

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

GRB EMP : Ganga River Basin Environment Management Plan

by

Indian Institutes of Technology



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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 has constituted National Ganga River Basin Authority (NGRBA) as a planning, financing, monitoring and coordinating authority for strengthening the collective efforts of the Central and State Government for effective abatement of pollution and conservation of the river Ganga. One of the important functions of the NGRBA is to prepare and implement a Ganga River Basin: Environment Management Plan (GRB EMP).

A Consortium of 7 Indian Institute of Technology (IIT) has been given the responsibility of preparing Ganga River Basin: Environment Management Plan (GRB EMP) by the Ministry of Environment and Forests (MoEF), GOI, New Delhi. Memorandum of Agreement (MoA) has been signed between 7 IITs (Bombay, Delhi, Guwahati, Kanpur, Kharagpur, Madras and Roorkee) and MoEF for this purpose on July 6, 2010.

This report is one of the many reports prepared by IITs to describe the strategy, information, methodology, analysis and suggestions and recommendations in developing Ganga River Basin: Environment Management Plan (GRB EMP). The overall Frame Work for documentation of GRB EMP and Indexing of Reports is presented on the inside cover page.

There are two aspects to the development of GRB EMP. Dedicated people spent hours discussing concerns, issues and potential solutions to problems. This dedication leads to the preparation of reports that hope to articulate the outcome of the dialog in a way that is useful. Many people contributed to the preparation of this report directly or indirectly. This report is therefore truly a collective effort that reflects the cooperation of many, particularly those who are members of the IIT Team. Lists of persons who are members of the concerned thematic groups and those who have taken lead in preparing this report are given on the reverse side.

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1. Introduction

River systems have been the birthplace of civilizations all over the world. They are woven into the social and economic fabric of society and penetrate deep into the psyche of the people living around them. Nowhere is this more evident than in India where the Ganga, Indus, Narmada and other rivers possess the cultural identity transmitted down the ages through sacred literature, the Puranas and the Vedas, as well as through popular myths and legends.

The river Ganga (commonly called as Bhagirathi in the stretch Gangotri to Devprayag and Hubli in the stretch Farakka to Ganga Sagar) occupies a unique position in the ethos of people of India. Emotional attachment to the river and the centers of pilgrimage on its banks runs deep and long in the Indian History.

The Ganga originates from the ice caves at Gaumukh (N 30°55', E 79°7') at an elevation of 4100 m. Alaknanda, its main tributary in the mountainous stretch, rises beyond Manna Pass, 8 km from Badrinath (N 30°44', E 79°41') at an altitude of 3123 m, and meets at Devprayag. The Ganga traverses a distance of ≈2510 km from its source to its mouth (Ganga Sagar), draining eleven states of India (Figure 1). In her course she is joined by many tributaries, important being Bhilangana, Alaknanda, Ramganga, Kali, Yamuna, Gomti, Ghagra, Gandak, Kosi and Sone (Figure 2 and 3).

The entire stretch of river Ganga (main stem) can be viewed into three segments:

- | | | |
|-----------|-------------------------------|--------------------------------|
| A. | Upper Ganga ≈ 294 km | Gaumukh to Haridwar |
| B. | Middle Ganga ≈ 1082 km | Haridwar to Varanasi |
| C. | Lower Ganga ≈ 1134 km | Varanasi to Ganga Sagar |

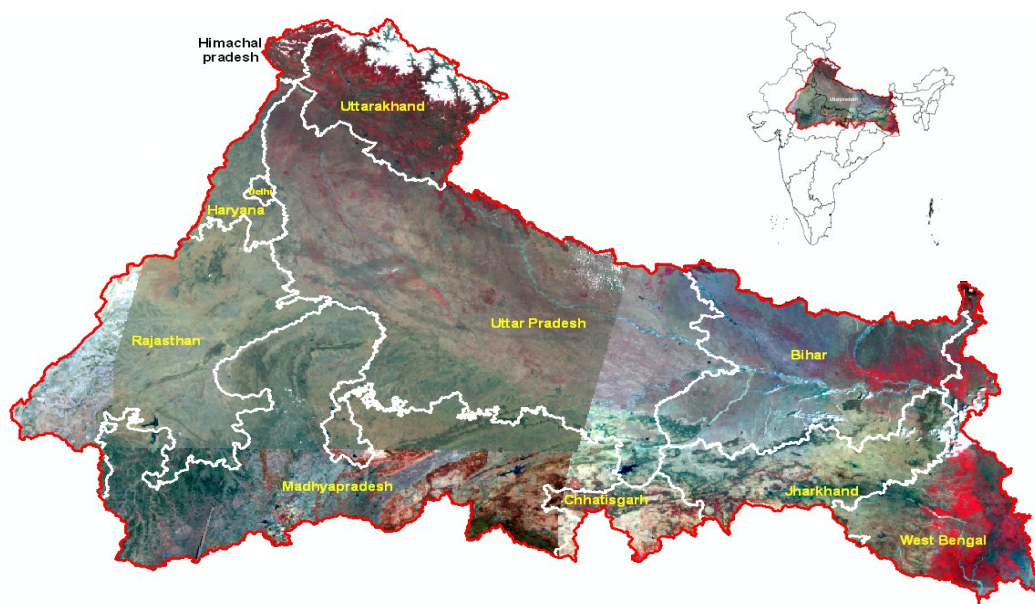


Figure 1: Drainage Area of the Ganga River Covering 11 States in India (AIWFS Data)

These three segments not only differ in their geomorphology, ecology and rheology but are different in terms of issues that need to be addressed:

- A. The river in the upper segment flows on steep and narrow bed, mostly rocks and boulders, carries cold water, is subjected to much less anthropogenic pollution, has highly sensitive and fragile ecosystem and biodiversity, and most importantly considered to have potential for harnessing hydropower.
- B. The river in the middle segment enters and flows in plains, meandering mostly on bed of fine sand, has wide river bed and flood plain, and most importantly modified through human interventions in terms of huge quantities of water diversion/abstraction and subjected to high degree of pollutant loads from domestic, industrial and agricultural activities.
- C. The river in the third segment has experienced considerable changes in the sediment transport and deposition, causes wide spread flooding, undergoes frequent changes in her channel path, and most importantly is subjected to international disputes on flows and interventions made and/or are being carried out/planned.

