritiera fomes*) and the exquisite and beautiful plants which look "Sundar" in Vernacular. The trees belong to Phylum Tracheophyta, Family Sterculiaceae. The forest covers an area of 14600 km^2. In India, portion of the forest is poor in growth due to high salinity and other biotic interactions and ecological succession. The mangrove is buttressed by trees 10-25 m tall with dense pneumatophores about 50 cm height. It prefers fresh water and is fast growing in low saline environment commonly found along tidal creeks, channels of coastal swamps. They regenerate through seeds. IUCN has categorized 'Sundari' as endangered and on the extinction threat. The *Heritiera* trees are useful due to hardness of wood and are used in boat building and other domestic uses including furniture.

The present status of 'Sundari' forests has reached due to drivers of change including past alterations, salinity increase, industrial pollution especially of oil and gas exploration, production and accidental release by large tankers. They cause defoliation and top drying. Increase in salinity is due to reduced water flow, reduction in periodic inundation, sediment and nutrient balance. Conservation and Management is necessitated by holistic management approach including vegetative propagation.

025_GBP_IIT_ENB_DAT_03_Ver 1_Jun 2012

Floral and Faunal Diversity of Middle Ganga

The Ganga enters the plains at Haridwar and follows 800 km arching course and continues its journey south east. The stretch of Ganga from Haridwar (downstream of Bhimgoda barrage) down upto Varanasi has been referred as middle Ganga (MG). The stretch is divided into five substretches (a. MG-1 Haridwar to Bijnor; b. MG-2 Bijnor to Narora; c. MG-3 Narora to Fatehgarh; d. MG-4 Fatehgarh to Allahabad; e. MG-5 Allahabad to Varanasi). The multipurpose barrages constructed at Rishikesh, Haridwar, Bijnor and Narora where large abstractions of water for irrigation and generation of power takes place. The middle Ganga stretch also having major diversions as Upper, Madhya and Lower Ganga canal. The river bed is wide with extensive flood plains, meandering streams on sand and pebbles. The water temperatures are moderate and velocities low 20-30 cm/sec. The river consists of pools, riffles and run of the river. The water is clean up to Fatehgarh and thereafter receives large pollution load from the tributaries and urban areas specially Kannauj, Kanpur, Fatehpur, Allahabad and Varanasi.

The data of biota in the middle Ganga is very fragmentary. All components have not been reported in all stretches, MG-1 to MG-5. Phytoplankton is represented by total of 355 taxa (166 sp. of Bacillariophyceae, 113 sp. of Chlorophyceae, 56 sp. of Cyanophyceae, 9 sp. of Euglenophyceae, 9 sp. of Dinophyceae, 1 sp. of Xanthophyceae and 1 sp. of Chrysophyceae) are reported in the middle stretch from Haridwar to Varanasi. Periphyton consists of total

114 taxa (75 sp. of Bacillariophyceae, 23 sp. of Chlorophyceae, 12 sp. of Cyanophyceae, 2 sp. of Euglenophyceae and 2 sp. of Xanthophyceae) from MG-1, MG-3 and MG-4. In the middle stretch of Ganga river, zooplankton were represented by 11 sp. of Protozoans, 28 sp. of Rotifers, 2 sp. of Copepods, 18 sp. of Cladocerans and 4 miscellaneous taxa. Zoobenthos in the middle Ganga region was represented by 7 orders of Insecta, Annelida and Mollusca. Among the various group of organisms, the Insecta population was dominant in the entire middle stretch and represented by Diptera and Trichoptera. The middle stretch is very productive in fish resources and is represented by 126 species belonging to 27 families. Cyprinidae is the most dominating fish family in all substretches. Higher vertebrates in the stretch is represented by Ganga river dolphin (*Platanista gangetica*), gharials (*Gavialis gangeticus*), soft (*Aspideretes gangeticus*, *A. hurum*, *Chitra indica, Lissemys punctata, Hardella thurji, Geoclemys hamiltoni and Melanochelys trijuga*) and hard shell turtles (*Kachuga smithii, K. tecta, K. tentoria, K. dhongoka and K. kachuga*).

026_GBP_IIT_ENB_DAT_04_Ver 1_Jun 2012

Floral and Faunal Diversity of Lower Ganga: Part A – Varanasi to Farakka

The lower segment comprises a fresh water zone (Varanasi to Farakka) 701 km (LG-A). The LG-A spreads through three states Uttar Pradesh, Bihar and West Bengal and includes five important towns Varanasi, Buxar, Patna, Bhagalpur and Farakka. The stretch LG-A is characterized by the presence of number of tributaries and no obstruction and abstraction. The river bed of this region is sandy in nature with 80-90% sand and low percentage of silt and clay. But from Bhagalpur to Farakka, the sand contribution declines considerably with 54-69% sand and substantial increase in silt content. This stretch of lower Ganga supports good growth of biological communities due to the presence of nutrients, higher temperature and clean water with high velocity. Good solar radiation also supports the primary productivity.

The biological profile of the Ganga in the stretch consists of phytoplankton, zooplankton, zoobenthos including macro-invertebrates, fish and higher vertebrates. Phytoplankton is represented by total of 270 taxa (91 sp. of Chlorophyceae, 81 sp. of Bacillariophyceae, 78 sp. of Cyanophyceae, 8 sp. of Euglenophyceae, 3 sp. of Chrysophyceae, 3 sp. of Xanthophyceae, 2 sp. of Dinophyceae, 2 sp. of Rhodophyceae, 1 sp. of Cryptophyceae, 1 sp. of Synurophyceae). Zooplankton comprises of Protozoans (8 sp.), Rotifers (26 sp.) and Crustaceans (5 sp. of Copepods and 13 sp. of Cladocerans). In this stretch all groups are represented though are low in specific composition. The stretch supports the zoobenthos *i.e.* Insects (43%), Annelids (21%) and Molluscs (36%). Nematodes are also reported in the stretch. Fish in the stretch is represented by total of 121 species belonging to 35 families. Thirty five commercially important fishes are included in the taxa along with six invasive species. Every third fish caught belongs to the family Cyprinidae. Beside the preponderance of fish species in this zone, an aquatic mammal, Gangetic dolphin *Platanista gangetica gangetica*, Indian Gangetic Gharials *Gavialis gengeticus*, Salt water crocodile *Crocodylus porosus* and number of fresh water turtles have been reported in this stretch.

027_GBP_IIT_ENB_DAT_05_Ver_Jun 2012

Floral and Faunal Diversity of Lower Ganga: Part B – Farakka to Ganga Sagar

Lower Ganga downstream of Farraka upto Gangasagar is named as LG-B (286 km). River Ganga bifurcates near Farakka into a major offshoot Padma, which flows further eastwards to Bangladesh and a minor offshoot Bhagirathi which flows southwards to Bay of Bengal through deltaic region of West Bengal. Below the confluence of river Jalangi with Bhagirathi, the river flows under the name of Hooghly, through Kolkata and Diamond Harbour and finally reaches its destination (Bay of Bengal). In lower reaches it joined by several tributaries like Ajay, Damodar, Roopnarayan, Haldi, Thakuran and river Matlah.

The Hooghly-Matlah estuarine system is the largest among the estuaries of Indian coast and is characterized by mixing of freshwater and regular tidal influxes which create a steady gradient of marine to freshwater conditions. Tides facilitate transportation of sediments, replenishment of nutrients, flushing out of wastes and mixing of fresh and salt waters. LG-B has been further subdivided into four stretches as the distributional pattern of both salinity and biota clearly demarcated the different stretches of the estuary.

The biodiversity of the lower Ganga Basin is largely controlled by freshwater flux, nutrient inputs and changing environmental condition like salinity, rainfall and temperature. Salinity is the most important chemical factor which affects the diversity and abundance of the biota of this basin directly. Depending on the different groups of animals and plants found in the basin, the diversity can be differentiated between Phytoplankton, Zooplankton, Macrobenthos, Nekton, Macrofauna and Angiosperms. Phytoplankton distribution in the LG-B is represented by 641 algal species (Cyanophyceae 280 taxa; Chlorophyceae 206 taxa; Bacillariophyceae 115 taxa; Rhodophyceae 17 taxa; Dinophyceae 14 taxa; Xanthophyceae 4 taxa; Euglenophyceae 3 taxa; Phaeophyceae 2 taxa) under 169 genera. The dominant algae in lower Ganga is Cyanophyceae followed by Chlorophyceae. Most of the zooplankton studies are centered on Hooghly estuary. Studies on zooplankton communities from the upper stretches are very few. The zooplankton communities in lower Ganga basin are represented by members of Cnidaria (25 taxa), Rotifera (102 taxa), Copepod (26 taxa), Cladocerans (53 taxa) and larval forms of Decapods and Cyclopods. Only some species of Chaetognaths under two genera, namely, *Sagitta* and *Krohnnitta* are reported from the Hooghly-Matlah estuary. Macrobenthos and Macro-invertebrates constitute Annelida (90 taxa), Arthropoda (Total 476 taxa; 240 species of Crustaceans, 33 species of Arachnids, 201 species of insects and 2 species of Merostomata), Mollusca (Total 68 taxa) and Echinodermata (17 taxa). The Ichthyo-fauna is represented by 175 species, out of which 103 species, under 69 genera and 37 families are strictly estuarine in nature. The higher aqatic vertebrates of Hooghly-Matlah estuary is represented by turtles, crocodiles, mammals, dolphin and porpoises. Angiosperms are represented by more than 1175 plant species in 680 genera under 154 families in LG-B.

