# REJUVENATING GANGA

## A CITIZEN'S REPORT


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**Publication by the Organizing Committee**

**November, 2019**

**Note:** This Report is an output from the deliberations held at the India Rivers Week, 2018 at New Delhi from 24-26 November 2018

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# 1.0 THE CHALLENGE

## 1.1 Dwindling Flows

1.1.1. It has been estimated using models (since flow data is not available in public domain) that the River Ganga and its tributaries have witnessed a drastic reduction in annual and seasonal flow over a period of 31 years (1975-2005)[1].

**Table 1:** Estimated flow reduction[1] in sub basins of River Ganga (1975-2005)

| S.No. | Sub Basin | Flow reduction (%) |
|---|---|---|
| **1** | Upper Ganga before Haridwar | 7 |
| **2** | Upper Ganga (before confluence with Ramganga river) | 36 |
| **3** | Ramganga (before confluence with Ganga river) - Left Bank | 37 |
| **4** | Upper Ganga (after confluence with Ramganga river) | 41 |
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| **6** | Upper Yamuna | 51 |
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| **8** | Sind (before confluence with Yamuna river) - Right Bank | 81 |
| **9** | Betwa (before confluence with Yamuna river) - Right Bank | 56 |
| **10** | Ken (before confluence with Yamuna river) - Right Bank | 48 |
| **11** | Lower Yamuna (before confluence with Ganga river) - Right Bank | 60 |
| **12** | Ganga (after confluence with Yamuna river) | 56 |
| **13** | Tons (before confluence with Ganga river) - Right Bank | 41 |
| **14** | Gomti (before confluence with Ganga river) - Left Bank | 31 |
| **15** | Ganga (after confluence with Gomti river) - Left Bank | 54 |
| **16** | Ghaghra (before confluence with Ganga river) - Left Bank | 34 |
| **17** | Ganga (after confluence with Ghaghra river) | 47 |
| **18** | Sone (before confluence with Ganga river) - Right Bank | 58 |
| **19** | Gandak (before confluence with Ganga river) - Left Bank | 34 |
| **20** | Punpun (before confluence with Ganga river) - Right Bank | 48 |
| **21** | Kiul (before confluence with Ganga river) - Right Bank | 51 |
| **22** | Burhi Gandak (before confluence with Ganga river) | 48 |
| **23** | Koshi (before confluence with Ganga river) | 27 |
| **24** | Farakka*at lower Ganga (before bifurcation to India and Bangladesh) | 45 |
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| **26** | Lower Ganga at Ganga Sagar (India) | 57 |

1.1.2. Table 1 shows that river Ganga has seen 45% reduction at Farakka and 57% reduction at Ganga Sagar in its flow in just over 30 years' time and but for few left bank tributaries (Ghaghra, Gandak & Koshi in particular) river Ganga would have been in much dire straits than it is today since all its right bank tributaries (Yamuna, Chambal, Sindh, Betwa, Sone, Kiul and Damodar) have already been heavily compromised with dams and barrages. (**see Map 1**).

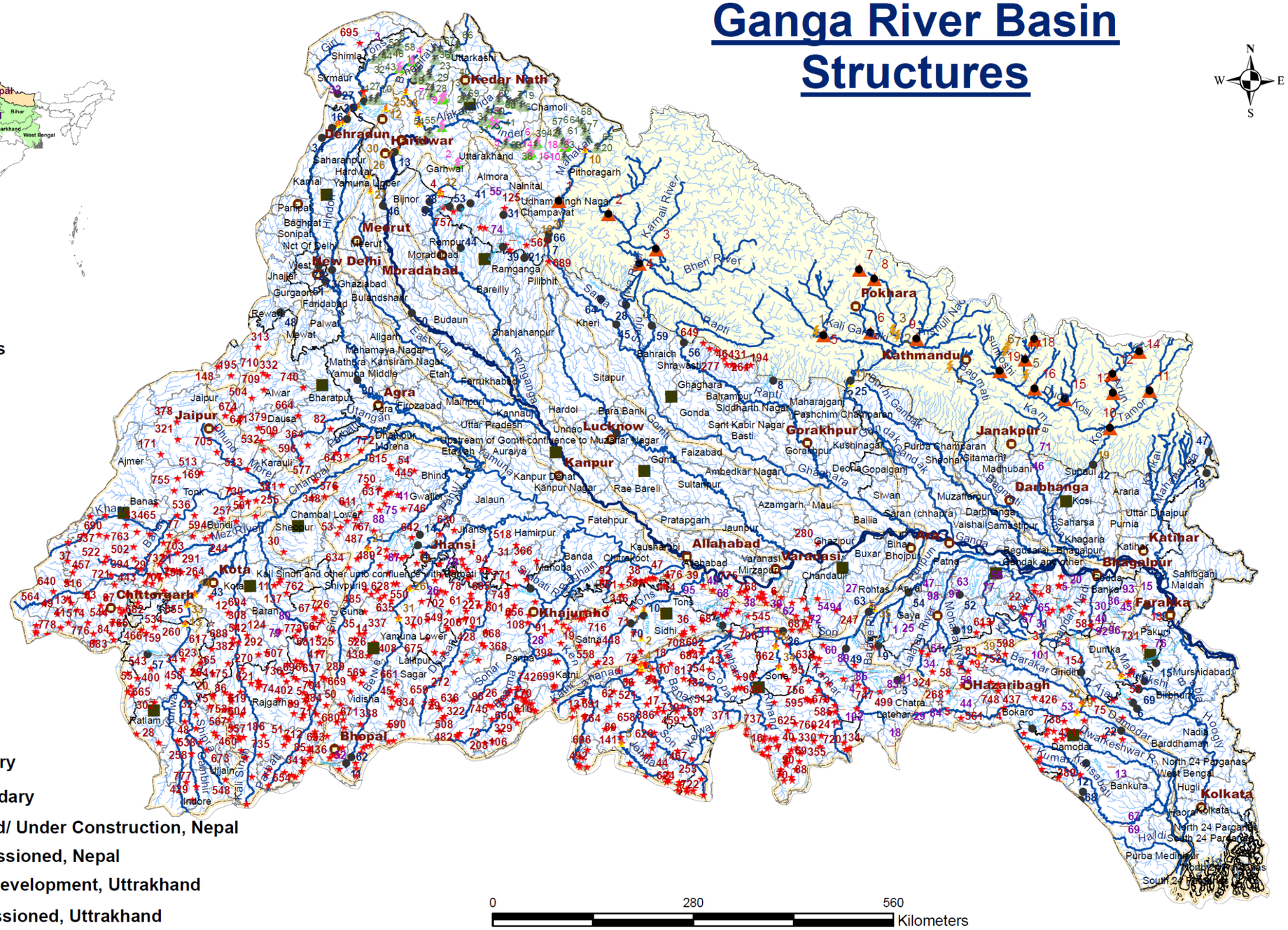
1.1.3. During the monsoon months the reduction in flow is variable over the different sub-basins of Ganga with the reduction in the sub-basins joining Ganga river from South having higher reduction (maximum being Sind with 75% reduction) in comparison to those joining Ganga river from North side (with maximum reduction of 40% for Upper Yamuna). However, the situation is drastically different during the Non-monsoon period. There is a very small fraction of flow left during the non-monsoon period especially in the sub-basins joining Ganga river from southern side. Reduction is also considerable even in the flows of the sub-basins joining Ganga River from the northern side ranging from 44% to 94%[1].