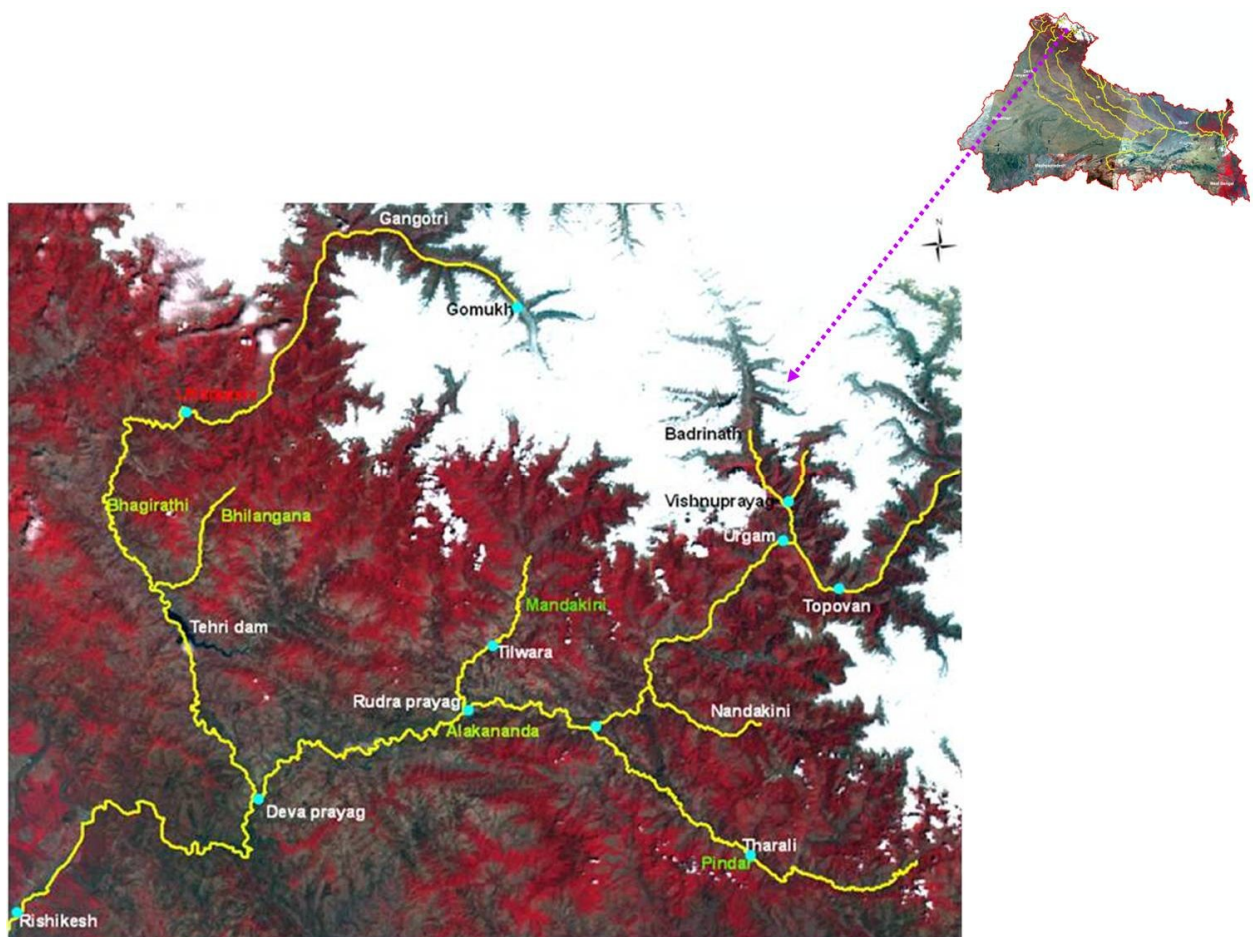


Figure 2: Major Tributaries of River Ganga (Bhagirathi) in the Upper Ganga Segment