028_GBP_IIT_ENB_DAT_06_Ver_Jun 2012

Status of Higher Aquatic Vertebrates in the Ganga River, India

Besides 297 species of fish, river Ganga sustains twenty seven species of Reptiles including Gharial, Crocodile, Soft and Hard shell Turtles and Dolphin as aquatic vertebrates. Two species of river Dolphin (*Platanista gangetica gangetica*) and *P. gangetica minor* are found in the Indian subcontinent. Ganga is the home of *P. gangetica gangetica*.

P. gangetica gangetica is exclusively riverine and occur in high densities where a river joins areas of eddy current. They prefer deep waters with sand/ silt bars. Once believed to be in tens of thousands are reduced to 1800 presently.

Dolphins are social animal and live in small groups associated with Crocodiles, Turtles and Wetland Birds. Adults remain in couples. Calving can occur anytime but peaks in Dec-Jan and March-May. Gestation lasts 10.5 months. Dolphin feed on several species of fish and invertebrates.

Three species of Gharial, Mugger and salt water Crocodile are reported. Gharial (*Gavialis gangeticus*) is endemic to India subcontinent. They are now becoming rare due to modifications of river morphology loss of nesting sites and flow regulation.

Gharials are thoroughly aquatic, prefer deep pools and high sand bars and good stock of fish. The mating season is Nov-Jan, egg laying takes place in dry season March-May. 30-50 eggs are deposited in holes dug in sand. Juveniles emerge in 90 days.

Five families of Turtles (Chelonians) are reported. In the Ganga river 12 species of fresh water hard and soft shelled Turtles belonging to *Kachuga* (5 sp.), *Aspideretes* (2 sp.) *Chitra indica*, *Lissemys punctata*, *Hardella thurjii*, are reported. Many of them are endangered and vulnerable. They prefer muddy banks with sand bars for basking, feeding and nesting. They lay egg in dry season which coincides with the Cucurbitaceous cropping in sandy banks.

029_GBP_IIT_ENB_DAT_07_Ver_Jun 2012

Hilsa : An assessment in lower Ganga river basin, India

The prized fish of Bengal *Hilsa* (*Tenualosa ilisha*) belongs to the Family Clupeidae, Subfamily Alosinae, grows in marine environment but migrates to fresh water for breeding is anadromus in nature. It tolerates variations in salinity and travels over 1200 km in inland water for breeding upto Allahabad. The distribution in the sea coincides with Indian monsoon. They are fast swimmers and move near the surface in sea while in inland water prefer movement at depth (14-18 m). In the rivers they may rise upto 2 m on cool drizzling day.

The *Hilsa* fish is heterosexual. Breeding appears to be with monsoon in July, peaks in September-December. Second spawning is attributed to rise in temperature.

The construction of Farakka barrage has altered the behavior past 1975. *Hilsa* now travels upto Farakka barrage and breeds in the entire fresh water area and gradient stretches of

Hooghly. Thus there has been considerable increase in population/ catch in this area. The average catch in Pre-Farakka period was 1457.1 tons. It has increased to 2126.2 tons (1975-1978) and 2135 tons (1984-1994).

030_GBP_IIT_ENB_DAT_08_Ver_Jun 2012

Status of Fish and Fisheries of River Ganga

River Ganga supports a large number of indigenous and exotic species of fishes. The fish population is constituted by large groups of carps and catfishes besides mullets, clupeids, feather back and other miscellaneous species. The fresh water population from Gangnani to Farakka is represented by 181 sp. under 89 genus and 37 families. The family Cyprinidae is conspicuous by large numbers and species richness. The Hooghly Matlah estuary is represented by 103 +72 species (72 sp. are common with fresh water), 69 genus and 37 families. The Chondrichthyes (cartilaginous fish) add up another 13 species. About 100 species have high commercial importance. These included Indian Major Carps (IMC), Catfishes, other Carps, Clupeids while *Hilsa*, *Polynemus*, *Liza*, *Pama* and *Harpodon*.

The Himalayan segment is characterized by the presence of Trouts and Mahseer. The substretch Gangotri to Gangnani is generally devoid of any fish through a few brown Trouts have been sighted. The middle Indogangetic plains and lower Ganga upto Farakka is represented by IMC and Catfishes. Some exotic fishes, common Carp (Cyprinus carpio) and Tilapia (*Oreochromis niloticus*) have started competing with endemic species and have assumed a bigger role down stream of Allahabad.

There has been a remarkable reduction in the production capacity of fresh water fishes due to human indulgence, dams, withdrawal to large quantities of water and pollution due to domestic/ industrial wastes and indiscriminate fishing.

The total catch has gone down significantly. The catch composition has also changed. The IMC component has come down with increase in less economically important fishes and marginal increase in catfishes.

The catch and catch composition in the Hooghly Matlah region has also changed. The fresh water forms are now available upto Diamond Harbour. Change in salinity pattern has also significantly altered the fish composition and availability.

Hilsa is now restricted in the estuarine zone only and its migration has been stopped in fresh water zone beyond Farakka. *Hilsa* has completely disappeared from Bhagalpur, Patna, Varanasi and Allahabad.

031_GBP_IIT_ENB_DAT_09_Ver_Jun 2012

Wetlands

Wetlands are areas transitional between terrestrial and aquatic ecosystem, where water table is usually at or near the surface. Ramsar convention (1971) has defined wetlands as areas of marsh, fen, peat land or water whether natural or artificial, permanent or temporary with static or flowing water, fresh, brackish or salt including areas of marine water the depth of which at low tide does not exceed 6 m.

Wetlands are repository of vital information and services. They provide maintenance of food web, habitat to aquatic flora and fauna, as well as to numerous birds, filtering of sediments and nutrients from surface water, controlling floods, recharging ground water, provide drinking water, fish, fodder, fuel and provide source of livelihood and recreation to local populace.

India has 58.2 million hectares of land including areas under cultivation for paddy. Fresh water wetlands alone support 20% of biodiversity in India. National Wetland Inventory and Association (NWIA) report 103882 ha area under wetland in Uttrakhand, 124530 ha in Uttar Pradesh, 403209 ha in Bihar, 1107907 ha in West Bengal, the major states in the Ganga basin.

Uttrakhand has 58 wetlands covering 8532 ha in 3 districts Uttarkashi, Tehri Garhwal and Haridwar. In Uttar Pradesh a large number of lakes, ponds and channels in 17 districts of Ganga basin with cumulative area of 314775 ha in 25112 wetlands. The river and streams account for 57.7% and 13.6% in water logged areas of the total wetland. In Bihar 12 districts are related to Ganga basin including lakes/ponds and cut off meander river and water logged areas. The river and stream related constitute 81.9% and the rest in small lakes and ponds. Jharkhand with lone district of Sahibganj accounts for 555 wetlands with 16118 ha area. The river and stream related wetlands represent 65% and small lakes and ponds 17.75%. Wetlands in West Bengal are many in seven districts related to Bhagirathi and Hooghly river. Wetlands upto Maldah district (Farakka barrage) have been included in this report. The Maldah district has 123 wetlands with aggregated area of 4608 ha.

Much of the information on biodiversity in wetlands is not available, however some of them have been monitored *viz.* Banganga wetland, Jhilmil jheel, Tehri dam in Uttarakhand. Lake Bahsri (Farrukhabad). Samaspur bird sanctuary (Balia) and Narora dam in Uttar Pradesh.

The wetlands are threatened due to encroachment for agriculture and buildings, deforestation, pollution, overfishing, poaching of wild animals, introduction of exotic plants and animals. Protection and conservation is the need of the hour. Sound conservation methods are in place to achieve their continuation but a will to do is needed.

The Maldah district has 123 wetlands with aggregated area of 4608 ha have been included in this report.

032_GBP_IIT_ENB_DAT_10_Ver_Jun 2012

Riparian Floral Diversity of Ganga River

River bank vegetation ecologically termed as Riparian vegetation is highly dynamic linking terrestrial and aquatic habitat under the influence of water ways. Riparian plant habitats and communities are characterized by hydrophilic plants. They consist of macrophytes, native grasses, sedges, climbers, shrubs and trees. Water current plays decisive role in dispersal of vegetative propagates. They fulfill the demands of timber, fuel, fodder, medicines and fruits of local populace. Riparian vegetation grows luxuriantly after floods when conditions promote growth.

Krishnamurthi *et al.* (1991) have identified 475 species downstream Rishikesh including 49 types of tress with 16 having medicinal value with herbs 67%, shrubs 12%, climbers 6%, trees 10%, sedges 2% and native grass 3%. The riparian flora in Gangotri to Narora constitutes main vegetation as *Primula*, *Stellaria*, *Elatostema*, *Geranium*, *Rhododendron*, *Juniperus* and *Salix*. *Cedrus deodara* borders the bed on both sides on the flood plain deposit. The important families are Poaceae, Asteraceae, Euphorbiaceae, Moraceae and Lamiaceae. The stretch Mirzapur to Farakka has 40 macrophytes. The genera represented include *Eclipta*, *Polygonum*, *Ipomea*, *Rumex*, *Saccharum*, *Scirpus* and *Tamarind*. The Bihar Diara lands harbor Acanthaceae, Polygonaceae, Apocynaceae, Asteraceae, Boraginaceae, Amaranthaceae, Euphorbiaceae and Lamiaceae. West Bengal, with humid conditions has 212 macrophytes including the families of Acanthaceae, Acoraceae, Aizoaceae and Amaranthaceae. The total angiosperms in the middle and lower Ganga include 154 families and 680 genera (235 taxa of trees, 280 taxa of shrubs, 660 taxa of herbs, 680 taxa of weeds, terrestrial 832 and cultivated 289 taxa). The canopy trees include Saal (*Shorea robusta*), Teak (Tectona grandis), Sheesham (*Dalbergia sissoo*), Mango (Mangifera indica), Neem (*Azadirachta indica*), Banyan (*Ficus benghalensis*), Peepal (*Ficus religiosa*), Jamun (*Syzygium cumini*), Mahua (*Madhuca longifolia*) and Simal (*Bombax* sp.).