1.1.4. This state of affairs could be either due to:

a) Drastic fall in the mean annual rainfall over the years in different sub basins or
b) Major diversion of flow away from the rivers in the sub basins

1.1.5. Since most studies that have looked at rainfall variability over time in the Ganga basin do not show any drastic change in mean annual rainfall in the basin, it can but be large scale impoundment and diversion of river water at dams and barrages (**see Map 1**) in the basin that alone can explain significant fall in flow in Ganga main stem and its key tributaries.

# Ganga River Basin Structures


Map Prepared By : Abhishek Kumar Upadhyay
**Natural Heritage Division [NHD], Indian National Trust For Art And Cultural Heritage [INTACH]**

**Dated : May, 2019**
Primary Data Source : WRIS, UREDA and UJVN Ltd.



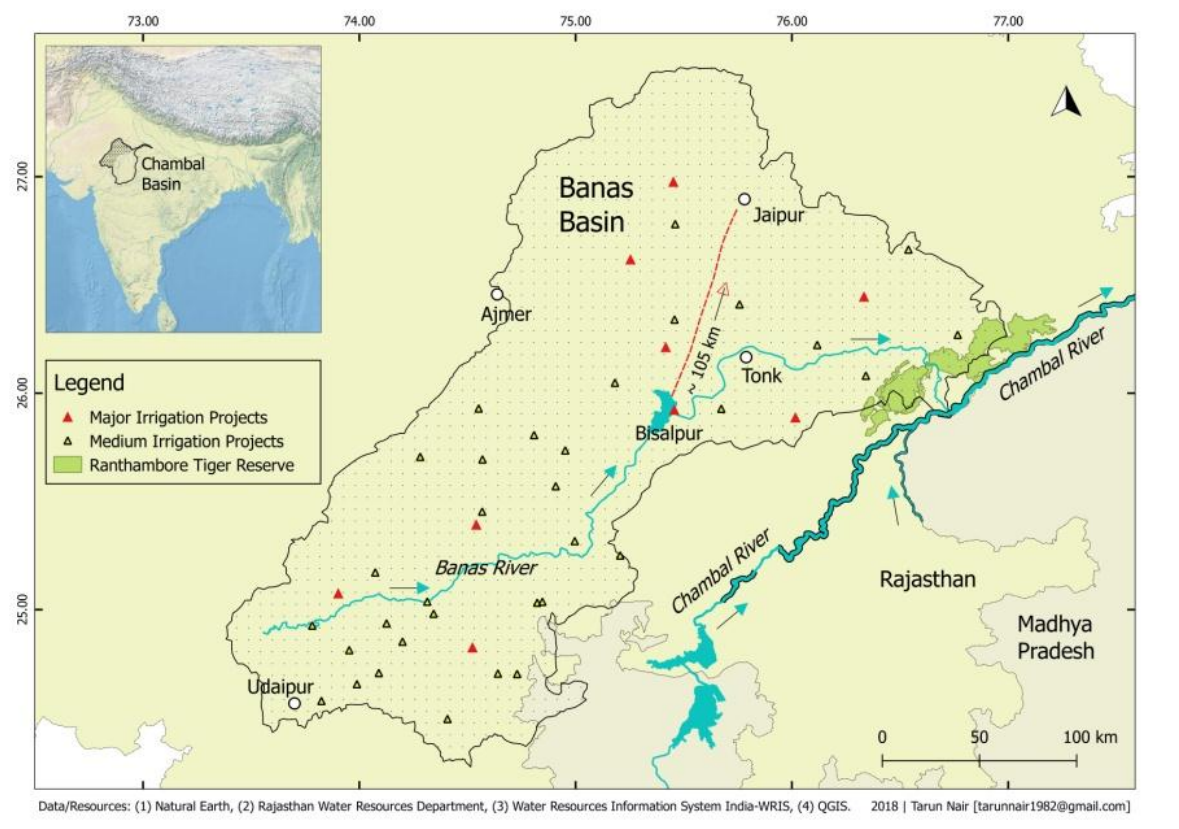
**Map 1 : Dams, Barrages in Ganga Basin**

**Sad state of River Banas in Rajasthan**

Tarun Nair, ATREE, Bangalore

A desk study carried out by Tarun Nair (2018) on river Banas (major tributary of River Chambal) in the state of Rajasthan found that "the abandonment of traditional water management systems, intensifying water exploitation, and water appropriation by urban centres have led to the steady drying of the Banas River and degradation of its catchment[2]. Although the total weighted monsoon rainfall and theoretical yield (1979-2013) in the Bisalpur catchment show an increasing trend, actual inflow is declining due to changes in land use and land cover in the catchment area[3]."