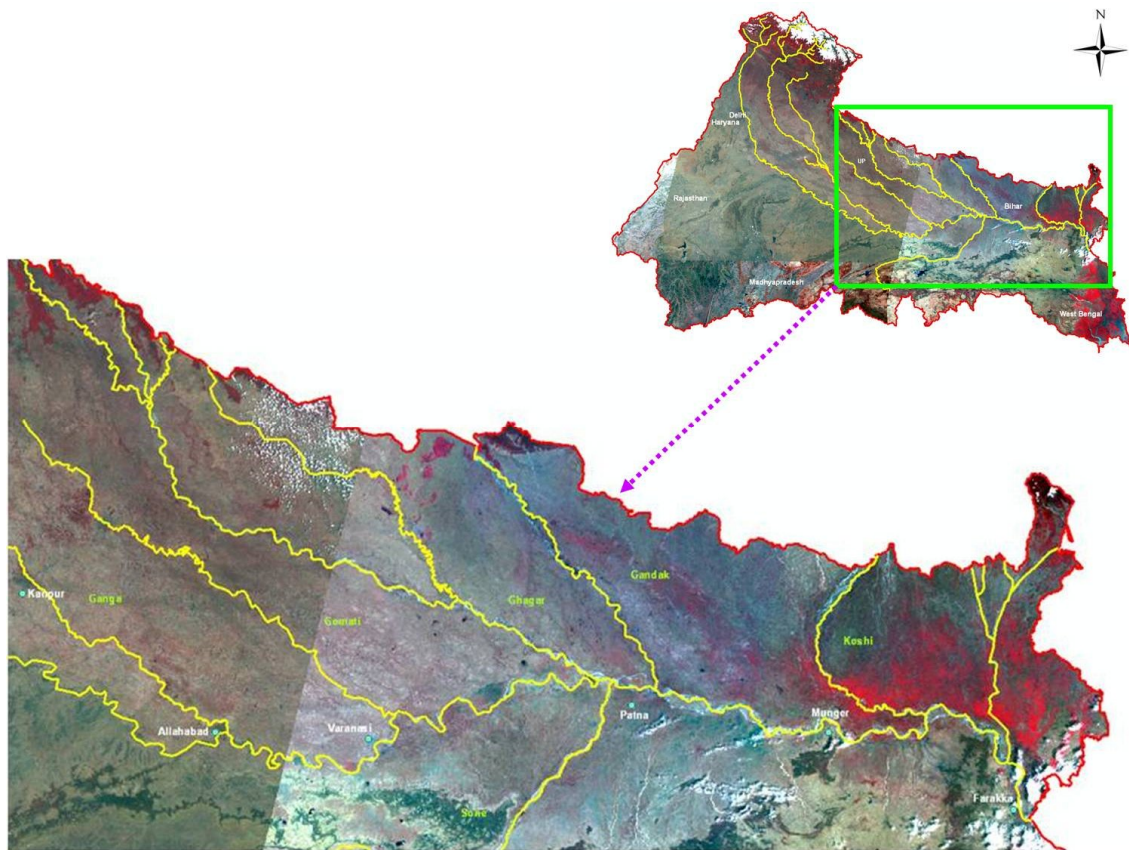


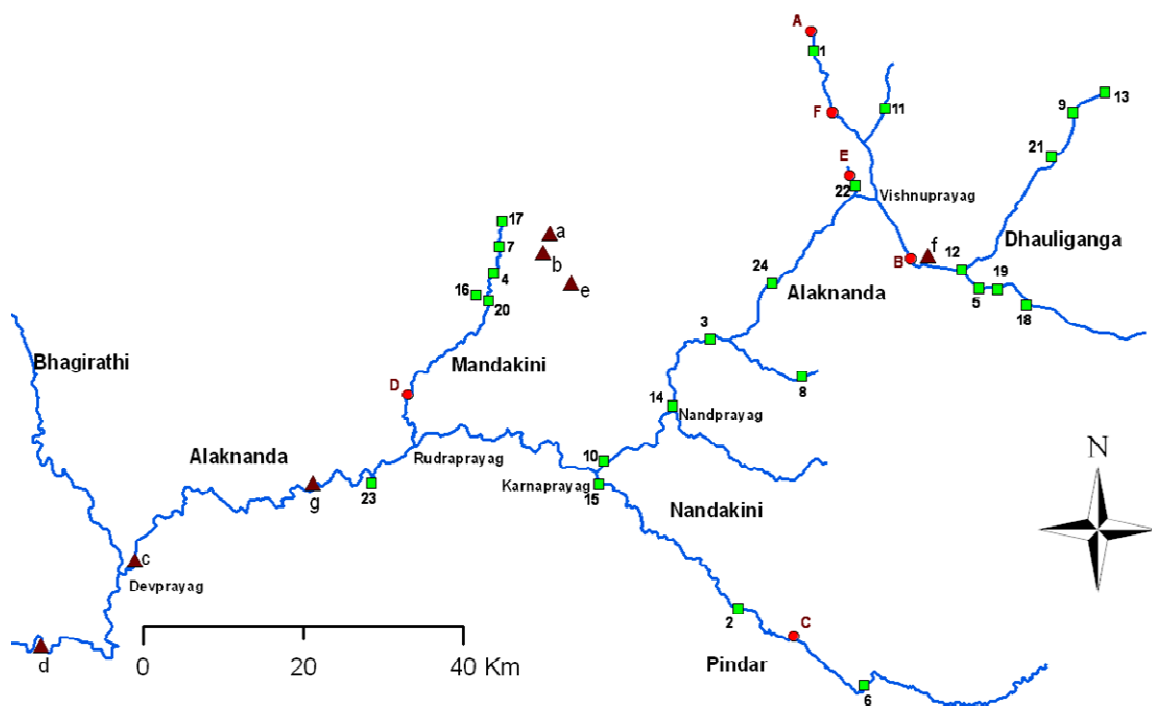
Figure 3: Major Tributaries of River Ganga (Bhagirathi) in the Middle and Lower Ganga Segments

2. Upper Ganga Segment: Gaumukh to Haridwar

In the Upper Ganga Segment (UGS) from Gaumukh to Rishikesh, the river flows mostly on steep bed with an average approximate slope 1 in 70. The river has turbulent flow and high velocities in most part of this segment. The habitat is stony intermingled with pebbles and sand. With limited nutrients in the water body, the growth of phytoplankton and other aquatic plants is limited. The grazing food chain with fish (carps, occasionally cat fish) as top species predominates. Mahasheer and Trout have been sighted at many places. Specifically Trout has been reported at Harshil, Uttara Khand and in one of the tributaries of river Ganga (i.e. in river Assi, a few thousand meters upstream of its confluence with river Ganga at Uttarkashi). The phytoplankton is dominated by diatoms (*Bacillariophyceae*) in winters followed by green algae (*Desmids*, *Chlorophyceae*). The zooplankton is represented mostly by ciliates. A few rotifers also have been reported.

