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Measures for Ecological Revival of River Ganga

GRBMP : Ganga River Basin Management Plan

by

Indian Institutes of Technology

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

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 Management Plan (GRBMP).

A Consortium of 7 Indian Institute of Technology (IIT) has been given the responsibility of preparing Ganga River Basin Management Plan (GRBMP) 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 Management Plan (GRBMP). The overall Frame Work for documentation of GRBMP and Indexing of Reports is presented on the inside cover page.

There are two aspects to the development of GRBMP. 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 have contributed directly and those who have taken lead in preparing this report is given on the reverse side.

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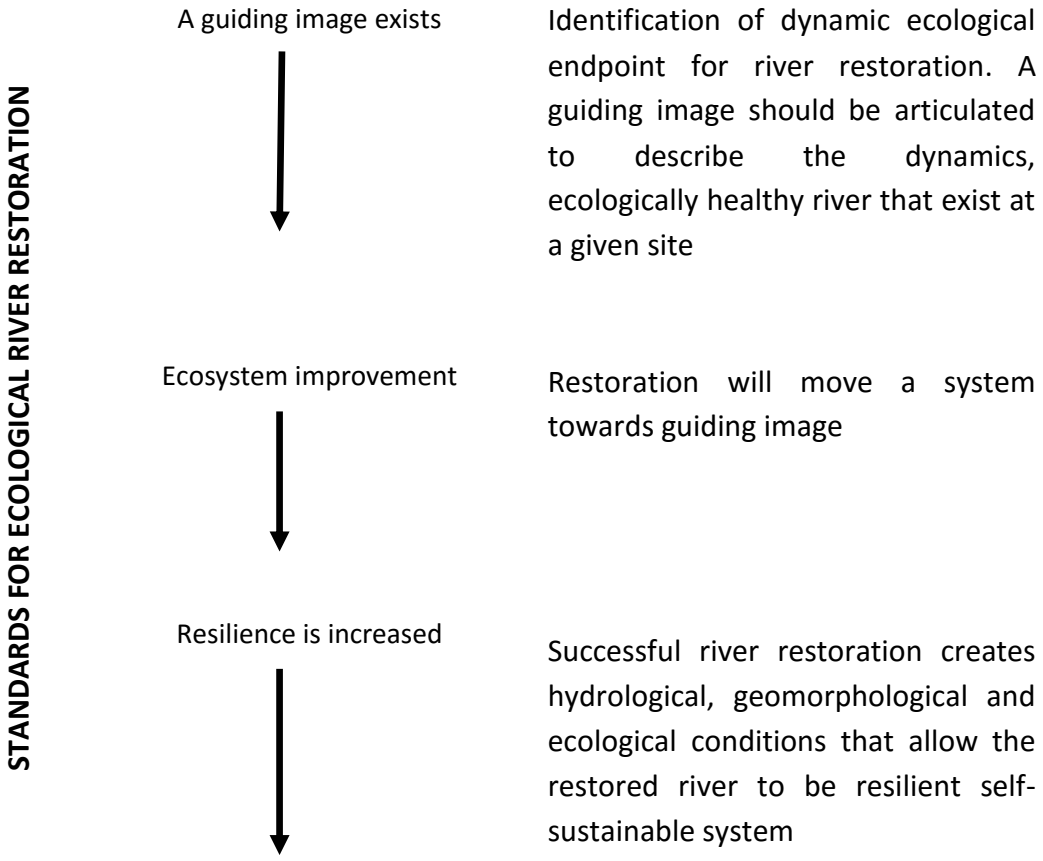
1. Introduction

The river Ganga is home to a vast variety of living organisms from simple microscopic flora and fauna to a large assemblage of higher invertebrates (Arthropods, Annelids, Molluscs) and vertebrates (Fishes, Reptiles and Mammals). The biodiversity of the river Ganga is unique as it synthesizes three major eco-regions of India situated along different climatic gradients - the Himalayan mountainous region, the Gangetic plains and the Estuarine region including Hooghly-Maldah delta. These regions have different geologic and evolutionary history and hence the biota is diverse.

The main problems of Ganga river basin arise by unsustainable use of water resources; obstruction in flows resulting in river fragmentation and loss of longitudinal connectivity on account of exploitation of its hydro-electric potential in the Himalayan segment; abstraction of large quantities of water for irrigation in plains; and ever increasing water pollution in the middle and lower segments. These issues have been addressed as missions “Aviral Dhara”, “Nirmal Dhara” and “Eco-restoration” in the Ganga River Basin Management Plan (GRBMP).