It may be mentioned that over some 47,000 sq. km of the River Banas catchment with 10 major sub-catchments namely Banas, Berach, Menali, Kothari, Khari, Dai, Dheel, Sohadara, Morel, and Kalisil there are **31,610 structures** (9 major, 33 medium and 1302 minor) standing over different streams. Rajasthan water resources department has declared (2010) 27,000 private anicuts in the basin to be 'illegal'? Whatever the fact is that in the non-monsoon period River Banas remains bone dry at its confluence point with River Chambal.




If the above was not enough in the near future, the proposed Eastern Rajasthan Canal Project, involving 6 barrages and 1 dam, to irrigate Dholpur and Sawai Madhopur districts (EAC-RVP 2018) is expected to aggravate the hydrological disruptions in the Banas and neighboring basins.

## 1.2 Runaway Pollution

1.2.1. It was a visible increase in the pollution levels of rivers, in particular Ganga and Yamuna within the Ganga basin that brought the river question centre stage in public discourse beginning the 1970s and 80s. Launch of Ganga Action Plan in 1986 and Yamuna Action Plan in 1994 were the result.

1.2.2. But despite these plans the pollution levels in the rivers of Ganga have shown little respite.

1.2.3. Except for the upper Ganga stretch (till Rishikesh) the water quality both in terms of FC and BOD is much beyond the standards.