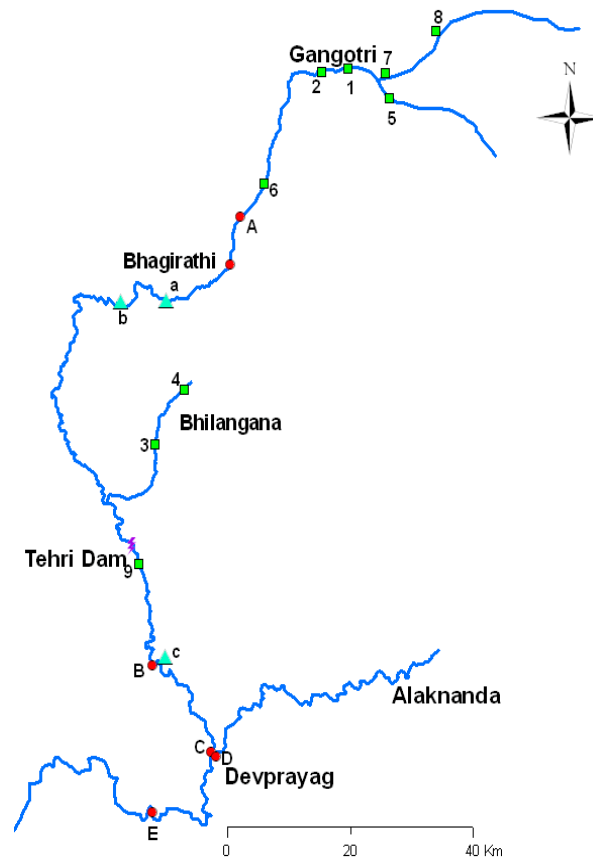
The most important modifications in the river system in this segment have occurred due to construction of Run of the River and Run of the River with Ponding (ROR + RORP) hydro-electric projects. Location of most of such projects (under operation, construction and proposed) is presented in Figure 4 and 5. Implementation of these projects have resulted in significant alteration in hourly, daily and seasonal flows over substantial river length. A substantial part of the river flow is forced through tunnels or the river stretch has been

converted into deep impoundments. An estimated 82 km length of the river in this segment out of total UGS length (≈ 294 km) has been converted into impoundments or the major portion of the flow has been forced into the tunnels and only an estimated 80 km stretch from Gaumukh to some distance downstream of Jhala flows in natural and near pristine form. The area under the influence of hydroelectric projects is suspected to undergo decline in its forest cover and experience enhanced landslides. Potential release of greenhouse gases from impoundments, drying of local water resources, and damage to residential structures, moderation in local climate leading to breeding of mosquito and other insects causing health hazard, are also reported. The river ecosystem is under stress and the riverine environment tends to shift to lacustrine environment. Some salient features of different stretches (refer Figure 6) within the UGS are presented in Exhibit 1.



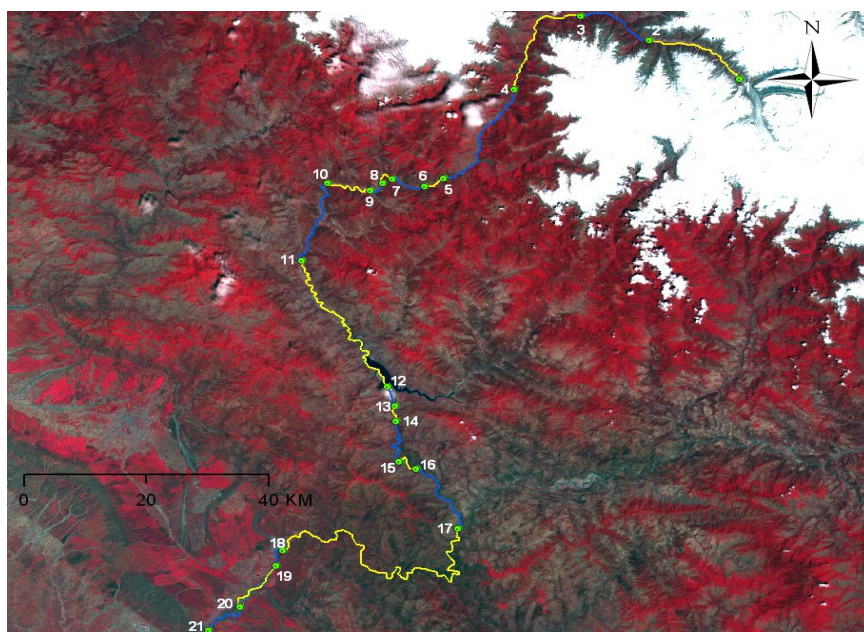
- **Existing:** A. Badrinath (1.25MW); B. Tapovan (0.8MW); C. Tharali (0.2MW); D. Tilwara (0.2MW); E. Urgam (3MW); F. Vishnuprayag (400 MW)
- ▲ **Under Construction:** a. Kaliganga-I (4MW); b. Kaliganga-II(6MW); c. Kotli Bhel IB (93.20MW); d. Madhmaheswar (10 MW); e. Topovan Vishnugad(520 MW); f. Shrinagar (330MW)
- **Proposed:** 1. Alaknanda (Badrinath) (300MW); 2. Bagoli (72MW); 3. Bowla Nandprayag (132MW); 4. Chuni Semi (24MW); 5. Deodi (60MW); 6. Devsari Dam (255MW); 7. Gaurikund (18.6MW); 8. Gohana Tal (60MW); 9. Jalam Tamak (60MW); 10. Karnaprayag (160MW); 11. Lakshmanganga (4.4MW); 12. Lata Tapovan (310MW); 13. Maleri Jalam (55MW); 14. Nandprayag Langasu (141MW); 15. Padli Dam (27MW); 16. Phata-Byung (10.8MW); 17. Rambara (24MW); 18. Rishi Ganga-I (70MW); 19. Rishi Ganga-II (35MW); 20. Singoli-Bhatwari (99MW); 21. Tamak Lata (280MW); 22. Urgam- II(3.8MW); 23. Utiyasu Dam (860MW); 24. Vishnuprayag Pipalkoti (444MW)