Degradation and Strategies to conserve are elucidated.

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Floral and Fauna Diversity in Alaknanda River

The Alaknanda basin is characterized by hilly terrain, deep gorges and river valleys. The river originates at the water divide between Satopanth and Bhagirathi glacier (near Vasudhara falls) flows eastward joins Saraswati river at Mana and then flows downstream in south east direction to Joshimath where it meets Dhauliganga. It moves south west and meets river Bhagirathi at Devprayag. Several rivulets in the Garhwal region merge with Alaknanda at Panch Prayag i.e. Vishnuprayag (Dhauliganga), Nandaprayag (Nandakini) Karanprayag (Pindar), Rudraprayag (Mandakini) and Devprayag (Bhagirathi). One hydro electric project is under operation and 36 others are proposed as Run of the River Projects (ROR).

Rapids are major habitat type followed by riffles and ponds. Mature cobbles, pebbles and boulders constitute the major substrate. Water is clear, cold with high velocities.

Alaknanda has been ecologically differentiated into two stretches **(A)** Mana to Vishnuprayag and **(B)** Vishnuprayag to Devprayag. The biodiversity of stretch A is generally unexplored attributed to very cold water and very high current. Diatoms (6 sp.), green algae (1 sp.) and blue green algae (1 sp.) however has been reported. No fish has been reported.

The stretch **(B)** has diatoms as dominant group with (145 sp.), green algae (11 sp.), blue green algae (6 sp.) as phytoplankton and Periphyton. Protozoans (8 sp.), Rotifers (2 sp.) and crustaceans (3 sp.) represented as zooplankton. Dipterans, Trichopterans and Ephemeropterans constitute the Zoobenthos. Forty three species of fish belonging to Cyprinidae (26 sp.), Sissoridae (7 sp.), Balitoridae (6 sp.), Cobitidae (3 sp.) and Ambyceptidae (1 sp.) families have been reported. Trout is the characteristic species while Snow Trout (*Schizothorax richardsonii*) has been identified as keystone sp.

034_GBP_IIT_ENB_DAT_12_Ver_Jun 2012

Floral and Faunal Diversity in Yamuna River

The river Yamuna, originates from Yamunotri glacier at Bandar Punch in the region of Simla at 6387 m (amsl) in the lower Himalayas. After flowing through the Shivaliks it emerges on the plains at Tajewala and flows down to south west to south through National Capital Region, Delhi to Mathura, Agra, Etawah and merges with Ganga at Allahabad traversing a distance of 1170 km. During its course the river joins Hindon, Chambal, Sind, Betwa, Ken and Paisuni.

The course of Yamuna has been differentiated into five sub stretches: Himalyan, (YR_1) origin to Tajewala (172 km); Upper stretches, (YR_2) Tajewala to Wazirabad barrage (224 km); Delhi stretch (YR_3) Wazirabad barrage to Okhla barrage (22 km); Eutrophic stretch, (YR_4), Okhla barrage to Chambal confluence (490 km); Diluted stretch, (YR_5), Chambal confluence to Ganga confluence (468 km).

The soils of Yamuna vary considerably as they have developed under different lithological, climatic, and pedogenetic conditions. River bed is primarily sandy.

The biodiversity of river Yamuna varies profoundly due to obstruction of water, large abstraction and indiscriminate addition of treated and untreated domestic and industrial wastes. The ecological condition in (YR_3), Delhi stretch is highly stressed. The poor conditions prevail upto Agra downstream.

The phytoplankton is represented by 218 sp. in the entire stretch with Chlorophyceae as dominant group (110 sp.), followed by diatoms, Bacillariophyceae (56 sp.) and blue green algae, Cyanophycea (37 sp.), Euglenophyceae (7 sp.) and others (8 sp.). They include sensitive and tolerant species. The Periphyton is more common and includes 394 sp. mostly in YR_1, YR_2 and YR_3. The Bacillariophycea, Chlorophyceae and Cyanophyceae constitute the

major component of periphyton. The Zooplankton is constituted by Protozoans (97 sp.), Rotifers (105 sp.), Crustaceans (42 sp.) and many others including Gastropoda, Nematoda, Insecta and Annelida.

The Zoobenthos is represented by 3 orders of Arthropods, 9 orders of Insecta, 2 classes of Mollusca, 4 classes/subclasses of Annelida and 1 order of Nematoda.

The distribution and status of fish fauna reported 139 species belonging to 78 genus and 33 families. A total of 88 species belonging to 47 genus and 21 families have been recorded from YR1, while in YR2, 20 species belonging to 11 genus and 4 families have been reported. In YR_3 stretch 49 species belonging to 33 genus and 19 families have been reported. YR4 and YR5 stretch represented by 50 species, 35 genus, 19 families and 67 species, 51 genus, 23 families, respectively. Cyprinidae continued to throng the river followed by Bagridae, Sissoridae, Channidae and Siluridae. The catch is gradually getting reduced and composition changing drastically. The carps are being reduced and catfishes increased.

035_GBP_IIT_ENB_DAT_13_Ver_Jun 2012

Floral and Faunal Diversity in Ramganga River

The river Ramganga originates as two streams as Western and Eastern Ramganga and flows down in plains independently. Western Ramganga originates near Gairsain (Uttarakhand) of Doodha Toli ranges in the lower Himalayas. The river flows down through Patli Dun of lower Shivalik and flows through Corbett National Park, Moradabad, Rampur, Bareilly, Badaun and Shahjahanpur and joins Ganga downstream of Farrukhabad. Eastern Ramganga merges with river Sarju at Rameshwar ghat and finally confluences with river Kali and joins Ganga at Farrukhabad adjacent and opposite Ramganga.

Phytoplankton constitutes the main producer component and comprise of three important classes Bacillariophyceae (26 sp.), Chlorophyceae (9 sp.), Cyanophyceae (11 sp.) and Xanthophyceae (1 sp.). The Periphyton is represented by Chlorophyceae (24.4-47.9%) and Bacillariophyceae (52.1-75.6%) of total population.

The Zooplankton constitutes Protozoans (5 sp.) and 24-44.7% of total population and the Rotifers (6 sp.) and Crustaceans (6 sp.) together constituting 59.1-76% of the total population.

The Zoobenthos is represented by seven orders of Insecta *viz.* Ephemeroptera, Diptera, Coleoptera, Trichoptera, Hemiptera, Plecoptera and Odonata.

The diversity of fish is rich and is supported by 49 sp. belonging to seven families under 22 genera. Family Cyprinidae is the most dominant group 28 sp. and 11 genera. The important fishes are game fishes Trout (*Schizothorax*) and Mahseer (*Tor* sp.) and *Labeo*, *Catla* and *Puntius*.

The variation in the number of genus and species under different families are mentioned as: Cyprinidae (11/28) > Balitoridae (2/8) > Sisoridae (4/5) > Cobitidae (2/4) > Channidae (1/2) > Belonidae and Mastacembelidae (1/1)*

Appendix III

THE NATIONAL RIVER GANGA BASIN MANAGEMENT BILL, 2013

(An ACT to provide for Regulation, Conservation and Development of the National River Ganga Basin, and for the establishment of National River Ganga Basin Management Commission and National River Ganga Basin Tribunal for effective and expeditious disposal of matters affecting the River Basin with a view to restore and conserve the river basin and for matters connected therewith or incidental thereto.)

WHEREAS, the river Ganga is declared as the National River of India on November 5, 2008 by the Government of India considering its unique position in Indian society and world's natural heritage.

AND WHEREAS, it shall be desirable to adopt an integrated river basin management approach that focuses on maintenance and restoration of wholesomeness of rivers of the Ganga Basin in public interest.

AND WHEREAS 'Wholesomeness' in this context shall mean sanctity of the river system as imbibed in the following points:

a. Continuous Flow ("Aviral Dhara") in time and space including maintenance of connectivity of flow in the river systems.
b. Un-polluted Flow ("Nirmal Dhara") meaning that quality of river waters is not significantly affected by human activities.
c. Rivers as Geologic Entities that is, rivers as the earth's creations of past geological ages, which may not be recoverable if damaged.
d. Rivers as Ecological Entities that is, rivers as a delicately structured ecological balance with various living species achieved over thousands of years and vulnerable to irreversible change.

AND WHEREAS 'Public Interest' in this context shall mean welfare or wellbeing of all beings including the future generations.

AND WHEREAS, to attain the wholesomeness, it is mandated to adopt preventive and corrective approach, the Act shall prohibit, restrict and promote activities that directly or indirectly affect the wholesomeness of all rivers in the National River Ganga Basin.

AND WHEREAS, the Act shall establish appropriate authorities to achieve the objectives of the Act and matters related thereto.

AND WHEREAS the Act shall be enacted to realize fundamental right guaranteed under Article 21 and to give effect to provisions of the Directive Principles of State Policy under Articles 39(b), 48 A, 49 and the Fundamental Duties enshrine under Article 51A (f) and(g) of the Constitution of India.