A healthy, self sustaining river system provides important ecological and social goods upon which human life depends (Postel and Richter, 2003). Efforts in mitigating damages done to the river system and promote ecosystem goods and services and achieve a healthy, stable and sustainable ecosystem is referred as **Eco-restoration**. Palmer *et al*. (2005) have proposed criteria for measuring success of eco-restoration steps referred to as standards for ecological successful river restoration (Figure 1).



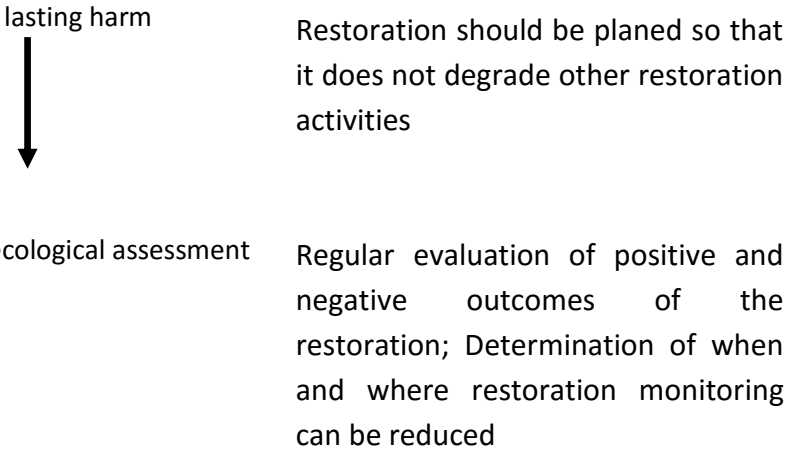


Figure1: Standards for Ecological Restoration

1.1 Goals and Objectives of Eco-restoration

The following goals and objectives have been comprehended:

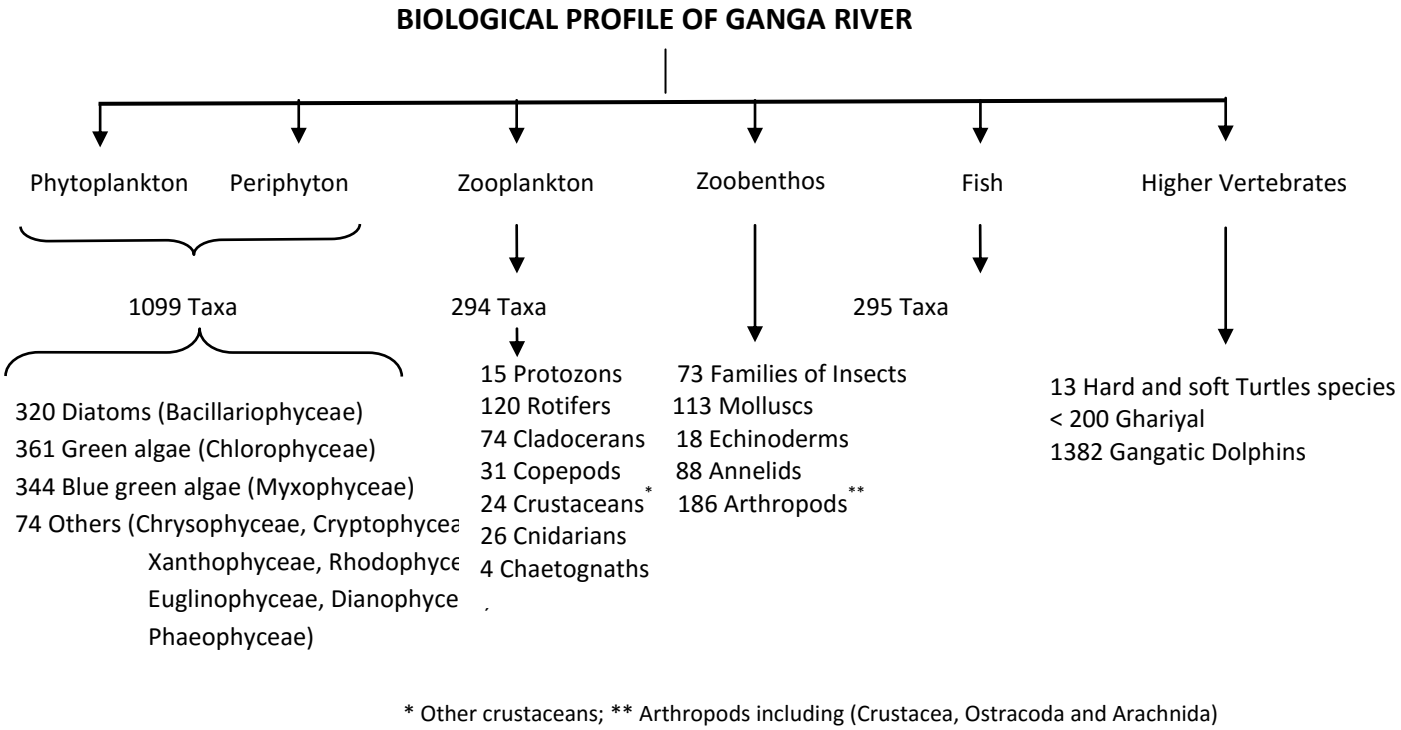
- **i.** Provide space to endemic flora and fauna for survival by maintaining longitudinal and later connectivity.
- **ii.** Assure pollution free (stress free) environment for existence of sensitive and endemic flora and fauna.
- **iii.** Eco-restoration measures implemented in defined stretches to conserve aquatic biodiversity; sustain breeding sites for fish and aquatic vertebrates; restrict overexploitation of fish; eliminate invasive species; and replenish and rejuvenate endemic biota.