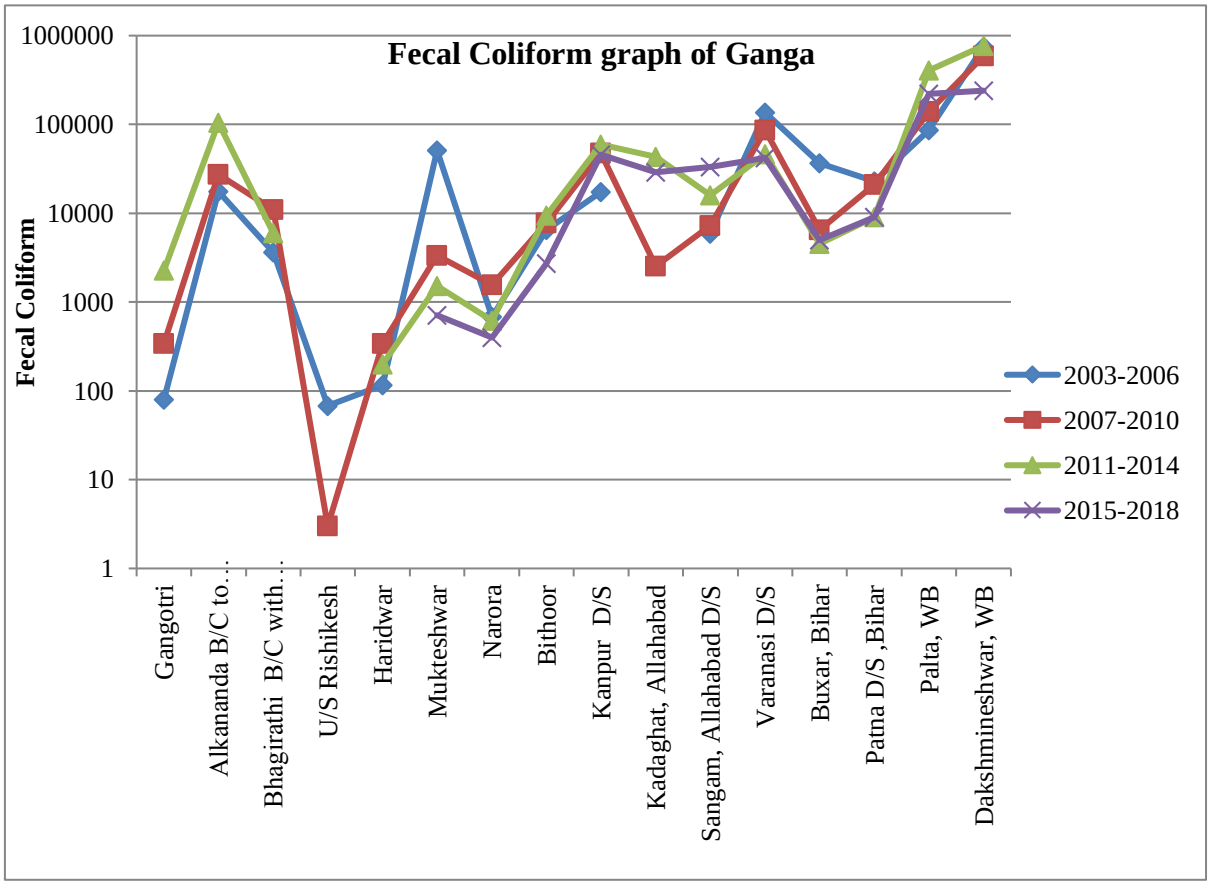



**Figure 1 : Changes (FC) in water quality (2003 -2018) on the main stem of River Ganga**

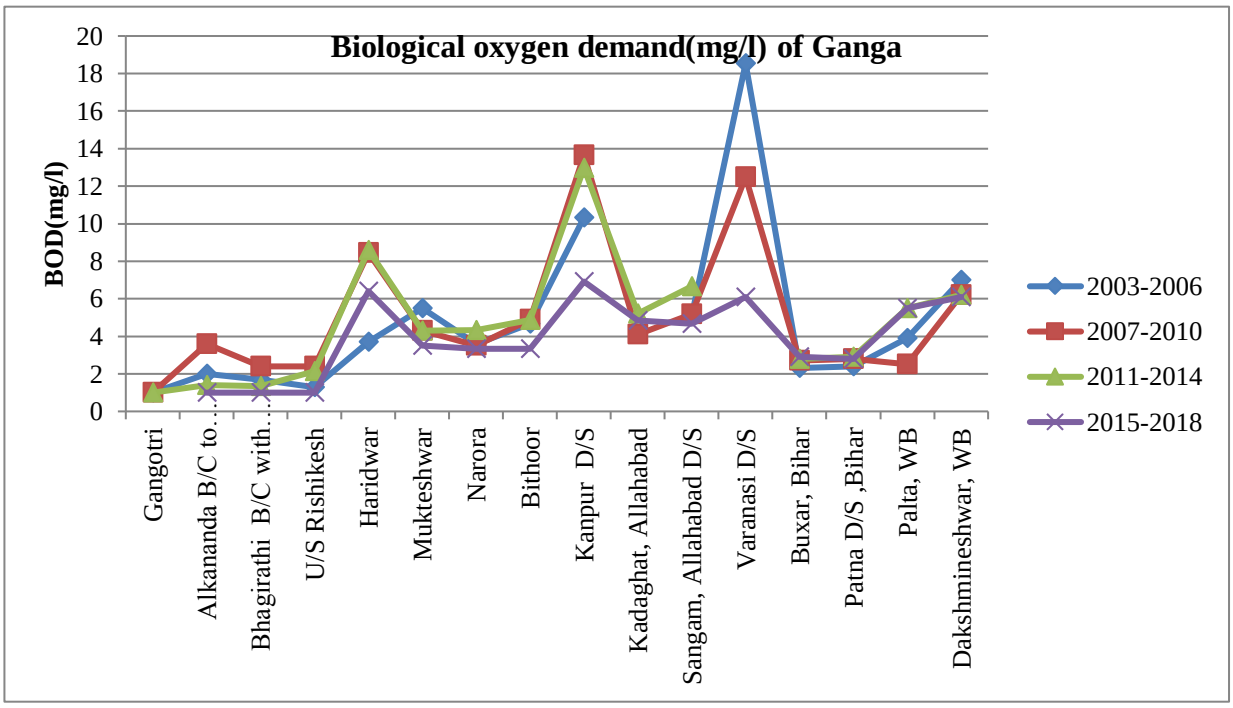



**Figure 2 : Changes (BOD) in water quality (2003 -2018) on the main stem of River Ganga**

*Source: 2003 to 2016 CPCB website and 2017 and 2018 UPPCB website (only UP part)*

## Polluted stretches of Rivers in Ganga Basin

1.2.4. It is not just the main stem Ganga but almost all its tributaries which are facing pollution issues.

1.2.5. According to CPCB 2018 report titled "River stretches for restoration of water quality (State wise and Priority wise) Central Pollution Control Board, Sep 2018":

**Table 2: Polluted River Stretches in Ganga Basin[4]**

| State | River | Sub basin | Stretch | BOD |
|---|---|---|---|---|
| **MP** | Chambal | Chambal | Nagda to Rampura | 12 - 80 |
| | Khan | Chambal | Kabit Khedi to Khajrana | 30.8 - 80 |
| | Kshipra | Chambal | Siddhawat to Trivenisangam | 4 - 38 |
| | Betwa | Betwa | Mandideep to Vidisha | 3.3 - 20.2 |
| | Sone | Sone | Along Amlai | 12.4 |
| | Chamla | Chambal | Along Badnagar | 4.0 |
| | Choupan | | Along Vijaipur | 3.4 |
| | Kaliasot | Betwa | Mandideep to Samardha | 4.1 |

| | | | | |
|---|---|---|---|---|
| | Mandakini | Paodhoi | Along Chitrakut | 5.8 |
| | Gohad | Kunwari/ Sindh | Gohad dam to Gormi | 6.3 |
| | Malei | Chambal | Jaora to Barauda | 3.5 |
| | Newaj | Chambal | Along Shujalpur | 4.0 |
| | Parvati | Chambal | Batawada to Pilukhedi | 3.2 |
| | Simrar | Katni | Along Katni | 3.9 |
| | Tons | Tons | Chakghat to Chapper | 3.5 |
| **Rajasthan** | Banas | Chambal | Along Bisalpur Dam till Newta Dam | 13.2 |
| | Chambal | Chambal | Kota to Sawaimadhopur | 3.2 – 4.8 |
| **Haryana** | Yamuna | Yamuna | Panipat to Sonepat | 4 - 55 |
| **Delhi** | Yamuna | Yamuna | Wazirabad to Asgarpur | 9 - 80 |
| **Uttar Pradesh** | Hindon | Yamuna | Saharanpur to Ghaziabad | 48 - 120 |
| | Kali nadi | Hindon/ Yamuna | Muzzafarnagar to Gulaothi town | 8 - 78 |
| | Varuna | Ganga | Rameshwar till confluence with Ganga | 4.5 – 45.2 |
| | Yamuna | Yamuna | Asgarpur to Etawah Shahpur to Allahabad | 12 - 55 |
| | Gomti | Ganga | Sitapur to Varanasi | 3.1 – 18.0 |
| | Ganga | Ganga | Kannauj to Varanasi | 3.5 – 8.8 |
| | Ramganga | Ganga | Moradabad to Kannauj | 6.6 |
| | Betwa | Yamuna | Hamirpur to Wagpura | 3.5 – 4.2 |
| | Ghaghara | Ganga | Barhalganj to Deoria | 4.0 – 4.5 |
| | Rapti | Ganga | Dmnigarh to Rajghat | 4.7 – 5.9 |
| | Sai | Ganga | Unnao to Jaunpur | 4.0 – 4.5 |
| | Saryu | Ganga | Ayodhya to Elafatganj | 4.3 |
| **Bihar** | Sirsia | Ganga | Ruxol to Koirea Tola (Raxaul) | 20 |
| | Farmar | Ganga | Along Jogbani | 3.6 |
| | Ganga | Ganga | Buxar to Bhagalpur | 3.2 |
| | Punpun | Ganga | Gaurichak to Fatuha | 3.3 |
| | Ram rekha | Ganga | Harinagar to Ramnagar | 5 |
| | Sikrahna | Ganga | Along Narkatiaganj | 4.5 |
| **Jharkhand** | Garga | Damodar | Along Talmuchu | 6.2 |
| | Damodar | Damodar | Phusro rd to Turio | 3.9 |
| | Konar | Damodar | Tilaya and Konar | 3.4 – 3.6 |
| | Nalkari | Damodar | Along Patratu | 3.8 |
| **W Bengal** | Vindadhari | Ganga | Haroa Bridge to Malancha burning ghat | 26.7 - 45 |