AND WHEREAS, the Act shall be enacted by Parliament by invoking legislative power under Article 246 read with Entry 56 of the Union List of the Constitution of India.

CHAPTER I
PRELIMINARY

1. Short Title, Extent and Commencement

1) The Act may be called The National River Ganga Basin Management Act, 2012.
2) It shall extend to the whole National River Ganga Basin.
3) It shall come into force on such date as the Central Government may, by notification in the Official Gazette, appoint and different dates may be appointed for different States.

2. Definitions

In this Act, unless the context otherwise requires –

1) Active Flood Plain" is the area on the two sides of a river that gets in undated by a flood having a mean recurrence interval of 2.33 years;
2) Afforestation means plantation of trees to restore or reestablish the forest cover;
3) Authority means any authority, board, corporation, council, department, institute, university or any other body corporate, established by or under any Central, State or Provincial Act in force in the territory of India and includes,
   a. The Central Government,
   b. The State Governments,
   c. A Department of the Government,
   d. Local authorities;
4) Aviral Dhara" (in a river or stream) means continuity of flow in both time and space, including connectivity of flow throughout the river;
5) Basin includes land, water, vegetation and other natural resources on a catchment basis;
6) Basin" means the entire catchment (of a water body or water course) including the soil, water, vegetation and other natural resources in the area;
7) Catchment" (or "Catchment Area", or "Watershed", or "Drainage Basin") is the entire land area whose runoff from rain, snow or ice drains into a water body or a water course (before the water course joins another river or discharges into a water body);
8) Class I town means a town whose population is greater than 100,000;

9) Class II town means a town whose population is greater than 50,000 and less than 100,000;
10) Commercial fishing" means large-scale fishing for commercial purposes by nets, cyanide poisoning, or other modern fishing gear or methods.
11) Commission means National River Ganga Basin Management Commission;
12) "Connectivity" (of a river) means continuity of flow in the three directions, viz. longitudinal connectivity (along the length of the river), lateral connectivity (across the width of river), and vertical connectivity (below the water surface in vertical direction).
13) "Deforestation" means removal or reduction of forest cover, especially when caused by anthropogenic activities;
14) "Degraded Forest" means a forest having loss or reduction of native forest cover and/ or vegetation density;
15) "Direct Injection" (of water) means injection or introduction (of water) directly into subsurface waters through natural or artificial crevices, faults, channels or conduits without the natural passage through porous soil strata;
16) "Ecological Park" is a protected area for conservation of native and endangered species;
17) "Ecology" is the totality of relations between organisms and their environment. It includes the composition, distribution, amount, number and changing states of organisms within and among ecosystems;
18) "Ecosystem" is a community of organisms and their physical environment, considered to function together as a unit, and characterized by a flow of energy that leads to trophic (or nutritional) structure and material cycling;
19) "E-Flows" means Environmental Flows;
20) "Embankment" is a raised wall of earth, stone or other material to hold back water within a water body or water course; it includes levees constructed on either side of a river as a flood protection measure;
21) "Engineered Diversion" means a structure or device constructed or installed to transfer the river water into a canal or other engineering structure;
22) "Environmental Flows" are the regime of flows including sediments and other natural constituents required to maintain the ecological integrity of a river and the goods and services provided by it, computed by Building Block Method;
23) "Flood" means the overflowing of water from a water course or water body that inundates normally dry land;
24) "Flood Plain" is the land area susceptible to inundation by flood waters;
25) "Flood Routing Channel" is a channel designed to carry the excess water of a water course during high flows;
26) "Geologic Entity" is an entity formed by ancient earth processes over geologic ages;

27) "Ghat" is a sloping or cliffed part of a riverbank, often with artificially constructed steps, used for providing easy human access to river water;
28) "Ground Water Recharge" is replenishment (in part or wholly) of water depleted from ground water reservoirs;
29) Hazardous Solid Waste (HSW) includes as provided in the Act;
30) "Hydrological Cycle" is the natural cycle of change through which water moves on earth;
31) Industrial Effluents includes as it is mentioned in the Act;
32) Kharif Canals means Irrigation canals used for crops grown in rainy season;
33) Landfills means a place used for disposal of solid waste on land;
34) Large Scale Industries provided in the Act;
35) Medium Scale Industries provided in the Act;
36) Municipal Solid Waste provided in the Act;
37) "National River Ganga" is the entire length of six head-streams in the state of Uttarakhand namely, Rivers Alaknanda, Dhauli Ganga, Nandakini, Pinder, Mandakani and Bhagirathi starting from their originating glaciers up to their respective confluences at Vishnu Prayag, Nand Prayag, Karn Prayag, Rudra Prayag and Dev Prayag as also the main stem of the river thereafter up to Ganga Sagar including Prayag Raj;
38) "Nirmal Dhara" or "Un-polluted Flow" means flow in a river or stream that is not significantly polluted by anthropogenic activities;
39) "Paleo-Channel" is the remnant of an extinct river or stream that got filled with sediments deposited in later periods;
40) "person" includes—
    a. an individual;
    b. a Hindu undivided family;
    c. a company;
    d. a firm;
    e. an enterprise;
    f. an association of persons or a body of individuals, whether incorporated or not, in India or outside India;
    g. any corporation established by or under any Central, State or Provincial Act or a Government company as defined in section 617 of the Companies Act, 1956 (1 of 1956);
    h. any body corporate incorporated by or under the laws of a country outside India;
    i. a co-operative society registered under any law relating to cooperative societies;
    j. a local authority;
    k. every artificial juridical person, not falling within any of the preceding sub-clauses;

41) Ritual Bathing means taking dip in the water for religious or spiritual purposes;
42) Rivers in National River Ganga Basin include, but is not restricted to, all major and minor tributaries of the National River Ganga within the basin;
43) River Bank means the land at the side of a river which retains the river in its natural channel, when there is the greatest flow of water;
44) River Bed means dried portion of the river, the place where the river run its course; when it fills with water. River Bed Farming includes seasonal agriculture/farming on the river bed during low flows when the bed is exposed;
45) River Port means a place on a waterway with facilities for loading and unloading ships;
46) River System means network of rivers rather than a single river;
47) Rivulets includes very small tributaries of a major river;
48) Sand Mining means large scale removal of river sand from the dried channel belt or a part of it;
49) Sewage means as provided in the Act;
50) Small Scale Industries as provided in the Act;
51) Solid Waste as provided in the Act;
52) Sludge as provided in the Act;
53) Tribunal means the National River Ganga Basin Management Tribunal;
54) "Water Body" (or "Surface Water Body") is a depression on land or a lowland area that usually holds water or remains saturated through most of the year, such as a lake, tank, pond, marsh or swamp;
55) "Water Course" (or "Surface Water Course") is an overland channel (natural or manmade) through which water flows, such as a river, stream, rivulet (or "nala") or canal;
56) Water Recharge Structures includes arrangements made for enhancement of sub surface flow and storages of water;

CHAPTER II
DUTY TO ENSURE RESPECT AND DIGNITY OF NATIONAL RIVER GANGA

3. Respect and Dignity

Every person shall ensure utmost respect and dignity for the National River Ganga and desist from activities prejudicial to her interests.

4. Duty of State and Citizen

It shall be the duty of the State and every other person to ensure the protection, preservation, conservation and maintenance of wholesomeness of National River Ganga.

CHAPTER III
USAGE OF WATER IN NATIONAL RIVER GANGA BASIN

5. Usage of water shall be determined in accordance with the following

1) The usage of water shall be posterior to nature and ecology.
2) The usage shall have sequential priority from 'water for life' to 'livelihoods' to 'developmental activities'.
3) There shall be institutional arrangements for usage of water based on principles of equity, resource-conservation, protection of water resources, and harmonization of water use.

CHAPTER IV
PROHIBITION AND RESTRICTION OF ACTIVITIES

6. Prohibition of Activities relating to the National River Ganga Basin

Notwithstanding anything contained in any law whatsoever, no person or authority shall indulge in any activity relating to any of the following:

1) engineered diversion and/or storage of water in any river unless E-flows are maintained in the immediate downstream of the diversion/storage; or
2) discontinuity in the flow due to engineered diversion/storage in any river; or
3) discharge of sewage (either treated or untreated) from Class I towns, either directly or indirectly, into any river; or
4) discharge of industrial effluents (either treated or untreated) from any large, medium or cluster of small industries, either directly or indirectly, into any river; or
5) direct injection of sewage and industrial effluents (either treated or untreated) into the subsurface; or
6) disposal of un-burnt and partially burnt corpses and animal carcasses in any river or riverbank; or
7) open defecation and dumping of municipal/industrial solid wastes or sludge in any river or its active flood plain; or
8) setting up of or continuation in dwellings or other encroachments in the river banks or its active river flood plains; or
9) construction of new permanent structures for residential, commercial and industrial purposes in the active flood plain of any river;

   Provided that construction of bridges and associated roads, jetties/ghats/ports and hydraulic structures for storage/ diversion/ control/ channelization of river waters shall not be thereby prohibited.

10) any other like activities as may be prescribed by the commission.

7. Restriction of Activities relating to the National River Ganga Basin

No person shall indulge in any of the following activities except in accordance with the rules and regulations as may be laid down in this regard from time to time.