2. Aquatic Biodiversity in River Ganga

The biodiversity in terms of species richness of different communities, phytoplankton, periphyton, zooplankton, zoobenthos, fishes and higher aquatic vertebrates is spelled out in the form of four reports (refer Table 1) prepared by the Ecology and Biodiversity (ENB) thematic group of the Consortium of 7 IITs (IITC) involved in preparation of the Ganga River Basin Management Plan (GRBMP). A snapshot of the type of communities identified and reported in river Ganga is provided in Figure 2. The details and stretch wise interrelationship of communities and the desired levels of characteristic/keystone species are depicted in Table 2 and 3, respectively.

Table 1: List of Relevant Reports Prepared by ENB Group of IITC

S No	Title of the Report	Report Code
1.	Floral and Faunal Diversity in Upper Ganga Segment Gangotri – Haridwar (Upstream Bhimgoda Barrage)	020_GBP_IIT_ENB_DAT_01_Ver 1_DEC 2011
2.	Floral and Faunal Diversity in Middle Ganga Segment Haridwar – Varanasi	025_GBP_IIT_ENB_DAT_03_Ver 1_SEP 2012
3.	Floral and Faunal Diversity in Lower Ganga Varanasi – Farakka	026_GBP_IIT_ENB_DAT_03_Ver 1_JUN 2012
4.	Floral and Faunal Diversity in Lower Ganga Farakka – Gangasagar	027_GBP_IIT_ENB_DAT_04_Ver 1_JUN 2012



* Other crustaceans; ** Arthropods including (Crustacea, Ostracoda and Arachnida)

Figure 2: Aquatic Biodiversity in River Ganga at a Glance

Table 2: Biological Profile of Different Stretches in 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	☆/ ☆	☆	☆	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, Gariyal, Gangetic Dolphins
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 to 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 to 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, Gariyal, Gangetic Dolphins, Porpoise, Chrocodile

☆A couple of brown trout *Salmo trutta fario* were cited by Nautiyal (2007); D* G* BG*= Diatoms, Green algae, Blue green algae; RET= Rare, Endangered, Threatened; IMC= Indian major carps; CF= Cat fishes

Table 3: Desired Levels of /Conditions for Characteristic/Keystone Species

River Stretch	Characteristic/ Keystone Species	Desired Conditios/Levels
Upper Ganga		
UG1 (Gangotri to Gangnani)	No Fish	
UG2 (Gangnani to Devprayag)	Snow Trout (*Schizothorax richardsonii*)	Trout should be able to migrate for feeding and breeding
UG3 (Devprayag to Haridwar)	Golden Mahseer (*Tor putitora*)	Mahseer should be able to migrate for feeding and breeding
Middle Ganga		
MG1-MG3 (Haridwar to Fatehgarh)	Indian Major carps, Catfishes, Dolphins	Indian Major carps- 40-50% Catfishes-10-15% Dolphins sighting
MG4-MG5 (Fatehgarh to Varanasi)	Indian Major carps, Catfishes, Dolphins	Indian Major carps- 40-50% Catfishes- 10-15% Dolphins sighting
Lower Ganga		
Lower Ganga LGA (Varanasi to Farakka)	Indian Major carps, Catfishes, Hilsa	Indian Major carps- 40-50% Catfishes-10-15% Hilsa
LGB (Farakka to Ganga Sagar)	Indian Major carps, Catfishes, Hilsa, Irrawaddy Dolphin *Polynemus paradiseus*, *Liza parsia*, *Harpadon nehereus*	Indian Major carps- 15-25% CF-10-15% Hilsa-30% Irrawaddy Dolphin sighting *Polynemus paradiseus*, *Liza parsia*, *Harpadon nehereus*

3. Gaps in Available Information

The GRBMP reports related to biodiversity of Ganga River Basin (GRB) are based on secondary data collected from published literature, reports of different organizations (e.g. MoEF, CIFRI, CSIR, NGO's), undergraduate, master's and doctoral projects and dissertations/thesis, etc. Perusal of the data collected reveals that it is available in fragments in geospatial terms and there are distinct gaps in information. The information is in different time domain and isolated stretches largely governed by the period of study and proximity of a river stretch/ water body to the investigating institutions, organization or individuals involved in the study. Due to lack of any definitive biomonitoring program by the concerned agencies (e.g. Central Pollution Control Board, State Pollution Control Boards and National River Conservation Directorate, etc.) the analysis is based on extrapolation of scattered, mostly qualitative data/ information. Most of the data collected relate to periods prior to construction of dams/ barrages in upper Ganga mountainous segment. The procedures followed did not reveal in-depth scientific information and missed out many small organisms in sediments and/ or sediment water interface.