| | | | | |
|---|---|---|---|---|
| | Mahananda | Ganga | Siliguri to Binaguri | 6.5 - 25 |
| | Churni | Ganga distributary | Santipur town to Majhadia | 10.3 – 11.3 |
| | Dwarka | Ganga | Tarapith to sadhak Bamddeb ghat | 5.6 - 17 |
| | Ganga | Ganga | Tribeni to Diamond harbour | 5.0 – 12.2 |
| | Damodar | Damodar | Durgachakm to Dishergarh | 4.4 – 8.2 |
| | Jalangi | Ganga | Laal Dighi to Krishna nagar | 8.3 |
| | Kansi | Ganga | Midnapore to Ramnagar | 9.9 |
| | Mathabhanga | Ganga | Madhupur to Gobindapur | 8.5 |
| | Barakar | Damodar | Kulti to Asansol | 5.7 |
| | Dwarakeshwar | Damodar | Along Bankura | 1 – 5.6 |
| | Mayurakshi | Ganga | Suri toDurgapur | 5.2 |
| | Rupnarayan | Damodar | Kolaghat to Benapur | 5.2 |
| | Silabati | Damodar | Ghatal to Nischindipur | 3.8 |
| **Himachal Pradesh** | Giri | Yamuna | Along Sainj | 4.4 - 6 |
| | Pabbar | Yamuna | Along Rohru | 3.6 - 4 |
| **Uttarakhand** | Bhela | Ram Ganga | Kashipur to Rajpura | 6 - 76 |
| | Dhela | RamGanga | Kashiput to Garhuwala | 12 - 80 |
| | Suswa | Ganga | Mothrowala to Raiwala | 37 |
| | Kichha | Ram Ganga | Along Kiccha | 28 |
| | Kalyani | Ram Ganga | Downstream Pantnagar | 16 |
| | Ganga | Ganga | Haridwar to Sultanpur | 6.6 |
| | Kosi | Ganga | Sultanpur to Pattikalan | 6.4 |
| | Nandour | Ganga | Along Sitarganj | 5.6 - 8 |
| | Pilkhar | Ram ganga | Along Rudrapur | 10 |

1.2.6. Clearly the river cleaning efforts in the country in place since the mid nineteen eighties have failed to deliver.

## 1.3 Unsustainable extraction of biota and other resources (ground water and sand, boulder mining)

1.3.1. It is known that there has been unsustainable extraction of living and non- living resources available in the Ganga river basin. These include fishes, turtles and other biota found in various rivers in the basin as well as groundwater and sand and

boulders that sustain the integrity of the rivers as a vibrant ecological entity round the year.

1.3.2. Dwindling flows over the years have only added to the river woes faced from extractive influences.

## 1.4. Encroachment and land use change within river-space

1.4.1. River space is defined as lands on either bank of a river that inundates during high floods and which form, as its riparian edge an integral part of the river system.

1.4.2. Flood plains as these are popularly called serve a number of ecological functions and offer number of ecosystem services.

1.4.3. Over time it has been observed that river space has been encroached, embanked and its land use converted into either agriculture in rural stretches of the river or into residential, commercial or industrial use in most of its urban stretches.

1.4.4. Such conversion of river space not only plays havoc with the integrity of a river system but also brings misery and loss of life and property to people when the river floods.

## 1.5. Absence of Appropriate Institutional Mechanism for Holistic Governance

1.5.1. It is lamentable that despite immense cultural, economic and ecological importance attached to river Ganga and its tributaries, there have been poor or little inputs made by the state to usher in appropriate and adequate Institutional mechanisms for a holistic governance of it.

1.5.2. While the Ganga Authorities Order, 2016 notified on 7 Oct 2016 remains the singular legal enactment made for the governance of river Ganga basin, it remains awfully inadequate, for being primarily pollution abatement focused in its intent, approach and implementation.

# 2.0 THE STATE's RESPONSE

## 2.1 Pollution Abatement

2.1.1. The rising pollution levels in the Ganga, in the decades after Independence [1947], brought the issue of the holy river's deteriorating health to the attention of decision makers in 1984. This led to the formulation of the Ganga Action Plan, launched by then PM Shri Rajeev Gandhi, on 14 Jan. 1986, with the main objective of pollution abatement and *inter alia* to improve the water quality by "interception, diversion and treatment of domestic sewage and present toxic and industrial chemical wastes from identified grossly polluting units entering in to the river."

2.1.2. The other objectives of the Ganga Action Plan were:

- Control of non-point pollution from agricultural runoff, human defecation, cattle wallowing and throwing of unburnt and half burnt bodies into the river.
- Research and Development to conserve the biotic, diversity of the river to augment its productivity.
- New technology of sewage treatment like Up-flow Anaerobic Sludge Blanket (UASB) and sewage treatment through afforestation has been successfully developed.
- Rehabilitation of soft-shelled turtles for pollution abatement of river have been demonstrated and found useful
- Resource recovery options like production of methane for energy generation and use of aquaculture for revenue generation have been demonstrated
- To act as trend setter for taking up similar action plans in other grossly polluted stretches in other rivers

2.1.1. The ultimate objective of the GAP was to have an approach of integrated river basin management considering the various dynamic inter-actions between abiotic and biotic eco-system."

2.1.2. Despite holistic objectives laid out in the GAP the approach was anything but holistic. In practice, a capital-technology-energy intensive approach dominated the GAP with an emphasis on sewage treatment plants. In retrospect this approach was doomed to fail for several reasons:

- Foreign donors pushed unsuitable treatment technologies
- STPs were often stranded for lack of energy
- In the absence of sewer networks plants rusted without any available influent
- Sewage load at places outstripped treatment capacity
- Non-point sources of pollution and industrial effluents remained unaddressed

2.1.3. Pollution is, however, an issue wherever there are major urban settlements on the river banks. Recent data shows that upstream and somewhat downstream of the towns water quality is often within prescribed ranges.

## 2.2 Diversion of Flow

2.2.1. It is only belatedly being recognized that the runaway water diversion from the Ganga and its tributaries has led to anaemic flows in the river, impacting several eco-system services provided by a free-flowing river. The data shows that the Ganga is being bled at almost a 1000 diversion points in its basin. And still more diversionary proposals are on the drawing boards. It is notable that addressing the issue of flow was not amongst GAP objectives in 1986.