Figure 4: Hydroelectric Projects in Alaknanda River Basin



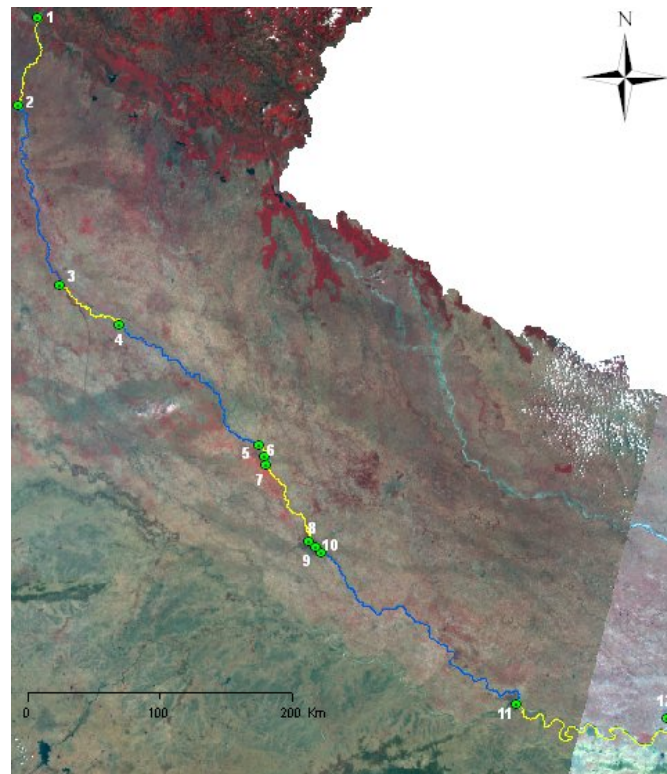
- ▲ **Existing:** a. Maneri Bhali I (99 MW); b. Maneri Bhali II (304 MW); c. Tehri (1000 MW)
- **Under Construction :** A. Loharinag Pala, now abandoned (600 MW); B. Koteswar (400 MW); C. Kotli Bhel IA (195MW); D. Kotli Bhel IB (320 MW); E. Kotli Bhel II (530MW); F. Pala Maneri I (480MW)
- **Proposed:** 1. Bhaironghati I (380 MW); 2. Bhaironghati II (65 MW); 3. Bhilangana I (22.5 MW); 4. Bhilangana II (11 MW); 5. Gangotri (55 MW); 6. Harsil (210 MW); 7. Jadhganga (50 MW); 8. Karmoli (140 MW); 9. Tehri PSS (1000 MW)

Figure 5: Hydroelectric Projects on Ganga (Bhagirathi) and Bhilangana River



Station	Longitude, E	Latitude, N	Elevation, m
1. Gomukh	79.03	30.56	4238
2. Gangotri	78.54	31.00	3037
3. Mukhaba	78.47	31.02	2569
4. Jhala	78.40	30.55	2120
5. MB-1-U/S	78.33	30.45	1355
6. MB 1	78.31	30.44	1297
7. MB-1 Tail water	78.28	30.45	1278
8. MB 2-U/S	78.27	30.44	1126
9. MB 2	78.26	30.44	1122
10. MB-2 Tail water	78.21	30.44	1055
11. Tehri Dam U/S	78.19	30.36	845
12. Tehri Dam	78.28	30.23	830
13. Tehri Dam Tail water	78.29	30.21	653
14. Koteswar U/S	78.29	30.20	604
15. Koteswar Dam	78.29.	30.15	555
16. Koteswar Tail water	78.31	30.15	551
17. Devprayag	78.36	30.09	474
18. Rishikesh U/S	78.18	30.06	345
19. Rishikesh Barrage	78.17	30.04	334
20. Satyanarayana	78.14	30.00	316
21. Bheem Gauda Barrage	78.10	29.57	290

Figure 6: Upper Ganga Segments



Station	Longitude, E	Latitude, N	Elevation, m
1. Bheem Gauda Barrage	78.10	29.57	290
2. Bijnore Barrage	78.02	29.22	221
3. Narora Barrage	78.23	28.11	182
4. Kachla Ghat	78.51	27.56	165
5. Kusumkher	79.56	27.08	130
6. Kannauj U/S	79.59	27.04	128
7. Kannauj D/S	79.59	27.00	127
8. Kanpur Barrage	80.19	26.30	118
9. Shuklaganj	80.22	26.28	116
10. Jajmau	80.24	26.26	115
11. Allahabad	81.53	25.25	76
12. Varanasi	83.01	25.18	74

Figure 7: Middle Ganga Segments

2.1. Suggestions and Recommendations

- Gangotri Valley to be viewed as a place of pilgrim tourism and spiritual activities. All commercial activities in the vicinity of Gangotri (say within 500 m) to be transformed into eco friendly activities. Plan for environment protection and preservation of natural and pristine conditions (e.g. hotel culture to be changed to hut culture; severe restrictions on overnight stay of tourists, promotion of pilgrim tourism than commercial tourism, facilitating “Pad Yatra”, encouraging use of locally available materials, provision for segregated collection of entire solid waste of all kinds, entirely eliminating disposal of

any kind of waste from anthropogenic sources in the valley, complete recycle/reuse and conversion into acceptable products of wastes generated; sanitation and bathing facilities with no direct/indirect discharge into river valley, control of noise and artificial lighting, etc.).

- Harshil to be developed as nature friendly, zero waste terminal pilgrim tourist spot with facilities of ashrams, guest houses, parking, internet, etc.
- Environmental Flow (E Flow) to be estimated at various places, particularly for those stretches where river flow has been modified (IIT Consortia to work on this as part of the efforts to develop GRBMP). Flow measurement and display devices to be developed for all such stretches by the project implementer.
- All existing hydro electric projects may be redesigned and operated based on requirement of E flows.
- Community toilets and wash rooms with zero discharge of solid and liquid wastes to be developed at number of places as per approved plan for the entire UGS.
- River Bank and River Water Quality Management Plan to be prepared as described in the report prepared by IIT consortia developing GRBMP for Uttarkashi, Shrinagar, New Tehri Town, Rudra Prayag, Dev Prayag and Rishikesh on priority.
- Eutrophication potential of all impoundments to be assessed and measures taken to control release of nutrients from point and non-point sources.
- Detailed studies and documentation on changes due to implementation of hydroelectric projects in the region including, but not limited to the following: (i) drying of local water sources, (ii) enhancement of landslides, (iii) impact on hills surrounding the impoundments due to yearly fluctuations in water levels because of filling and emptying, (iv) damage/changes to residential buildings and hills, (v) potential changes in forest cover due to draining of waters in the tunnels, (vi) estimation of release of greenhouse gases from impoundments, (vii) differences in water temperature between a free flowing river and modified river, (viii) changes in the travel time/distance for local residents, (ix) employment generation, (x) loss of livelihood for local people, (xi) rehabilitation issues, (xii) effect of release of E flows on income from power generation, (xiii) aesthetic value, and (xiv) socio-cultural aspects (IIT Consortia to make such documentation as part of GRBMP efforts with help/assistance from concerned agencies if MOEF provides reports of all studies (including backup data) conducted through sponsored projects/consultancy assignments given to various agencies, institutions, universities, etc.).