4. Role and Impact of Riparian Vegetation in Eco-restoration

Riparian ecosystem is a connecting link between stream environment and terrestrial catchment. Riparian forest is an area of trees accompanied by shrubs and herbs that is adjacent to the water body. It influences the structure of both aquatic and upland terrestrial community. The components influenced by riparian ecosystem are modifying storage capacity and aquifer recharge, in-channel primary and secondary productivity, organic matter quality and quantity, biodiversity and migratory patterns, and biogeochemical pathways and rates (Sharitz *et al*., 1992). Riparian flora also helps in trapping pollution, filtering and converting sediments, nutrients and other chemicals. They absorb periodic flood fluxes and supply food cover and thermal protection to biota. Ecological buffers that are important to riparian ecosystem are mentioned as follows.

- ✓ Predominance of wood plant community.
- ✓ Presence of surface water and abundant soil moisture.
- ✓ Diversity interspersion of habitat features.
- ✓ Corridor for dispersal and migration.

Riparian ecosystem has many functional characteristics. They are highly productive because of convergence of energy and material, and unique hydrological conditions. Existing riparian systems have economic, social and biological values (Kauffman *et al*., 1997) (Figure 3).

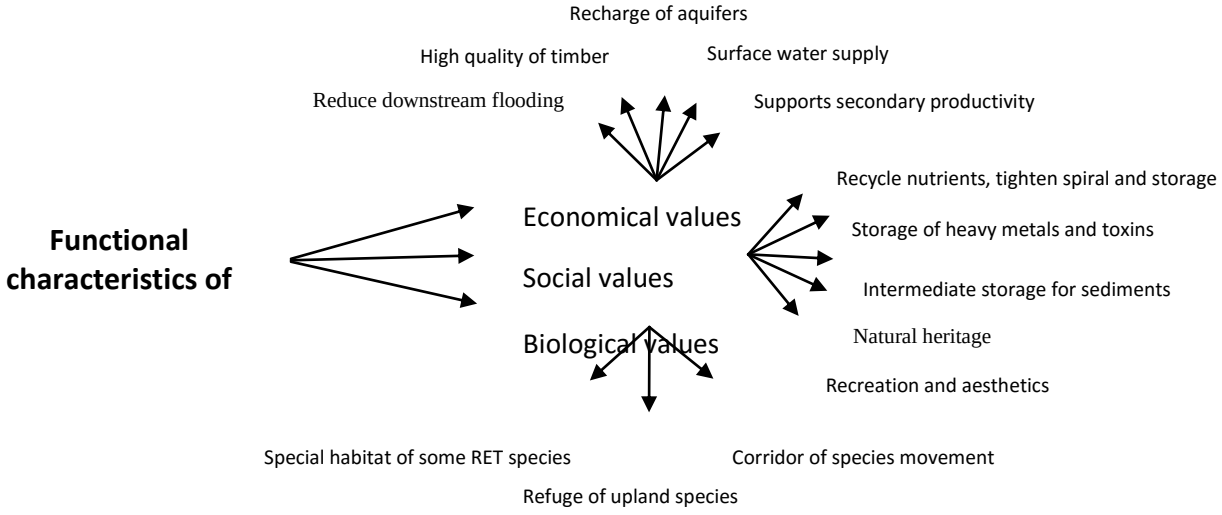


Figure 3: Functional Characteristics of Riparian Zone

Riparian zones hampered regularly by various anthropogenic activities to achieve multiple objectives such as channelization, road construction, timber harvesting, livestock grazing, mining, and water diversion. Degradation of riparian zones and streams diminishes their capacity to provide critical ecosystem functions, including the cycling and chemical transformation of nutrients, purification of water, attenuation of floods, maintenance of stream flows and stream temperatures, recharging of groundwater, and establishment and

maintenance of habitats for fish and wildlife. To conserve and maintain ecological integrity and pristine nature of the river, our strategy of ecological restoration requiring holistic approach of activities and conditions should also include the riparian zone restoration.