1) discharge of sewage (either treated or untreated) from Class II town and smaller towns and villages, either directly or indirectly, into any river; or
2) disposal of sludge derived through treatment of sewage and industrial effluents except in secure landfills/hazardous waste sites; or
3) discharge of industrial effluents (either treated or untreated) from small scale industry into any river; or
4) disposal and/or discharge of mining and construction debris in any river's flood plain, river bank or the river itself; or
5) construction of bridges and associated roads, jetties, ghats, ports and permanent hydraulic structures for storage/diversion/control/channelization of waters in any rivers; or
6) withdrawal of ground water by electric/diesel operated shallow and deep tube wells; or
7) sand mining, stone crushing, sediment removal and mining of other minerals from the river bed of any river; or
8) dredging or any other excavation activity on river bed for any purposes threatening the balance of the natural environment; or
9) river bed farming and agricultural activities in the active flood plain of any river; or
10) commercial fishing or aqua culture in any river; or
11) ritual immersion of idols, and floral and other offerings in any river; or
12) wallowing of animals, washing of clothes, vehicles, etc., in any river; or
13) deforestation of hill slopes and notified forest and other sensitive areas; or
14) hazardous or harmful emissions into the atmosphere that can affect terrestrial waters directly or indirectly in any river; or
15) use of chemical fertilizers and pesticides in agriculture, horticulture, aquaculture, animal husbandry, forestry, etc. in any river; or
16) any activity that may lead to geologically disruptive phenomena such as heightened seismic activity, ground subsidence, and leaching or erosion of contaminants into water bodies; or
17) cattle grazing on erodible hill slopes and over-grazed areas; or
18) any other like activities as may be prescribed by the commission.

CHAPTER V
CONSERVATION, DEVELOPMENT OF NATIONAL RIVER GANGA BASIN

8. Conservation and Development

1) The appropriate authority shall take all measures necessary for the conservation and development of the National River Ganga Basin.
2) Such conservation shall include measures relating to the following:
   a. ensuring that E-Flows are maintained in all rivers at different locations and in different seasons;
   b. protecting both geology and ecology in the river basin;
   c. using of floodplains in environmentally safe manner, and after ensuring Environmental Impact Assessment for approval of flood plains projects;
   d. ensuring both short-term and long-term measures for conservation and improvement of natural resources in National River Ganga Basin;
      Explanation - The term "appropriate authority" in this section and the subsequent one shall be taken to include the Central Government or State Government or such Local authorities responsible for implementation as the context indicates;
   e. monitoring, review and dissemination of the National River Ganga Basin's environmental status in the public domain.

9. Promotion of Activities relating to the National River Ganga Basin

The appropriate authority shall adopt special measures to promote the following activities in the National River Ganga Basin:

1) reuse and recycle of treated domestic and industrial sewage and use of products derived from sewage sludge, with mechanism for commercial use/ reuse where feasible;
2) measures including construction of sewer lines, provision of sanitation services, construction of wastewater treatment plants for municipal and industrial effluents, construction of secure solid waste landfills, hazardous waste landfills and other related facilities in the River Basin;
3) facilities for environmentally safe cremation/burial of corpses and measures for disposal of animal carcasses;
4) ground water recharge with unpolluted water (including use of kharif canals, paleo-channels, nalas, check dams, unlined ponds and lagoons, etc.) to increase ground water levels and enhance river base flows;
5) higher efficiencies in irrigation water use (through appropriate irrigation techniques, rationalization of cropping patterns, recycling of return flows, etc.) for agriculture, horticulture, fodder cultivation, etc;

6) higher efficiencies in institutional, commercial, industrial, domestic, municipal and community water uses through minimization of losses, wastage control and provision of adequate water treatment facilities;
7) afforestation and/or grassland development in degraded forest lands, wastelands and denuded hill slopes (for control of surface runoff and erosion, and for enhancing groundwater recharge);
8) activities related to flood control, including development of flood routing channels, embankments and other methods for controlling sediment flows and distribution;
9) protection of breeding areas and natural habitats of indigenous and migratory species of fishes, birds, reptiles, amphibians and mammals, and the prevention of the spread of exotic species;
10) eco-friendly Tourism, pilgrimage, recreational and sporting activities in all rivers and riverbanks;
11) use of the riverbank and active flood plains of rivers for development of water-recharge structures and ecological parks;
12) use of bio-fertilizers and bio-pesticides (in place of chemical fertilizers and pesticides) in agriculture, horticulture, aquaculture, forestry, etc., to protect groundwater from agricultural pollutants;
13) any other like activities as may be prescribed by the commission.

CHAPTER VI
DUTIES OF CENTRAL AND STATE GOVERNMENTS

10. Duties of Central and State Governments

1) It shall be the duty of the Central Government to constitute the National River Ganga Basin Management Commission to carry out the provisions of the Act.
2) The Central and State Governments shall render all assistance and cooperation necessary for the effective implementation of the provisions of the Act.
3) The Central Government shall, in consultation with and concurrence of the Commission, make rules and regulations necessary for the effective implementation of the provisions of the Act.
4) In accordance with the directions of the Commission, the Central and the State governments, as the case may be, shall take necessary measures towards prohibition and restriction of activities in any river of the National River Ganga Basin as well as conservation and development of the basin.

CHAPTER VII
NATIONAL RIVER GANGA BASIN MANAGEMENT COMMISSION CONSTITUTION, POWER AND FUNCTIONS

11. Establishment of Commission

1) With effect from such date as the Central Government may by notification decide, there shall be established for the purposes of this Act, a Commission to be called the "National River Ganga Basin Management Commission" hereinafter referred to as the Commission.
2) The Commission shall be a body corporate by the name aforesaid having perpetual succession and a common seal with power, subject to the provisions of this Act, to acquire, hold and dispose of property, both movable and immovable and to contract and shall, by the same name, sue of be sued.
3) The Head Office of the Commission shall be at such place as the Central Government may decide from time to time.
4) The Commission may establish offices at other places in India.

12. Composition of Commission

1) The Commission shall consist of the following Members, namely:
   a. A Chairperson,
   b. A Retired or sitting Judge of the High Court,
   c. Six other independent members of Civil Society/Academia/Experts in related areas.
2) The Chairperson shall be the Chief executive of the Commission and shall exercise such powers and perform such duties, as may be prescribed.
3) The Chairperson shall be the Chief executive of the Commission and shall exercise such powers and perform such duties, as may be prescribed and he shall be responsible for the business of the Commission.
4) The Chairperson and other members of the Commission shall be persons of ability, integrity and standing and who have special knowledge of and such professional experience in, not less than 15 years, Science and Technology, Ecosystems, Hydrology, Environmental Engineering, Social Concern, Legal Affairs or other pertinent areas related to river basin management.

13. Selection of Chairperson and other members of the Commission

1) The Chairperson and Independent members shall be appointed by the Central Government from a panel of names recommended by a selection committee consisting of
   a. The Prime Minister of India: Chairperson
   b. Leader of Opposition: Member
   c. Cabinet Secretary, Central Government: Member Secretary

2) The Retired or sitting Judge of the Supreme Court shall be selected by the Chief Justice of India.
3) The term of the Selection Committee and the manner of selection of panel of names shall be such as may be prescribed by way of notification.
4) The Chairperson and every other member shall, before entering upon his office, make and subscribe to an oath of office for secrecy and maintain integrity in such form and manner as may be prescribed.

14. Term of Office and Chairpersons and Other Members

The term of office of the members shall be as follows:

1) The Chairperson and every other member shall hold office as such for a term of five years from the date on which he enters upon his office but shall not be eligible for reappointment.
   Provided that the Chairperson and other members shall not hold office as such after he has attained the age of 70 years.
2) A vacancy caused by the resignation or the removal of the Chairperson or any other member or by death or otherwise shall be filled by fresh appointment in accordance with the previous provisions.
3) The Chairperson and every other member shall, before entering upon his Office, make and subscribe to an oath of office and of secrecy in such form, manner and before such Commission as may be prescribed. In the event of the occurrence of a vacancy in the Office of the Chairperson by reason of his death, resignation or otherwise, the senior-most member shall act as the Chairperson till the new Chairperson enters upon his Office.
4) When the Chairperson is unable to discharge his function owing to absence, illness or any other cause, the senior-most member shall discharge the routine functions of the Chairperson till the date on which the Chairperson resumes his Office.
5) No person shall be appointed as Chairperson or member of the Commission who shall have direct or indirect interest in any business or commercial activity related to the River Basin.

15. Resignation, Removal and Suspension of Chairperson and other members

1) The Chairperson or any other member may, by notice in writing, address to the Central Government resign from Office.
   Provided that the Chairperson or any other member shall, unless he is permitted by the Central Government to relinquish his Office sooner, continue to hold Office until the expiry or three months from the date of receipt of such notice or until a person duly appointed as his successor enters upon his Office or until the expiry of his term of Office, whichever is the earliest.

2) Notwithstanding anything contained above, the Central Government may, by order, remove the Chairperson or any other member from his Office if such Chairperson or Members, as the case may be:
    a. Is or at any time has been, adjudged as an insolvent; or
    b. Has engaged at any time, during his term of office, in any paid employment; or
    c. Has been convicted of an offence which, in the opinion of the Central Government involved moral turpitude; or
    d. Has acquired such financial or other interest as his likely to affect prejudicially his functions of a member; or so abused his position as to render his continuance in office prejudicial to public interest; or
    e. Has become physically or mentally incapable as such.
3) Notwithstanding anything contained herein before, no member shall be removed from his office unless the Supreme Court, on a reference being made to it in this behalf by the Central Government, has on an enquiry, held by it in accordance with such procedure as may be prescribed in this behalf by the Supreme Court, reported that the Chairperson or the members, ought on such ground or grounds to be removed.