3. Middle Ganga Segment: Haridwar to Varanasi

The river enters into the plains. The river bed consists of boulders, gravels and sand initially but subsequently consists of fine sand only. The river bed is essentially flat (slope ≈ 1 in 5000) and the river channel meanders, bifurcates into several channels in some parts and consists of dynamic system of pools and riffles. Substantial portion of the river flow is diverted to support agricultural activities through system of canals referred as Upper Ganga

Canal (from Bhimgaura Barrage commissioned in 1854 and renovated in 1984-85 just upstream of Haridwar), Madhya Ganga Canal (from Bijnore Barrage commissioned in 1977-78; essentially flood water or kharif canal system), and Lower Ganga Canal (from Narora Barrage commissioned in 1878). Substantial amount of flow, conveyed through a feeder canal originating from the barrage at Kalagarh on the river Ramganga, is introduced into the river Ganga just downstream of Garhmukteshwar to ensure sufficient quantities of water for Narora Atomic Power Plant. The confluence of Ramganga at Kusumkher, Kali at Kannauj and Yamuna at Allahabad augment the flow in the river. However, these rivers, particularly Ramganga and Kali also bring in a lot of domestic/industrial pollution load. In addition, several towns, industries and agricultural activities contribute to the point and non-point pollution load in this segment. Thus river flow and water quality are the key concerns in this segment in addition to general degradation of river system and encroachment of river bed, gravel/sand mining, riverbed farming, active netting of fish, open defecation, etc. In many places dumping of solid wastes including floral offering and other materials used for religious purposes, washing of clothes, wallowing of animals, throwing un-burnt/partially burnt dead bodies adversely affect aesthetics, water quality and aquatic life. Many important small, large and mega religious conglomerations are a part of socio-cultural dimensions of the riverine system at several places, the most important being at Haridwar, Allahabad and Varanasi.

In the initial parts of this segment, fish population predominates depending upon grazing and detritus food chain. The next portion has turtles, crocodiles, ghariyals and Gangetic dolphin alongwith active breeding sites. Pallaze, a practice to grow cucurbitaceous crop in the sand bed produced by meandering river is very common. At a number of places water is pumped out from the river or riverside wells to grow sugarcane and other crops. Riparian vegetation also is noteworthy. Some salient features of different stretches (refer Figure 7) within the UGS are presented in Exhibit 2.

3.1. Suggestions and Recommendations

- River Bank and River Water Quality Management Plan to be prepared as described in the report prepared by IIT consortia developing GRBMP for Haridwar, Garhmukteshwar, Kanpur, Allahabad and Varanasi on priority. IIT consortia to give priorities for the various work packages in the above plan. The priority work packages to be executed on fast track as per the guidelines.
- Industries directly or indirectly discharging their solid/liquid wastes into Ramganga, Kali and Ganga must be directed to follow best available practices for managing solid/liquid wastes and attain complete recycling of water and proper disposal of solid wastes/sludges as per norms enforced by the regulating agencies.
- Ganges Dolphin Conservation Zone Garhmukteshwar – Narora Barrage to be declared as “NO GO AREA” for which detailed studies have been done by WWF-India.

4. Lower Ganga Segment: Varanasi to Ganga Sagar

In this segment, the river Ganga receives water from three categories of rivers. In the first category are perennial rivers that originate in Himalayas and carry snow fed flows with significant discharge in the non-monsoon season. This includes Kosi, Gandak, Karnali (Ghaghra) and Mahakali (Sharda) river systems. In the second category are the rivers which originate in the midlands of Mahabharat range of mountains and are fed by precipitation as well as ground water, including springs. Mechi, Kankalm, Kamla, Bagmati, West Rapti and Babai rivers fall under this category. Although these rivers are also perennial, they are commonly characterized by wide seasonal fluctuations in discharge. The third category of river systems includes a large number of small rivers in the terrain which originate from the southern Shiwalik range of hills. These rivers are seasonal with little flows during the dry season but characterized by flash floods during the monsoon. This part of the basin, particularly the alluvial belt, is viewed as play ground for many rivers. There is spilling of river banks and drainage congestion because of peculiar deltaic formation of soil.

Major changes in nature of surface flow have been observed in this segment. This change is due to the massive silt coming along with the flow. Planning for this massive silt is as important as the surface water flow itself. The problem of development and water resources management is highly complex in this segment. Flood, drought and water logging occur frequently. Flood is a big menace and agriculture is badly affected, though the land is very fertile.

Several towns, industries and agricultural activities contribute to the point and non-point pollution load in this segment. In addition to general degradation of river system, encroachment of river bed, sand mining, riverbed farming, active netting of fish, open defecation, etc. are also of concern. In many places dumping of solid wastes including floral offering and other materials used for religious purposes, washing of clothes, wallowing of animals, throwing un-burnt/partially burnt dead bodies adversely affect aesthetics, water quality and aquatic life. Many important small, large and mega religious conglomerations are a part of socio-cultural dimensions of the riverine system at several places, the most important being at Ganga Sagar where the river merges into the sea. This segment offers unique biodiversity with many important wetland systems. In some portions Ganges Dolphins are of great significance from ecological point of view and the general health of the river system. The food chain is typically detritus with dominance of fishes.

4.1. Suggestions and Recommendations

- Hydrological and geomorphological studies for managing sediment transport and water resources. FGM, WRM and EQP group of IIT Consortia to work on this.
- River Bank and River Water Quality Management Plan to be prepared as described in the report prepared by IIT consortia developing GRBMP for priority towns to be identified

within the next three months (Action by the EQP group of IIT consortia). IIT consortia to also give priorities for the various work packages in the above plan. The priority work packages to be executed on fast track as per the guidelines.