5. Major Threats on River Ganga Ecosystem

The riverine ecosystem has been exploited for meeting human needs. Major threats to the Ganga basin as well as other river basins in the country affecting/disturbing ecological integrity are briefly described as follows.

5.1 Changes in the Flow Regime

Obstruction: The flow patterns in the river Ganga have been altered due to number of run-of-the-river (ROR) hydro-electric projects in the Bhagirathi and Alaknanda head streams. Some of the projects which have been completed and under operation are listed in Table 4.

Table 4: Hydro-electric Projects on the River Bhagirathi and Alaknanda

Project	Installed capacity (MW)	Status	River
Vishunprayag	400	On	Alaknanda
Maneri Bhali I	99	On	Bhagirathi
Maneri Bhali II	304	On	Bhagirathi
Tehri	1000	On	Bhagirathi Bhilangna confluence
Koteshwar	400	On	Bhagirathi

In addition to the mentioned projects, six projects on Alaknanda and four projects on Bhagirathi are under construction and twenty four projects on Alaknanda and nine on Bhagirathi are proposed (Tare and Mathur, 2010).

These hydro-electric projects have fragmented the river and obliterated the migration routes of some important fishes *viz., Schizothorax* sp. and *Tor* sp. The salient features of two keystone migratory species *Schizothorax richardsonii* (Snow trout) and *Tor putitora* (Golden mahseer) are indicated in Table 5.

Table 5: Ecological Requirements of Schizothorax richardsonii and Tor putitora

Organism	Snow trout	Golden Mahseer
Zoological name	*Schizothorax richardsonii*	*Tor putitora*
Size	200-255 mm (maximum 509 mm)	200-260 mm (maximum 610 mm)
Water temperature	7.2-22°C	18.5-27.6°C
Current speed	Swift	Moderate
Water shed	Snow covered hills and spring	Lower reaches of snow fed streams and springs
Substratum	Boulders and stones covered with slimy algal material	Pitted rocks and stones covered with periphytic and filamentous algae
Spawning period*	August-October	May-September
Food and feeding	Herbivorous: feed on algae, periphyton, inferior mouth with hard cartilaginous disc adopted for scrapping; Diatoms (>90%), Green algae (≤6.0%), Desmids (≤1.0%); bottom feeder	Omnivorous (Green algae, insects); Diatoms (≥85%); Green algae (≤4.0%), Desmids (≤3.0%); Water column feeder
Benthos	May fly (≥40%), Caddis flies 30%, Diptera and Coleoptera	May fly (≥25%), Caddis flies 30%, Diptera and Coleoptera
Other requirement	Adult prefers deep pools and runs (1-3 m); It migrates to lower reaches of the stream for breeding	Adult prefers deep waters (pools and runs 1-3 m), while brooders migrate to shallow stream for breeding; Breed at graveled surface depth 0.5-1.0 m

* Period including the migration; Shrestha and Khanna (1976); Singh and Sharma (1995); Kishor *et al*. (1998); Bhatt et al. (2004)

Abstractions: Downstream of Rishikesh (Veerbhadra), Pashulok Barrage diverts nearly all the water in lean season into power channel for Chilla power station. The tail water of this power station joins the river near Bhoopatwala into river Ganga. A stretch of about 15 km from Pashulok Barrage to the confluence of the tail waters to the river essentially has no flow during the lean season (Plate 1). Further downstream, at Bhimgauda Barrage nearly all water is diverted to Upper Ganga Canal through Har ki Pauri at Haridwar. The flow of this diverted section is regulated at Mayapur Head Works and let off in the Upper Ganga Canal. The water in excess of requirements is passed through an escape channel which joins Ganga at Kankhal. Thus the stretch between Bhimgoda Barrage to Kankhal is nearly water less except some flow on account of leakage. The movement of major fishes including mahseer is intercepted and growth of other flora and fauna is impeded.

Water abstraction at Bijnor into Madhya Ganga Canal (Kharif Canal) and at Narora into Lower Ganga Canal further creates obstacle for biota. Further downstream Farakka Barrage has blocked the migration route of an anadromous fish called Hilsa which migrates from sea to fresh water for spawning.

Plate 1: Comparative Conditions of Flow Upstream and Downstream of Pashulok barrage

5.2 Habitat Alterations

In addition to changes in the flow regime, the river morphology and habitat are also altered steadily. Large scale gravel and sand mining, dumping of construction wastes and other solid wastes have lead to changes in flow direction causing erosion, channelization and river realignment. This reduces stream width, altering flood plains and riparian vegetation. The ecology is seriously impaired with changes in habitat. The alteration in habitat, changes benthic flora and fauna, fish breeding sites and egg laying sites, for soft and hard shell turtles (*Kachuga smithii*, *K. tecta*, *K. tentoria*, *K. dhongoka* and *K. kachuga*, *Aspideretes gangeticus* and *A. hurum*).