16. Restrictions on Employment of Members in certain cases:

The Chairperson and every other member shall not, for a period of two years from the date which he ceases to hold Office, accept any employment in, or be connected with the Management or Administration of, any enterprise which has been a party to a proceeding under the Act or associate in any capacity or establish any NGO in related field;

Provided that nothing in the section shall apply to any employment under the Central Government or a State Government or Local Commission or in any statutory Commission or any corporation established by or under any Central, State or Provincial Act or a Government company as define in Section 617 of the Companies Act 1956 (1 of 1956).

17. Salary and Allowances and other terms and conditions of service of Chairperson and other members

1) The salary and other terms and conditions of service, of the Chairperson and other members including travelling expenses, house rent allowance and conveyance facilities, sumptuary allowance and medical facilities shall be such as may be prescribed.
2) The salary allowances and other terms and condition of service of the Chairperson or any member shall not vary to his disadvantage after appointment.

18. Procedure for Transaction of Business

1) The Commission shall meet regularly at its Office at such time as the Chairperson thinks fit, but four months shall not intervene between its last and next meeting.
2) All decisions shall be taken by majority;
3) Provided that in the case of equality of votes, the Chairperson or in his absence the person presiding, shall have exercise casting vote;
4) The Commission shall observe such rules of procedure in the transaction of its business at a meeting, including the quorum at such meeting, as may be prescribed by the Central Government under the Act;
5) All decisions of the Commission shall be authenticated by the Chairperson or any other officer duly authorised in this behalf.

19. Duties, Powers and Functions of the Commission

1) The powers and function of the Commission shall relate to the following:
   a. To formulate strategies, plans, programmes, policies and guidelines for the due discharge of functions in furtherance of the object of the Act;
   b. To review the working of the Commission and prepare Annual Report;
   c. To review and monitor the working of the Wings under the Act;
   d. To coordinate and strengthen the efforts of the Central and State Governments for conservation and development of the National River Ganga Basin, and prohibition, restriction and promotion of activities in National River Ganga Basin in consonance with the object of the Act;
   e. Issue Directions to the Central and State government;
   f. To inquire and investigate into alleged contraventions of provisions of the Act;
   g. To direct such investigations and inquiries as may be necessary from time to time;
   h. To pass such orders or issue such directions as it may deem fit.
2) It shall be the duty of the Commission to take necessary steps for the elimination of all practices prejudicial to the interests of the National River Ganga Basin and promote the conservation and development of the Basin in consonance with the object of the Act.

20. Power of Superintendence

The Chairperson of Commission shall have the powers of general superintendence direction and control in respect of all matters of the Commission.

Provided that the Chairperson may delegate such office powers relating to administrative matters, as he may think fit, to any other member or officer of the Commission, including the power to monitor the working of the wings hereinafter stated.

21. Appointment and service conditions of Director, officers, inter alia of the Commission

1) The Commission shall appoint the Director, Additional Director, Joint Director, Deputy Director and Assistant Director, officers and other employees required to assist the Commission in the discharge of its functions.
2) The terms and conditions of the service of the Director, Additional Director, Joint Director, Deputy Director and Assistant Director, officers and other employees of the Commission shall be made by the Chairperson in such manner as may be prescribed.
3) The officers and other employees of the Commission shall discharge their functions under the general superintendence of the Chairperson.
4) The salaries and allowances and conditions of service of the officers and other employees of the Commission shall be such as may be prescribed.

22. Constitution of Wings

1) The Commission shall constitute the following Wings for the efficient discharge of its duties and functions under the Act:
   a. The Investigation Wing;
   b. The Research and Development Wing;
   c. The Environment and Ecosystems Monitoring Wing;
   d. The Information and Communication wing;
   e. Advocacy and Policy Planning Wing;
   f. The General Administration and Finance Wing;
2) The Commission may constitute such other regional or specialised units under each of the wings, and at such places, as may be necessary from time to time.

23. Composition of Wings

1) Each wing shall consist of the following:
   a. The Director;
   b. Such other Officers and Employees as may be necessary for the efficient performance of the functions under the Act;
2) The wing shall be headed by the Director who shall be assisted by Additional, Joint, Deputy and Assistant Directors and such other officers or employees as may be decided by the Commission;
3) The Director shall be of the level of Joint Secretary or equivalent of the Central Government;
4) Regional units/branches shall be headed by the Joint Director and he shall report to the Director on all matters relating to the unit/branch.
5) The Director and other officials shall be whole time members.

24. Powers and Functions of Wings

The wings shall discharge the necessary powers, functions and responsibilities in furtherance of its specific subject matter.

1) The Investigation Wing shall investigate matters relating to:
   a) Non-implementation of appropriate measures relating to prohibition, restriction, conservation and promotion activities;
   b) Non-compliance of policy decisions and guidelines in furtherance of integrated River Basin Management;
   c) Continuance of existing practices in contravention of the provisions of the Act; and
   d) Such other matters as the Commission may direct from time to time.

2) The Research and Development Wing shall
   a) Identify research needs of National River Ganga Basin;
   b) Undertake and/or outsource need based specific research;
   c) Conduct economic, social and cultural analysis on National River Ganga Basin;
   d) Prescribe scientific details on measures relating to prohibition, restriction, conservation and promotion activities on National River Ganga Basin, as may be necessary from time to time;
   e) Provide technical know-how related to building of infrastructure on National River Ganga Basin;
   f) Such other matters as the Commission may direct from time to time.

3) The Environment and Ecosystems Monitoring Wing shall
   a) Conduct regular and random field measurement on environment related data on river basin;
   b) Monitor developmental and infrastructure projects on the river basin approved by the Government;
   c) Coordinate developmental projects and anthropogenic activities on National River Ganga Basin;
   d) Conduct impact assessment of existing practices, activities and infrastructure on National River Ganga Basin;
   e) Such other matters as the Commission may direct from time to time.

4) The Information and Communication wing
   a) Procure all types of data relating to scientific, technological, economic, social, cultural and such other forms as the commission may determine time to time on river basin;
   b) Preprocess all data collected referred to in clause (a);
   c) Compile data and reports referred to in clause (a);
   d) Store the data and reports in easily retrievable system;
   e) Provide public access to all such data;
   f) Such other matters as the Commission may deem fit.

5) Advocacy and Policy Planning Wing
   a) Periodically review and frame the environmental strategies, plans, programmes, policies and guidelines on National River Ganga Basin;
   b) Formulate good governance guidelines;
   c) Promote awareness of issues pertaining to National River Ganga Basin;
   d) Conduct advanced interactive Programmes, including Seminars, Workshops and Training of stakeholders;
   e) Conduct special campaigns to sensitize and motivate people;
   f) Prepare educational material; and
   g) Such other matters as the Commission may deem fit.

6) The General Administration and Finance Wing shall
   a) Undertake all activities pertaining to the internal management of the Commission;
   b) Creation and maintenance of the National River Ganga Basin Management Fund to be generated from the deposit of compensations awarded by the Commission from time to time;
   c) Disbursement of funds for restitution, restoration and conservation of the National River Ganga Basin as may be directed by the Commission from time to time;
   d) Allocation of funds for research on National river Ganga Basin as may be identified by the commission;
   e) Maintain proper accounts and relevant records;
   f) Prepare annual reports and statement of accounts;
   g) Audit Accounts as may be required by the Central Government.

POWERS OF INQUIRY AND INVESTIGATION

25. Procedure for Inquiry and Investigation

1) On receipt of a complaint by any person or a reference from an Authority or on its own knowledge or otherwise, if the Commission is of the opinion that there exists a prima facie case, it shall direct the Director, Investigation to cause an investigation to be made into the matter.
2) Where however the Commission is of the opinion that there exists no prima facie case, it shall close the matter forthwith and pass such orders as its deems fit and send a copy of its order to the Authority or the person concerned, as the case may be.
3) The Director shall, on receipt of direction, submit a report on his findings within such period as may be specified by the Commission.
4) The Commission may forward a copy of the report to the parties concerned;

Provided that in case the investigation is caused to be made based on a reference from any authority, the Commission shall forward a copy of the report to the authority as the case may be.

5) If the report of the Director recommends that there is no contravention of the provisions of this Act, the Commission shall invite objections and suggestions from the Authority or the person concerned or any other person, as the case may be.
6) If, after consideration of the objections or suggestions, the Commission agrees with the recommendation of the Director, it shall close the matter forthwith and pass such orders as it deems fit and communicate its order to the Authority or the persons concerned, as the case may be.
7) If, after consideration of the objections or suggestions referred to above the Commission is of the opinion that further investigation is called for, it may direct such further investigation in the matter by the Director or itself proceed with further inquiry in the matter in accordance with the provisions of the Act.
8) On receipt of report of the Director or a further inquiry referred to above, the Commission may close the matter forthwith and pass such orders as he deems fit and communicate its order to the Authority or the persons concerned as the case may be.

26. Power of Commission to Regulate its own Procedure

1) The Commission shall not be bound by the procedure laid down by the Code of Civil Procedure, 1908 (5 of 1908), but shall be guided by the principles of Natural Justice and, subject to the provisions of these Act and of any rules made there under, the Commission shall have powers to regulate its own procedure including the places at which they shall have their sittings, duration of oral hearings when granted, and times of its inquiry.
2) The Commission shall have, for the purposes of discharging its functions under these Act, the same powers as are vested in a Civil Court under the Code of Civil Procedure, 1908 (5 of 1908), while trying a suit.
3) Every proceeding before the Commission shall be deemed to be a judicial proceeding within the meaning of sections 193 and 228 and for the purposes of section 196 of the Indian Penal Code (45 of 1860) and the Commission shall be deemed to be a civil court for the purposes of disposal of the matters pending before it and shall be deemed to be civil court for the purposes of section 195 and Chapter XXVI of the code of Criminal procedure 1973 (2 of 1974).
4) The Commission may call upon such experts, from the field of Science and Technology, Legal Affairs, Economics, Finance, Socio-Cultural, Faith Leaders as it deems necessary, to assist the Commission in the conduct of any inquiry or proceeding before it.