2.2.2. On the objective of integrated river basin management there has been no movement in over 3 decades. Although, all editions of National Water Policy [1987, 2002, 2012] emphasize the need for promoting basin management of rivers the political system and the hydrocracy has shown little interest in basin level management. On the other hand, 'Master Plans' of some sub-basins have been drawn up which only assess surface water availability, the availability of water for diversion and the location of exploitative structures.

2.2.3. River basin management [RBM] is a holistic approach which cuts across several relevant sectors and addresses a host of concerned issues. Primarily, RBM balances water resources with water demand while addressing the issues of eco-system services, surface and ground water interactions, ecological flows, biodiversity, climate induced changes etc. The RBM approach demonstrates the points of intervention in governance, policy, programs, projects at various levels and within various sectors.

## 2.3 Governance Model

2.3.1. It is no secret that our inability to improve the health of river Ganga, despite best of intentions and a number of action plans in place since 1984 has to do as much with systemic shortcomings neglecting the question of flows as with the developmental model that we as a nation has adopted.

2.3.2. The key attributes of the current developmental model are:

- Centralized irrigation projects marked with high dams and canals and drastic change in cropping patterns aimed at cash crops
- Disregard and disuse of traditional water harvesting and water use systems
- Laissez faire as the norm when it comes to use of ground water

- Runaway urbanization with an almost insatiable demand for sand and gravel
- Industrialization that brooks no pollution control
- Distracting mega projects like the ILR, River front beautification projects and commercial Navigation
- Decision makers inability to see the larger picture where water is an inter connected entity not to be fragmented into the fiercely held turfs and domains of CWC, CGWB, Irrigation Departments and urban water utilities.

2.3.3. The inadequacy of our laws and policies, institutional gaps or poorly functioning institutions (for e.g. CPCB, CGWB) have facilitated the above through acts of omission or commission.

2.3.4. Another issue is that data regarding rivers is collected by Central Water Commission (CWC) the same agency which assesses projects to exploit river waters, leading to a clear conflict of interest. This data in case of River Ganga basin is also treated as a state secret inhibiting third party research, validation and informed decision-making processes

2.3.5. Crises help initiate shifts in policy, paradigm and approaches. In recent years, the increasing frequency and spread of drought and deficient rainfall has begun to impact thinking regarding the water sector in general and rivers in particular. The NITI Aayog, too, has raised the spectre of ground water exhaustion in major metropolitan areas across the country and the situation in Chennai and Shimla in the last 2 years has only advanced the onset of an era of water crisis management. Old supply side exploitative ways will no longer do, especially when there is a plethora of options becoming available on the demand side.

## 2.4 A Brief Survey of Developments Since 2014

2.4.1. In 2014 the then new Central Government renamed the Union "Ministry of Water Resources" as the Ministry of "Water Resources, River Development and Ganga Rejuvenation". A paradigm shift from the business as usual (BAU) in form of the then existing but poorly performing Ganga and Yamuna Action Plans (GAP and YAP) was called for if River Ganga was to be truly 'rejuvenated' within a reasonable time frame.

2.4.2. Soon 'Namami Gange' program with large financial outlay (Rs 20,000 Crores) was launched and its executive arm namely the National Mission for Clean Ganga (NMCG) was on 7 October, 2016, given a legal backing through 'River Ganga (Rejuvenation, Protection and Management) Authorities Order, 2016'.

***River Ganga (Rejuvenation, Protection and Management) Authorities Order, 2016***

2.4.3. River Ganga (Rejuvenation, Protection and Management) Authorities Order, 2016 (in short called the Ganga Authorities Order, 2016), conveyed the State's intent and commitment as under:

a) Rejuvenate the River Ganga to its natural and pristine condition
b) River Ganga is of unique importance and hence has received the status of a National River
c) River Ganga has been facing serious threats on account of rapid urbanization and industrialization that discharge increasing quantities of sewage, trade effluents and other pollutants into it
d) Need to meet competing demands for water of River Ganga
e) Adopting a river basin approach to promote inter-state and inter-sectoral coordination for effective abatement of pollution
f) Maintain ecological flows in the River Ganga to restore its ecological integrity that enables self-rejuvenation
g) Impose restrictions in areas abutting the River Ganga where industries, operations or processes shall not be carried out or shall be regulated

2.4.4. It defined perhaps for the first time few critical terms:

- "**Flood plain**" means such area of River Ganga or its tributaries which comes under water on either side of it due to floods corresponding to its greatest flow or with a flood of frequency once in hundred years

- **"River Bed"** means the dried portion of the area of River Ganga or its tributaries and includes the place where the River Ganga or its tributaries run its course when it fills with water and includes the land by the side of River Ganga or its tributaries which retains the water in its natural channel, when there is the greatest flow of water

- **"River Ganga"** means the entire length of six head-streams in the State of Uttarakhand namely, Rivers Alakananda, Dhauli Ganga, Nandakini, Pinder, Mandakini 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 and includes all its tributaries;

- **"Stream"** includes river, water course (whether flowing or for the time being dry), inland water (whether natural or artificial) and sub-terrain waters

- **"Tributaries of River Ganga"** means those rivers or streams which flow into River Ganga and includes Yamuna River, Son River, Mahananda River, Kosi River, Gandak River, Ghaghara River and Mahakali River and their tributaries or such

other rivers which National Council for Rejuvenation Protection and Management of River Ganga may, by notification, specify for the purposes of this Order

***Principles for Rejuvenation, Protection and Management of River Ganga***

2.4.5. It also listed Principles for the Rejuvenation, Protection and Management of River Ganga

a) River Ganga shall be managed as a single system
b) Restoration and maintenance of chemical, physical and biological quality of the waters of River Ganga shall be achieved in a time bound manner
c) River Ganga shall be managed in an ecologically sustainable manner
d) Continuity of flow in the River Ganga shall be maintained without altering the natural seasonal variations
e) Longitudinal, lateral and vertical dimensions (connectivities) of River Ganga shall be incorporated into river management processes and practices
f) Integral relationship between the surface flow and sub-surface water (ground water) shall be restored and maintained
g) Lost natural vegetation in catchment area shall be regenerated and maintained
h) Aquatic and riparian biodiversity in River Ganga Basin shall be regenerated and conserved
i) Bank of River Ganga and its flood plains shall be construction free zone to reduce pollution sources, pressures and to maintain its natural ground water recharge functions
j) Public participation to be made an integral part of processes and practices of River Ganga rejuvenation, protection and management

2.4.6. Para 5 in the Notification laid special emphasis on the maintenance of ecological flow of water in River Ganga; enjoined every State Government for ensuring the same in a time bound manner and vested the NMCG to determine the average flow of water in River Ganga for different points of River Ganga having regard to its ecology.