5.3 Emergence of Invasive (Exotic) Species

Exotic species of fish especially common carp *Cyprinus carpio* and Tilapia *Oreochromis niloticus* have invaded Ganga water downstream of Allahabad. These fishes have gained access through water of Yamuna at Sangam. Downstream Allahabad up to Bhagalpur and beyond they have grown in large numbers. They compete with Indian Major Carps (IMC) and have out grown them due to their adaptability in variable flows. Seven species of exotic fish have been reported in river Ganga (Singh and Lakra, 2006) including Thai magur, (*Clarias gariepinus*) and Grass carp (*Ctenopharyngodon idella*). The CIFRI has reported their presence now up to Narora. Sighting of brown trout *Salmo trutta fario* - an exotic fish, at Jhala downstream (Nautiyal, 2007) is an important signal of the presence of invasive species reaching all the way up to Bhagirathi.

5.4 Introduction and Proliferation of Invasive Species in the River Ganga

Exotic species is an introduced species intentionally or accidently in the system creating various problems including extinction of local species. The other problems such as food and habitat competition, preying upon native species, inducing of new diseases and parasites, result in the production of hybrids and cause genetic erosion of indigenous species. More than 300 exotic fishes are reported in India. Some of them escaped from confinement and are reported in river Ganga and have become invasive to the ecological equilibrium. A snapshot of exotic species found in the river Ganga is presented in Table 6.

Table 6: Exotic Species Found in River Ganga

S No	Exotic Fish	Status	Rivers	Reservoirs	Lakes	Wetlands
1.	Cyprinus carpio	Introduce for aqua culture	Ganga	Most reservoirs	Most lakes	Bihar, West Bengal, U.P.
2.	Hypophthalmichthys molitrix	Introduce for aqua culture	Ganga Yamuna	Some reservoirs	Some lakes	Bihar, West Bengal, U.P.
3.	Ctenopharyngodon idella	Introduce for aqua culture	Ganga Yamuna	Some reservoirs	Some lakes	Bihar, West Bengal, U.P.
4.	Aristichthys nobilis	Illegally introduced (banned sp.)	Ganga Yamuna	Some reservoirs in U.P.	Some lakes	Bihar, West Bengal, U.P.
5.	Clarias gariepinus	Illegally introduced (banned sp.)	Ganga Yamuna	Some reservoirs in U.P.	Some lakes	Bihar, West Bengal, U.P.
6.	Oreochromis niloticus	Introduce for aqua culture	Ganga Yamuna	Many reservoirs	West Bengal	West Bengal, Bihar
7.	Salmo trutta fario	-	Asi Ganga	-	-	-
8.	Gambusia affinis	-	Ganga	-	-	-
9.	Pterygoplichthys perdalis and P. disjunctivus	-	Ganga	-	-	-

Singh *et al.* (2013); Kumar (2000)

Cyprinus carpio is widely spread in eutrophic waters. Wild populations are considered vulnerable to extinction. It is a very destructive fish being included in the list of l00 worst invasive species. *Oreochromis niloticus*, Tilapra is an omnivorous fish which devours on most of the living forms (plankton and macrophytes). Breeds in slow moving warm waters. The fecundity and feeding habits are deleterious to indigenous population. It has made Ganga second home where it competes with Indian Major Carps whose production has reduced to nearly half. In order to sustain the wild population it is necessary to control, if not eliminate the growth of exotic species. Natural hybrids have also been reported in the system.

A concerted strategy to curb the introduction to middle and upper Ganga and reduce proliferation in lower Ganga is needed. This requires research and development. Central Inland Fisheries Research Institute and National Bureau of Fish Genetic Resources along with other Academic/ Research Institutes may be given the responsibility of working out the approach and strategy for control.

5.5 Pollution

Pollution from domestic and industrial wastes is rampant in Ganga river downstream of Haridwar though it is not very serious up to Fatehgarh (Farukhabad) but assumes higher and alarming proportions downstream of Kannauj after the confluence of Ram Ganga and Kali rivers. It remains high at Kanpur and Allahabad, and up to Varanasi. On the basis of long

term water quality monitoring of river Ganga undertaken by various organizations on behalf of NRCD (1986-2010), it is apparent that microbial pollution is increasing in the river. Water quality corresponding to Class-I and Class-II (as per the Designated Best Use of CPCB) is reported only in the upper Ganga stretch up to Devprayag and up to Garhmukteshwar respectively; while further downstream all the way down to the estuarine regions water quality is very poor (Tare *et al*., 2012).