27. Power of Director, Investigation Wing

1) The Director, Investigation shall, when so directed by the Commission, assist the Commission in investigating into any contravention of the provisions of these Act or any rules or regulations made there under.
2) The Director shall have all the powers as are conferred upon the Commission herein before stated.
3) The Director shall have power to direct every person/company/authority against whom the enquiry/investigation is ordered to afford reasonable facilities for the same.

28. Orders by Commission after Inquiry/ Investigation

Where after inquiry or investigation, the Commission finds that any act in contravention of the provisions of the Act has been established on the part of any person or authority, it may pass all or any of the following orders, namely:

a. Direct the immediate discontinuance of the act;
b. Order payment of damages;
c. Order restitution, restoration and such other remedial measures for the conservation and protection of the National River Ganga Basin as may be necessary in the circumstances;
d. Pass such other order as it may deem fit.

29. Power to grant interim relief

1) Where during an inquiry or investigation before the Commission or under the directions of the Commission, it is proved to the satisfaction of the Commission, by affidavit or otherwise, that an act in contravention of the provisions of the Act has been committed or continue to be committed or that such act is about to be committed, the Commission may, by order, grant a temporary injunction restraining any party from carrying on such act till the conclusion of the inquiry/investigation or until further orders.
2) The provisions of rules 2A to 5 (both inclusive) of Order XXXIX of the first Schedule to the Code of Civil Procedure, 1908, shall, as far as may be, apply to a temporary injunction issued by the Commission under the Act, as they apply to a temporary injunction issued by a civil court, and any reference in any such rule to a suit shall be construed as a reference to any inquiry/investigation before the Commission.

30. Appeal

Any person or authority aggrieved by any decision or order of the Commission may file an appeal to the National River Ganga Basin Tribunal within sixty days from the date of communication of the decision or order of the Commission;

Provided that the Tribunal may, if it is satisfied that the appellant was prevented by sufficient cause from filling the appeal within the said period, allow it to be filed within a further period not exceeding thirty days.

31. Execution of Orders of Commission

1) Any order passed by the Commission under this Act shall be enforced and executable by the Commission in the same manner as if it were a decree or order made by Civil Court in a suit pending therein and for that purpose the Commission shall have all the executing powers of a civil court.
2) For the sake of expeditious disposal or otherwise the Commission if deems fit, may transmit any order or award or decision made by it to a civil court having local jurisdiction and such civil court shall execute it as a decree by that Court.

32. Penalty for failure to comply with orders of the Commission

Whoever fails to comply with any order made by the Commission, he shall be punishable with imprisonment for a term which may extend to 3 years, or with fine which may extend to ten crore rupees, or with both.

33. Members, Officers, etc. of Commission deemed to be Public Servants

All members, officers and other employees of the Commission shall be deemed, when acting or purporting to act in pursuance of any of the provisions of this Act, to be public servants within the meaning of Section 21 of the Indian Penal Code (45 of 1860).

34. Protection of Action taken in good faith

No suit, prosecution or other legal proceedings shall lie against any member, officer or employee of the Commission for anything done or intended to be done in good faith under this Act or rules or regulations made thereunder.

35. Contravention of Order by Companies and Authorities

1) Where any contravention under this Act has been committed by a company, every person, who, at the time, the contravention was committed was in charge of, and was responsible to, the company for the conduct of the business of the company, as well as the company itself, shall be deemed to be liable to be proceeded against in accordance with the provisions of the Act.

   Provided that nothing contained in this section shall render any such person liable, if he proves that the contravention was committed without his knowledge or that he had exercised all due diligence to prevent the commission of the contravention and the contravention was an Act of God.
2) Notwithstanding anything contained above, where any contravention under this Act has been committed with the consent or connivance of or is attributable to, any

neglect on the part of any director, manager, secretary or other officer of the company, such person aforesaid shall be deemed to be liable for such contravention and proceeded against.

Explanation: For the above purposes,

(a) "company" means any body corporate and includes a firm or other association of individuals; and

(b) "Director" in relation to a firm, means a partner in the firm and proprietor in a proprietorship firm and in case of trust, cooperative and society the person responsible for management of the same.

3) Where any contravention under this Act has been committed by an authority, every person, who, at the time, the contravention was committed was in charge of, and was responsible to, for the conduct of the business of the authority, as well as the authority itself, shall be deemed to be liable to be proceeded against in accordance with the provisions of the Act.

Provided that nothing contained in this section shall render any such person liable, if he proves that the contravention was committed without his knowledge or that he had exercised all due diligence to prevent the commission of the contravention and the contravention was an Act of God.

4) Notwithstanding anything contained above, where any contravention under this Act has been committed with the consent or connivance of or is attributable to, any neglect on the part of any superintendent, manager, secretary or other officer of the authority, such person aforesaid shall be deemed to be liable for such contravention and proceeded against.

CHAPTER VIII
NATIONAL RIVER GANGA BASIN TRIBUNAL

36. Establishment of Tribunal

1) The Central Government shall, by notification, establish an Tribunal to be known as National River Ganga Basin Tribunal:
   a. to hear and dispose of appeals against any direction issued or decision made or order passed by the Commission under the Act;
   b. to adjudicate on claim for damages that may arise from the findings of the Commission, or orders for the recovery of damages under this Act.
2) The Headquarter of the Tribunal shall be at such place as the Headquarter of the Commission.

37. Jurisdiction of the Tribunal

Any person or authority, aggrieved by any direction, order or decision passed by the Commission may prefer an appeal to the Tribunal.

38. Limitation

1) Every appeal under sub-section (2) shall be filed within a period of sixty days from the date on which a copy of the direction or decision or order made by the Commission is received by the authority or person referred to and it shall be in such form and be accompanied by such fee as may be prescribed within the rules so framed by the Commission;
2) The Tribunal may entertain an appeal after the expiry of the said period of sixty days if it is satisfied that there was sufficient cause for not filing it within that period.

39. Procedure of the Tribunal

1) On receipt of an appeal, the Tribunal may, after giving the parties to the appeal, an opportunity of being heard, pass such orders thereon as it thinks fit, confirming, modifying or setting aside the direction, decision or order appealed against.
2) The Tribunal shall send a copy of every order made by it to the Commission and the parties to the appeal.
3) The appeal filed before the Tribunal shall be dealt with by it as expeditiously as possible and endeavor shall be made by it to dispose of the appeal within six months from the date of receipt of the appeal and beyond that period on recording the reasons.
4) No appeal under clause (1) shall lie unless the memorandum of appeal is certified with the copy of the order, direction or decision passed by the Commission and with the grounds to the effect that the appellant has plausible defense to be protected against such order. However, while admitting the appeal, the Tribunal may direct to deposit a part or whole of the amount so payable under the direction, order or decision appealed against.
5) The appellant shall get the deposited amount back, with rate of interest fixed by nationalized bank during that time, in case he/it succeeds in the appeal.

40. Composition of Tribunal

The Tribunal shall consist of a Chairperson and at least one Judicial Member and other members to be appointed by the Central Government from the panels of name so recommended by the Selection Committee constituted for that purpose.

41. Qualifications for appointment of Chairperson and Members of Tribunal

1) The Chairperson of the Tribunal shall be a person, who is, or has been a Judge of the Supreme Court of India.
2) The other members of the Tribunal shall be persons of ability, integrity and standing having special knowledge of, and professional experience of not less than twenty years in science and technology, environmental matters, law and

policy, public affairs or in any other matter which in the opinion of the Central Government, may be useful to the Tribunal.

42. Selection Committee

1) The Chairperson and Members of the Tribunal shall be appointed by the Central Government from a panel of names recommended by a Selection Committee comprising of:
   a. the Chief Justice of India: Chairperson;
   b. the Cabinet Secretary, Central Government: Member Secretary
   c. the Chairperson, Law Commission of India: Member
   d. the Director of any National Institute of importance so nominated: Member
2) The terms of the Selection Committee and the manner of selection of panel of names shall be such as may be prescribed.

43. Term of office of Chairperson and Members of Tribunal

The Chairperson or a member of the Tribunal shall hold office as such for a term of five years from the date on which he enters upon his office, and shall be eligible for re-appointment only for a period of two years and not afterwards;

Provided that no Chairperson or other member of the Tribunal shall hold office as such after he has attained,

1) in the case of the Chairperson, the age of seventy years;
2) in the case of any other member of the Tribunal, the age of sixty-seven years.

44. Terms and conditions of service of chairperson and Members of Tribunal

1) The salaries and allowances and other terms and conditions of service including the conditions of removal of the Chairperson and other members of the Tribunal shall be such as may be prescribed by the rules so notified by the Central Government.
2) The salaries, allowances and other terms and conditions of service of the Chairperson and other members of the Tribunal shall not be varied to their disadvantage after their appointment.

45. Vacancies

1) If, for any reason other than temporary absence, any vacancy occurs in the office of the Chairperson of the Tribunal, the senior most Member shall act as Chairperson until another person is so appointed by the Central Government in the above stated manner to fill the vacancy and the proceedings may be continued before the Tribunal from the stage at which the vacancy is filled by the Tribunal with that new combination and there shall be no irregularity of law in disposal of such matter pending before the Tribunal.