- Industries directly or indirectly discharging their solid/liquid wastes into Ganga must be directed to follow best available practices for managing solid/liquid wastes and attain complete recycling of water and proper disposal of solid wastes/sludges as per norms enforced by the regulating agencies.

Exhibit 1: Salient Features in Various Parts of the Upper Ganga Segment

Sub-Stretch and Its Description

UGS_1: Gaumukh to Gangotri (≈ 19 km)

Represents near natural and pristine conditions; Steep bed with rocks and boulders; No apparent human intervention and negligible pollution

UGS_2: Gangotri to Mukhoba (≈ 14 km)

Represents near natural and pristine conditions; Known to reemerge as Janhavi river; narrowest channel; Steep bed with rocks and boulders; Deep Gorges; Slight distributed pollution due to wastes from eating-joints on the Gangotri-shrine; guest houses. Problem of sanitation is most important.

UGS_3: Mukhoba to Jhala (≈ 22 km)

Represent near pristine and natural conditions; Historical and religious importance due to joining of three rivers, known as Hari Prayag; Wide flood plain; Flat bed with pebbles and sand; Meandering and bifurcating into several channels with dynamic system of riffles and pools; Slight pollution due to domestic and commercial (hotels/guest houses) establishments

UGS_4: Jhala to U/S MB-1 (≈ 24 km)

Represents near pristine and natural conditions; Steep and narrow river bed intermingled with boulders, pebbles and sand; Slight pollution due to domestic activities

UGS_5: MB-1 U/S to MB-1 Barrage (≈ 4 km)

Modified to impoundment; Riverine environment shifting to lacustrine environment; Slight pollution due to domestic activities; High eutrophication potential

UGS_6: MB-1 Barrage to MB-1 Tail Waters (≈ 7 km)

Flow substantially reduced; River bed may dry up for sometime; Discontinuity in flow regime; Aquatic life severely affected

UGS_7: MB-1 Tail Waters to MB-2 U/S (≈ 4 km)

Modified fluctuating flows depending upon power generation at MB-1 power plant; Additional flows due to Gadera's; River bed consisting of small stones and pebble; River in combination of riffles and pools.

UGS_8: MB-2 U/S to MB-2 Barrage (≈ 3 km)

Modified to impoundment; Riverine environment shifting to lacustrine environment; Slight pollution due to domestic activities; High eutrophication potential

Sub-Stretch and Its Description

UGS_9: MB-2 Barrage to MB-2 Tail Waters (≈ 10 km)

Flow substantially reduced; River bed may dry up for sometime; Discontinuity in flow regime; Aquatic life severely affected

UGS_10: MB-2 Tail Waters to Tehri U/S (≈ 21 km)

Modified fluctuating flows depending upon power generation at MB-2 power plant; River bed consisting of small stones and pebble; River in combination of riffles and pools. Slight pollution due to domestic activities

UGS_11: Tehri U/S to Tehri Dam (≈ 38 km)

Modified to impoundment; Riverine environment shifting to lacustrine environment; Slight pollution due to domestic activities; High eutrophication potential; Potential for release of greenhouse gases due to decomposition of submerged biomass in the lake

UGS_12: Tehri Dam to Tehri Tail Waters (≈ 4 km)

Flow substantially reduced; River bed may dry up for sometime; Discontinuity in flow regime; Aquatic life severely affected

UGS_13: Tehri Tail Waters to Koteshwar U/S (≈ 3.5 km)

Substantially modified fluctuating flows depending upon power generation at Tehri power plant; River bed consisting of small stones and pebble; River in combination of riffles and pools. Slight pollution due to domestic activities

UGS_14: Koteshwar U/S to Koteshwar Dam (≈ 11 km)

Will be modified to impoundment; Riverine environment likely to shift to lacustrine environment; Slight pollution due to domestic activities; High eutrophication potential

UGS_15: Koteshwar Dam to Koteshwar Tail Waters (≈ 5 km)

Flow substantially reduced; River bed may dry up for sometime; Discontinuity in flow regime; Aquatic life severely affected

UGS_16: Koteshwar Tail Waters to Dev Prayag (≈ 17 km)

Modified fluctuating flows depending upon power generation at Koteshwar power plant; River bed consisting of small stones and pebble; River in combination of riffles and pools. Slight pollution due to domestic activities

UGS_17: Dev Prayag to Rishikesh U/S (≈ 64 km)

Substantially modified fluctuating flows depending upon power generation at Tehri and Koteshwar power plants; Flow augmented due to confluence with Alaknanda; Hydroelectric projects under construction/proposed on Alaknanda and its tributaries may further influence hourly variation in flow; River bed consisting of small stones and pebble; River in combination of riffles and pools. Slight pollution due to domestic activities, bathing and other cultural religious activities; Initiation of detritus food chain with fish at the top of food chain; Riverine ecosystem under stress due to frequent fluctuations in flow and water quality (e.g. temperature and turbidity)

Sub-Stretch and Its Description

UGS_18: Rishikesh U/S to Rishikesh Barrage (≈ 4 km)

Substantially modified fluctuating flows depending upon power generation at Tehri and Koteshwar power plants; Flow augmented due to confluence with Alaknanda; Hydroelectric projects under construction/proposed on Alaknanda and its tributaries may further influence hourly variation in flow; River bed consisting of large and small pebble with some boulders and sand; River in combination of riffles and pools. Slight pollution due to domestic activities, bathing and other cultural/religious activities; Development of detritus food chain with fish at the top of food chain; Riverine ecosystem under stress due to frequent fluctuations in flow and water quality (e.g. temperature and turbidity)

UGS_19: Rishikesh Barrage to Satyanarayana (≈ 11 km)

Flow pattern modified depending upon modified fluctuating flow received from upstream and power generation at Chilla power station; River bed consisting of small stones and pebble; Active fish breeding area; Fish netting and rampant stone mining; Riverine ecosystem under stress due to frequent fluctuations in flow and water quality (e.g. temperature and turbidity)