Partially treated and untreated wastes is discharged in the river through about 36 Class-I towns and 14 Class-II towns. As per CPCB report on pollution assessment 2013, 2723.3 MLD waste water is generated from these towns out of which 1208.8 MLD is partially treated, which is only around 40%. The maximum input in the river is in West Bengal followed by Uttar Pradesh, Bihar and Uttarakhand. In addition 138 storm water drains - natural or manmade also discharge 6087 MLD either in rivers/ lake/ sea. In this respect maximum volume of wastewater is contributed by Uttar Pradesh (45 drains, 3289 MLD) which is followed by West Bengal (54 drains, 1779 MLD), Bihar (25 drains, 579 MLD) and Uttarakhand (14 drains, 440 MLD).

Residues of organochlorine including HCH (hexachlorocyclohexane), DDT (dichlorodiphenyltrichloro-ethane), endosulfan and their metabolites are common in the river water (Vass *et al*., 2011). High concentrations were reported by Nayak *et al*. (1995) near Varanasi. There are reports on presence of organophosphates (Ray, 1992). Heavy metals are also reported in the river water and sediments (Vass *et al*., 2011). Some toxic metals which are reported comprise Cd, Cr, Cu, Mn, Ni, Pb and Zn (Saikia *et al*., 1988; Joshi, 1991; Mohammad *et al*., 1987; Israil, 1991; Singh *et al*., 1993). The pollutants can be traced to industrial wastes, agriculture run off and domestic wastes from point and nonpoint inputs.

5.6 Impact on Inland Fisheries

There has been conspicuous reduction in the fish yield, fish catch, fish size and fish composition in the Ganga river due to combined effect of changes in flow, changes in rainfall, loss of breeding sites, pollution and juvenile fishing. It has been generally observed that the size of fish has undergone reduction. Hamilton (1885) had reported Mahseer with maximum size of 2.74 m at Haridwar while in current times the reported maximum size varies between 1.0-1.5 m. The maximum size of Indian Major Carps has also reduced. The fish yield from the river Ganga is also declining gradually (reported at Allahabad) from 1344 kg/km in 1950 to as low as 362 kg/km in 2000 and a mere 300 kg/km in 2010. The catch composition has also changed. The percentage of IMC has gone down and there is increase in other species as depicted in the Figures 4 and 5.

In addition fish spawn of Indian Major Carps has also declined in the middle stretch due to destruction of spawning sites. The fish spawn availability index which used to be 281 ml in 1970 has declined to 27 ml as recorded during 1996-2000.

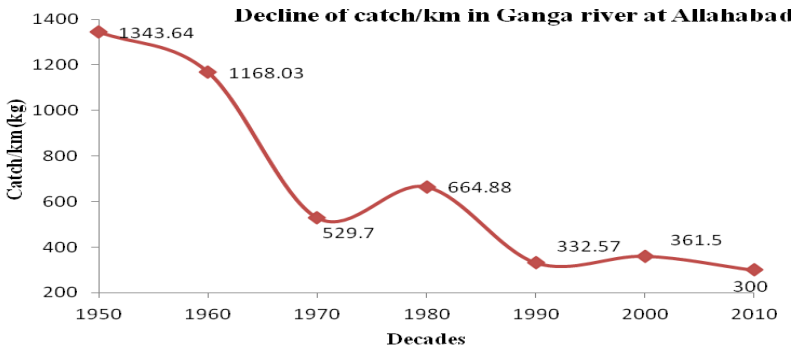


Figure 4: Decline of Fish Catch per km at Allahabad During 1950s to 2010

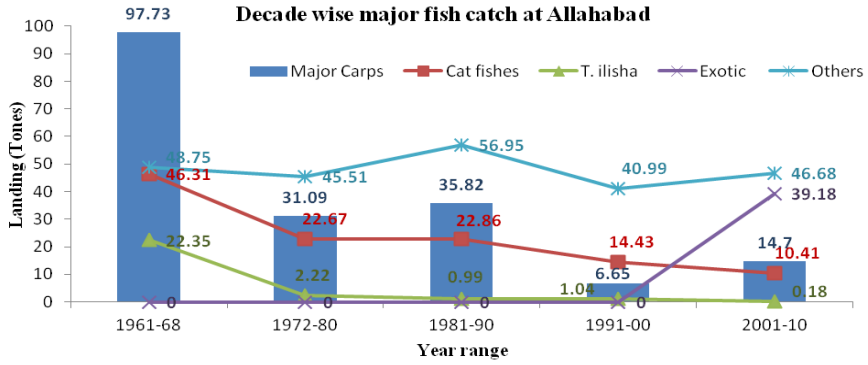


Figure 5: Fish Landing at Allahabad (CIFRI Annual Reports 1961-2010)

6. Restoration Measures

The following restoration measures seem inevitable in river ecosystem including research and data validation to bring river Ganga to sustainable, stable and healthy condition.