2) When the Chairperson of the Tribunal is unable to discharge his functions owing to absence, illness or any other cause, the senior-most member or, as the case may be, such one of the Members of the Tribunal, as the Central Government may, by notification, authorize in this behalf, shall discharge the functions of the Chairperson until the date on which the Chairperson resumes his duties.

46. Resignation of Chairperson and Members of Tribunal

The Chairperson or a member of the Tribunal may, by notice in writing under his hand addressed to the Central Government, seek resignation from his office;

Provided that the Chairperson or a member of the Tribunal shall, unless he is permitted by the Central Government to relinquish his office sooner, continue to hold office until the expiry of three months from the date of receipt of such notice and until a person duly appointed as his successor enters upon his office or until the expiry of his term of office, whichever is earlier.

47. Removal and suspension of Chairperson and Members of Tribunal

1) The Central Government may, in consultation with the Chief Justice of India, remove from office the Chairperson or any other member of the Tribunal, who;
    a. has been adjudged an insolvent; or
    b. has engaged at any time, during his term of office, in any paid employment; or
    c. has been convicted of an offence which, in the opinion of the Central Government, involves moral turpitude; or
    d. has become physically or mentally incapable of acting as such Chairperson or other Member of the Tribunal; or
    e. has acquired such financial or other interest as is likely to affect prejudicially his functions as such Chairperson or Member of the Tribunal; or
    f. has so abused his position as to render his continuance in office prejudicial to the public interest.
2) Notwithstanding anything contained above, no Chairperson or a Member of the Tribunal shall not be removed from his office on the ground specified in clause (e) or clause (f) of sub-section (1) except by an order made by the Central Government after an inquiry made in this behalf by a Judge of the Supreme Court in which such Chairperson or member had been informed of the charges against him and given a reasonable opportunity of being heard in respect of those charges.

48. Restriction on employment of Chairperson and other Members of the Tribunal

The Chairperson and other members of the Tribunal shall not, for a period of two years from the date on which they cease to hold office, accept any employment in, or connected with the management or administration of, any enterprise which has been a party to a proceeding before the Tribunal under this Act, nor shall they associate or personally establish any NGO in related field.

Provided that nothing contained in this section shall apply to any employment under the Central Government or a State Government or Local authority or in any statutory authority or any corporation established by or under any Central, State or Provincial Act or a Government Company as defined in section 617 of the Companies Act, 1956 (1 of 1956).

49. Staff of Tribunal

1) The Central Government shall frame the rules by way of Notification, in consultation with the Chairperson of the Tribunal, for providing the procedure of appointment of such officers and other employees as it may think fit.
2) The salaries, allowances and conditions of service, including tenure and terms of removal, of the officers and other employees of the Tribunal shall be such as may be prescribed.
3) The officers and other employees of the Tribunal shall discharge their functions under the general superintendence and control of the Chairperson of the Tribunal.

50. Procedures and Powers of Tribunal

1) The Tribunal shall not be bound by the procedure laid down in the Code of Civil Procedure, 1908 (5 of 1908), but shall be guided by the principles of natural justice and, subject to the other provisions of the Act and of any rules made by the Central Government, the Tribunal shall have power to regulate its own procedure including the places at which they shall have their sittings.
2) The Tribunal shall have, for the purposes of discharging its functions under this Act, the same powers as are vested in a Civil Court under the Code of Civil Procedure, 1908 (5 of 1908) while trying a suit in respect of the following matters, namely:
    a. summoning and enforcing the attendance of any person and examining him on oath;
    b. requiring the discovery and production of documents;
    c. receiving evidence on affidavit;
    d. subject to the provisions of Sections 123 and 124 of the Indian Evidence Act, 1872 (1 of 1872), requisitioning any public record or document or copy of such record or document from any office;
    e. issuing summons for the examination of witnesses or documents;

f. reviewing its decisions;
g. dismissing a representation for default or deciding it *ex parte*;
h. setting aside any order of dismissal of any representation for default or any order passed by it *ex parte*;
i. any other matter which may be prescribed.

3) Every proceeding before the Tribunal shall be deemed to be judicial proceeding within the meaning of Sections 193 and 228, and for the purposes of Section 196, of the Indian Penal Code (45 of 1860) and the Tribunal shall be deemed to be a Civil Court for the purposes of Section 195 (2 of 1974) and Chapter XXVI of the Code or Criminal Procedure, 1973.

51. Execution of Orders of Tribunal

1) Every order made by the Tribunal shall be enforced by it in the same manner as if it were a Court of appeal, and it shall be lawful for the Tribunal to send, in case of its inability to execute such order, to the court within the local limits of whose jurisdiction:
   a. in the case of an order against a company, the registered office of the company is situated; or
   b. in the case of an order against any other person, place where the person concerned voluntarily resides or carries on business or personally works for gain, is situated.
2) Notwithstanding anything contained in sub-section (1), the Tribunal may transmit any order made by it to a Court (civil or criminal, as the case may be) having local jurisdiction and such Court shall execute the order as if it were the orders passed by that court.

52. Saving of inherent Powers of the Tribunal

Notwithstanding anything contained in this Act or any other provisions of any enactment in force, nothing shall be deemed to limit or affect the inherent powers of the Tribunal as of the powers of any High Court of India, to make such orders as may be necessary to give effect to any order passed under this Act or to prevent abuse of the process of the Tribunal or otherwise, to secure the ends of justice, needed to impart justice inconsonance of object and reasons and effect to the enactment of the Act.

53. Suo-moto Powers of the Tribunal

Notwithstanding anything contained in this Act or any other provisions of any enactment in force, nothing shall be deemed to limit or affect the Suo-moto powers of the Tribunal as of the powers of any High Court of India or Supreme Court, to make such orders on its own motion if the Tribunal feels in rarest of rare circumstances and on taking cognizance of the facts to be taken by the Tribunal in

the interest or relating to the National River Ganga, as may be necessary to give effect to any order passed under this Act or to prevent abuse of the process of the Tribunal or otherwise, to secure the ends of justice, needed to impart by the Tribunal.

54. Power to Punish for Contempt

The Tribunal shall have, and exercise, the same jurisdiction, powers and authority in respect of contempt of itself as a High Court has and may exercise and, for this purpose, the provisions of the Contempt of Courts Act, 1971 (70 of 1971) shall have effect subject to modifications that:

1) the reference therein to a High Court shall be construed as including a reference to the Tribunal;
2) the references to the Advocate-General in Section 15 of the said Act shall be construed as a reference to such Law Officer as the Central Government may, by notification, specify in this behalf.

55. Contravention of Order of the Tribunal

Without prejudice to the Act, if any person or authority contravenes, any Order of the Tribunal, he/it shall be liable for a damages not less than fifty crore or forfeiture of property or imprisonment for a term upto ten years or with both.

56. Vacancy in Tribunal not to invalidate acts or proceedings

No act or proceeding of the Tribunal shall be questioned or shall be invalid merely on the ground of existence of any vacancy or defect in the constitution of the Tribunal.

57. Right to Legal Representation

1) A person or authority preferring an appeal to the Tribunal may either appear in person or authorize one or more legal practitioners or any of its officers to present his or its case before the Tribunal.
2) The Commission may authorize one or more legal practitioners or any of its officers to act as presenting officers and every person so authorized may present the case with respect to any appeal before the Tribunal.

58. Appeal to Supreme Court

Any person aggrieved by any decision, direction or order of the Tribunal, may, file an appeal to the Supreme Court, within ninety days from the date of communication of the decision, direction or order of the Tribunal, to him, on any one or more of the grounds specified in Section 100 of the Code of Civil Procedure, 1908.

CHAPTER IX
MISCELLANEOUS PROVISIONS

59. Power of the Central Government to Make Rules

The Central Government may, by the notification in the Official Gazette, make rules for carrying out the purposes of this Act, however such rules shall be framed only in consultation with the Full House comprising of the Chairman and the Members of the commission and only after confirmation.

60. Bar of Jurisdiction

No Civil Court shall have jurisdiction to entertain any suit or proceedings in respect of any matter which the Tribunal constituted under this Act is empowered by or under this Act to determine, and no injunction shall be granted by any court or other authority in respect of any action taken or to be taken in pursuance of any power conferred by or under this Act.

61. Overriding effect

The provisions of this Act shall have effect notwithstanding anything inconsistent therewith contained in any enactment other than this Act.

62. National River Ganga Basin Management Fund

1) Where any amount by way of damages is ordered to be paid under any order made by the Commission or Tribunal, that amount shall be remitted to the National River Ganga Basin Management Fund established under the Act;
2) The amount of damages credited to the National River Ganga Basin Management Fund under sub-section (1) shall be utilized by Central Government on the advice of and with concurrence of the Commission.
3) A part of the National River Ganga Basin Management Fund shall be used for environmental development and improvement of National River Ganga Basin.
4) Restitution, Restoration and Rehabilitation of the Basin caused due to Natural calamity or disaster shall be done by Government independent of funds being available from the National River Ganga Basin Management Fund established under the Act.

63. Institution of award

1) The Central Government shall institute Monetary Rewards for exceptional contributors including Researchers, Academicians, Institutes, Universities, Centres of Excellence and civil society for conservation, development and improvement of the National River Ganga Basin, in conformity with the Commission's goals and guidelines.
2) A part of the National River Basin Management Fund may be utilized for the above purposes.