UGS_20: Satyanarayana to Bhim Gauda Barrage (≈ 9 km)

Flow pattern modified depending upon modified fluctuating flow received from upstream; Wide flood plain; Flat bed with pebbles and sand; Meandering and bifurcating into several channels with dynamic system of riffles and pools; Much of the water diverted to Har-ki-paudi through canal and much less water released in the main stream as Neel Dhara; Moderate pollution due to domestic and commercial (hotels/guest houses) establishments

Exhibit 2: Salient Features in Various Parts of the Middle Ganga Segment

Sub-Stretch and Its Description

MGS_1: Bheem Gauda Barrage to Bijnor Barrage (≈ 82 km)

Most of the water is diverted to Har-ki-Paudi; Excess flow from canals is returned at 6-8 km downstream; Wide flood plain, River meandering and bifurcating into several channels; River bed consisting of pebble and sand; Reported re-appearance of Mahasheer at Balawali; Occurrence of Otters, Crocodiles, Ghariyal, Turtle in some parts indicating good biodiversity; Active breeding grounds for fish in some parts; Moderate pollution due to domestic and agricultural activities.

MGS_2: Bijnor Barrage to Narora Barrage (≈ 176 km) NO GO ZONE

Low flow during non-monsoon period in the initial portion of the stretch up to Garhmukteshwar; Subsequently flow modified through discharge of Ramganga waters through feeder canal; Impoundment and abstraction of water through Lower Ganga Canal system at the tail end; Wide flood plain and sandy bed with some pebbles; Ganges Dolphin conservation site; Moderate pollution due to domestic and agricultural activities

Sub-Stretch and Its Description

MGS_3: Narora Barrage to Kachla Ghat (≈ 70 km)

Extremely low flows during non-monsoon period; Only occasional releases of water during non-monsoon period; Wide flood plain; Meandering river with dynamic system of pools and riffles; Sandy bed; Breeding site for Turtles and Ghariyal; Agricultural activities in river bed, predominantly Cucurbitaceous crops known as “Pallaze”; Significant degradation of river water quality.

MGS_4: Kachla Ghat to Kusumkher (≈ 182 km)

Extremely low flows during non-monsoon period; Only occasional releases of water during non-monsoon period; Wide flood plain; Meandering river with dynamic system of pools and riffles; Sandy bed; Agricultural activities in river bed, predominantly Cucurbitaceous crops known as “Pallaze”; Significant degradation of river water quality.

MGS_5: Kusumkher to Kannauj U/S (≈ 12 km)

Additional flow and pollutant load from river Ramganga; Low flows during non-monsoon period; Only occasional increase in flows during non-monsoon period; Wide flood plain; Meandering river with dynamic system of pools and riffles; Sandy bed; Agricultural activities in river bed, predominantly Cucurbitaceous crops known as “Pallaze”; Use of excessive pesticides. Significant degradation of river water quality.

MGS_6: Kannauj U/S to Kannauj D/S (≈ 9 km)

Additional highly polluted flow from river Kali; Low flows during non-monsoon period; Only occasional increase in flows during non-monsoon period; Wide flood plain; Meandering river with dynamic system of pools and riffles; Sandy bed; Agricultural activities in river bed, predominantly Cucurbitaceous crops known as “Pallaze”; Use of excessive pesticides. Significant degradation of river water quality.

MGS_7: Kannauj D/S to Kanpur Barrage (≈ 78 km)

Low flows during non-monsoon period; Only occasional increase in flows during non-monsoon period; Wide flood plain; Meandering river with dynamic system of pools and riffles; Sandy bed; Impoundment in the part downstream of Bithoor near Barrage; Ganges Dolphins Spotted; Agricultural activities in river bed, predominantly Cucurbitaceous crops known as “Pallaze”; Use of excessive pesticides. Significant degradation of river water quality.

MGS_8: Kanpur Barrage to Shuklaganj (≈ 7.5 km)

Low flows during non-monsoon period; Only occasional increase in flows during non-monsoon period; Wide flood plain; Meandering river with dynamic system of pools and riffles; Sandy bed; Agricultural activities in river bed, predominantly Cucurbitaceous crops known as “Pallaze”; Use of excessive pesticides. Extensive degradation of river water quality due to domestic and industrial wastes, dumping of solid wastes, animal wallowing, throwing of un-burnt dead bodies.

Sub-Stretch and Its Description

MGS_9: Shuklaganj to Jajmau (≈ 5.5 km)

Low flows during non-monsoon period; Only occasional increase in flows during non-monsoon period; Wide flood plain; Meandering river with dynamic system of pools and riffles; Sandy bed; Agricultural activities in river bed, predominantly Cucurbitaceous crops known as “Pallaze”; Use of excessive pesticides. Extensive degradation of river water quality due to domestic and industrial wastes, dumping of solid wastes, animal wallowing, throwing of un-burnt dead bodies; The most critical stretch.

MGS_10: Jajmau to Allahabad (≈ 247 km)

Low flows during non-monsoon period; Only occasional increase in flows during non-monsoon period; Wide flood plain; Meandering river with dynamic system of pools and riffles; Sandy bed; Agricultural activities in river bed, predominantly Cucurbitaceous crops known as “Pallaze”; Use of excessive pesticides. Discharge of domestic and some industrial wastes, dumping of solid wastes, animal wallowing, throwing of un-burnt dead bodies; Gradual but very slow recovery of the river system; Ganges Dolphin spotted; Several important major and mega religious/cultural conglomeration held on the riverside.

MGS_11: Allahabad to Varanasi (≈ 212 km)

Slight increase in flow due to joining of a major tributary Yamuna; Wide flood plain; Meandering river with dynamic system of pools and riffles; Sandy bed; Agricultural activities in river bed, predominantly Cucurbitaceous crops known as “Pallaze”; Use of excessive pesticides. Discharge of domestic and some industrial wastes, dumping of solid wastes, animal wallowing, throwing of un-burnt/half burnt dead bodies; Ganges Dolphin spotted.