Longitudinal, lateral and vertical connectivity by maintaining Environmental Flows (E-Flows) in the entire stretch of Ganga system. This would provide enough space for endemic species of both flora and fauna for growth and migration. It will also provide connectivity with wetlands. Restoration of wetlands may be made point of focus so as to ensure breeding sites of fish and other aquatic animals.

To maintain wholesome quality under mission Nirmal Dhara, concerted efforts are needed to provide stress free, toxic free conditions to promote and sustain endemic flora and fauna. The two measures (longitudinal connectivity and maintaining desired water quality) are the focal points under the missions 'Aviral Dhara' and 'Nirmal Dhara'.

Rivers as a fishery resource are almost neglected by state governments. Over exploitation of fish in certain states with open or access fishing rights has reduced the fish catch/yield. Fishing is found to continue even in periods of breeding. Through legislation in River Act (proposed) fishing should come under regulated and restricted category. Broods and

juvenile should be protected from exploitation. Fishing during May-August (breeding season) should not be permitted.

Identify all the species including zoobenthos, fish and aquatic higher vertebrates which come under rare, endangered and threatened category and conserve them to maintain the ecological integrity.

Breeding sites for fish and other higher aquatic vertebrates may be identified and conserved. Soft and hard shelled turtles lay eggs in the flood plains during the post monsoon period which coincides with the growth of pelage, a local phenomenon in U.P. and Bihar.

To assess and monitor river health, primary data collection for all parameters including biomonitoring from selected stretches should be done by recognized and reputed research institutions through empowering and involving local riverside communities.

Use of chemical fertilizers and pesticides in agricultural in flood plains and riparian zone be regulated and restricted.

The Gangetic dolphin *Platanista gangetica gangetica* was declared a National aquatic animal by Ministry of Environment and Forest on May 10, 2010 and a Conservation Action Plan was published for 2010-2020 (Sinha *et al*., 2010). The document provides general and scientific information of the Flagship species including preference for habitat and conservation status. The threats to its population include Human-Dolphin conflict (Poaching, accidental killing, use of dolphin products), habitat degradation, pollution and riverine resource extraction. Strategy for conservation as per principles elucidated in the IUCN Workshop held in 1997 in Bangladesh on water development and Cetacean were adopted.

- Gangetic Dolphin requires sufficient year round water flow to move, forage and carry out activities that ensure reproductive success and recruitment into breeding population.
- Large daily fluctuations in flow should be avoided.
- Equilibrium between sediment erosion and deposition is necessary to maintain essential habitat features.
- Access to flood plains should be preserved to ensure natural spawning and rearing habitat for fishes which are prey base of the dolphins.
- Information on the pre development ecological conditions of a river is essential for evaluating migration efforts and to implement future development decisions.
- Post development empirical studies are needed to monitor the operational aspects as well as the effects on upstream and downstream populations of cetaceans and their habitat.
- Cumulative and synergistic impacts of multi development should be considered in assessment of environmental impact.

- Enhancing the capacity and governance frame work for Gangetic Dolphin conservation is needed.

Some areas of Ganga river system, identified as a critical stretch for Dolphins, are mentioned as follows.

1. Uttar Pradesh:-

Madhya Ganga Barrage at Bijnor to Lower Ganga Canal at Narora (165 km)
Fatehpur to Mirzapur (150 km)
Chambal Yamuna confluence near Etawah
Ganga Yamuna confluence at Allahabad

2. Bihar:-

Gangi-Ganga confluence near Sinha Ghat (20 km)
Upstream of Ghaghara-Ganga confluence at Doriganj, Chhapra to Fatuha (80 km)
Barh to Mokama to Manihari Ghat (Katihar) (210 km) (This includes Vikramshila Dolphin Sanctuary ~50 km)
River Gandak from Triveni Barrage at Indo-Nepal border to Ganga-Gandak confluence at Patna (332 km)

(i) Invasive species of fish like Chinese carp (*Cyprinus carpio*), Chinese grass carp (*Ctenopharyngodon idella*) and Tilapia (*Oreochromis niloticus*) have made Ganga their second home where it competes with IMC, and need to be control. The protocol and procedure required needs to be worked out through the concerted efforts of Central Inland Fishery Research Institute and other scientific bodies.

(j) Regulations and restriction of certain activities through legal instruments:

- ✓ Sand and gravel mining should be regulated and dumping of solid wastes must be prevented which are responsible for habitat modification and channelization.

- ✓ Cultivation of “pelage” (Cucurbitaceous crops) in the flood plains of the river needs to be restricted to protect breeding sites of higher aquatic vertebrates and prevent contamination from fertilizers and pesticides

- ✓ Fishing during the breeding period of commercial fish, brood and juveniles (spawn, fry and fingerlings) should be prohibited or restricted.

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