***National Mission for Clean Ganga (NMCG)***

2.4.7. The National Mission for Clean Ganga (NMCG) is the implementation wing of National Ganga Council which was set up in October 2016 under the River Ganga (Rejuvenation, Protection and Management) Authorities order 2016.

2.4.8. The mandate of NMCG is:

"*to take up measures and interventions for pollution abatement, sustaining ecological flow and for rejuvenation of Ganga river basin system*."

2.4.9. Presently the various ongoing activities of NMCG as on 30 April 2019 include works related to:

a) Sewage Infrastructure
b) Rural sanitation
c) Industrial pollution abatement
d) Ghats and crematoria development
e) River surface cleaning
f) Biodiversity conservation
g) Afforestation
h) Public participation

***Martyrdom of Swami Sanand (Prof. GD Agarwal)***

2.4.10. Dr. Guru Das Agrawal, aka Swami Sanand, sacrificed his life on October 11, 2018 after 112 days of fasting, seeking effective action from the Government of India, for the well-being of river Ganga. Not receiving an acceptable response, he stopped taking water on October 9th and chose martyrdom.

2.4.11. In February 2018, after waiting for almost four years for PM Modi to fulfill his election promise to rejuvenate Ma Ganga, Dr. Agrawal, now known as Swami Sanand, wrote to him asking the PM to fulfill four demands or he would fast-unto-death from June 22nd. These were:

(i) Present a comprehensive Bill in Parliament to conserve and protect River Ganga, based on a draft prepared by Ganga Mahasabha in 2012;
(ii) Cancel all under- construction and proposed HEPs in the upper reaches of the Ganga and its six headstream tributaries;
(iii) Ban river-bed sand mining in the main stem of the Ganga, particularly in the Haridwar Kumbh Mela area, and
(iv) Form an empowered autonomous Authority of capable and committed persons to ensure the Ganga's well-being.

2.4.12. The Prime Minister never responded. On September 9th, Swami Sanand announced that he would give up drinking water from October 9th, the first day of the Navratras. Negotiations thereafter with government officials, cabinet ministers and senior leaders of the BJP and RSS were unproductive.

2.4.13. In the face of the government's obstinacy the iron-willed Swami Sanand chose martyrdom hoping that it would awaken the conscience of the Government and the people of India. "I think my body will last for another six weeks. But don't worry about me. I am satisfied with what I have done and my going will only give you more strength to do what needs to be done," he told Dunu Roy and Ravi Chopra on August 24th.

2.4.14. Dr. Guru Das Agrawal remained faithful to his science and scientific in his faith till his end.

### *E- Flow Notification*

2.4.15. NMCG in the Ministry of Water Resources, River Development & Ganga Rejuvenation published on 10 October 2018 a Notification specifying:

**Table 3:Minimum environmental flows at locations in Upper Ganga River Basin Stretch**

| S No | Season | Months | Percentage of monthly average flow observed during each of preceding 10-day period |
|---|---|---|---|
| 1 | Dry | November - March | 20 |
| 2 | Lean | October, April, May | 25 |
| 3 | High Flow Season | June to September | 30*# |

*# 30% of monthly flow of High Season Flow

**Table 4: Minimum Flow releases (downstream of Barrages) in Stretch of main-stem river Ganga from Haridwar (Uttarakhand) and Unnao (Uttar Pradesh)**

| S No | Location of Barrage | Minimum Flow release immediately downstream of Barrages (cumec) in Non monsoon (Oct – May) | Minimum Flow release immediately downstream of Barrages (cumec) in Monsoon (June – Sep) |
|---|---|---|---|
| 1 | Bhimgoda | 36 | 57 |
| 2 | Bijnor | 24 | 48 |
| 3 | Narora | 24 | 48 |
| 4 | Kanpur | 24 | 48 |

2.4.16. The above said ecological flows are subject to the following, namely:

a) The compliance of minimum ecological flow is applicable to all existing, under construction and future projects
b) The existing projects which currently do not meet the norms of these environmental flows, shall comply and ensure that the desired environmental flow norms are complied within a period of three years from the date of issue of this order
c) The project which is at different stages of construction, where physical progress on ground has been initiated and made and reported to appropriate authority

shall also make necessary provisions to maintain the stipulated environmental flow before and after commissioning of the project

d) The mini and micro projects which do not alter the flow characteristics of the river or stream significantly are exempted from these environmental flows
e) To ensure the release of desired quantities of water to maintain environmental flows, flow conditions in these river reaches shall be monitored at hourly intervals from time to time
f) The Central Water Commission shall be the designated authority and the custodian of the data, and shall be responsible for the supervision, monitoring and regulation of flows, and reporting of necessary information to the appropriate authority as and when required and also authorized to take emergent decisions about the water storage norms in case of any emergency. The Central Water Commission shall submit flow monitoring cum compliance report on quarterly basis to National Mission for Clean Ganga
g) The concerned project developers or authorities shall install automatic data acquisition and data transmission facilities or required necessary infrastructure at project sites within six months from the date of this order. The installation, calibration and maintenance of flow monitoring facility shall be the responsibility of the project developers or authorities and they shall submit the data to the Central Water Commission from time to time
h) The Central government through National Mission for Clean Ganga may direct release of additional water in river Ganga to meet special demand as and when required

2.4.17. The e-flow Notification by NMCG was criticized and found to be too less too late by most commentators.

2.4.18. Later the NMCG has directed all existing hydro-projects in upper Ganga river basin in Uttarakhand to start releasing the stipulated flows in the river by December 2019 itself.

***Jal Shakti Ministry***

2.4.19. The new central government in May 2019 has created a Ministry of Jal Shakti by merging previous two ministries of Ministry of Water Resources, River Development & Ganga Rejuvenation and the Ministry of Drinking Water and Sanitation, which now form two departments within the new ministry.

2.4.20. It is hoped that now with all the water related issues under one ministry greater holistic planning and execution of policies and programs would be possible.

# 3. PONDERABLES

Some relevant issues that emerge out of the Ganga Authorities Order, 2016 (**River Ganga (Rejuvenation, Protection and Management) Authorities Order, 2016)** and even otherwise are considered here.

## 3.1 Fundamental concepts as enunciated in the Ganga Authorities Order, 2016

***Are we clear on few fundamental concepts as enunciated in the Ganga Authorities Order, 2016?***

*a) Ganga rejuvenation to its natural and pristine condition:*

- Ganga Authorities Order 2016 commits the State to rejuvenate River Ganga to its natural and pristine condition. While the objective is laudable but it would be far more useful to clearly define upfront the 'natural and pristine condition' that the State is aiming to achieve for river Ganga and in what kind of time frame?
- Is there a '**reference past**' in terms of natural and pristine condition of River Ganga?
- And in tune with the 'reference past' is there a defined '**flow condition**' all along the river that is aimed to be achieved?
- Shall we be fine with just an improvement in the '**water quality'** of River Ganga in terms of BOD and Coliform levels as measured from time to time at few locations on the main stem or move beyond in our periodic assessment of the state of health of River Ganga?
- Would we look for the presence/absence of '**iconic biodiversity species**' at locations on the main stem as well as the tributaries as an indicator of success?
- Would we aim for the return of '**local livelihoods**' that flourished on River Ganga when its condition was natural and pristine?
- Shall River Ganga's '**capacity to assimilate wastes**' as a flowing body of water acquire the importance that it deserves?

*b) Maintain ecological flows in the River Ganga to restore its ecological integrity that enables self-rejuvenation*

- It would be extremely helpful for the success of Namami Gange program to define upfront the desired flows in River Ganga main stem and all its tributaries which could be termed as their ecological flows to meet the needs of restoring its ability of self-rejuvenation. This is also a mandate given to the NMCG by Para 5 of Ganga Authorities Order, 2016.
- How shall we ensure/restore connectivities (longitudinal, lateral, vertical)?

c) *River Ganga shall be managed in an ecologically sustainable manner and as a single system*

- Terms like 'ecologically sustainable manner' and 'a single system' need better enunciation so that there is no confusion remaining as to what the State is actually aiming for.

## 3.2 Current status of the IIT Consortium Reports

3.2.1. A Consortium of 7 Indian Institute of Technology (IIT) was in 2010 given the responsibility of preparing the Ganga River Basin Management Plan (GRBMP) by the then Ministry of Environment and Forests (MoEF), GOI, New Delhi. By the year 2015, some 62 reports (https://nmcg.nic.in/Grbmpreports.aspx) relating to various aspects of the plan had been submitted by the IIT Consortium. Presumably substantial expert effort and time and public funds has been invested in the preparation of these reports. They would also be carrying useful information and recommendations that needs to be mainstreamed into the action plans of the NMCG.

3.2.2. The NMCG website presently mentions that "*The Plan is being prepared with the objectives of taking comprehensive measures for restoration of the wholesomeness of the Ganga ecosystem and improvement of its ecological health, with due regard to the issue of competing water uses in the river basin. The wholesomeness of the river can be grasped in terms of four defining concepts: "Aviral Dhara" (Continuous Flow"), "Nirmal Dhara" ("Unpolluted Flow"), Geologic Entity, and Ecological Entity*."

3.2.3. If indeed the IIT Consortium is still busy preparing the plan, then is it not time to give it a final shape after a thorough peer review and revisions if need be carried out in it?

## 3.3 Lessons learned from the Ganga and Yamuna Action Plans

***Where are the lessons if any learned from the Ganga and Yamuna Action Plans?***

3.3.1. Ganga Action Plan and Yamuna Action Plan have been in operation since 1985 and 1994 respectively. It is well recognized that these plans have for various reasons failed to meet the objectives of delivering a 'clean' Ganga. So, when a new program, namely 'Namami Gange' was launched it was to be expected that the NMCG would look for lessons and learnings from the GAP and YAP to avoid repeating the same mistakes and to build upon their achievements, if any.

3.3.2. It is not known if such an exercise has been carried out and useful lessons have been learned. Thus, while on paper, the NMCG with its mandate on Ganga River 'Rejuvenation' and Maintenance of 'Ecological Flow' is a distinct improvement over merely 'Pollution abatement' that both the Ganga and Yamuna Action Plans

talked about and tried to implement, yet in deed the flagship program 'Namami Gange' still remains overtly focused on pollution abatement and that too primarily in the River Ganga main-stem.

*Sri Paritosh Tyagi, former Chairman CPCB and perhaps the only surviving member of the original Ganga Action Plan (GAP) team listed the following as some of the lessons learned from the Ganga Action Plan (GAP) at the India Rivers Week, 2018*

-Focus was on a fragment, that is, water pollution rather than the river.
-In the absence of an uninterrupted source of power, effluent overflowed to the river.
-Cost recovery measures were not an essential component of the project.
-Building capacity for operation and maintenance of the completed facilities was not part of the project.
-There was no activity related to research on how to make the river sustainable and healthy.
-Socio-economic aspects related to the population dependent on the river were overlooked
-There was no thought given to the need for a certain quantity of flow in the river (later identified as environmental flows).
-There was no provision for dealing with pollution caused by tributaries.
-Local bodies and local authorities were not involved in the planning and implementation of the project.

## 3.4 Pollution Abatement and Relevant Bodies

***With continued emphasis on pollution abatement, how far are our existing pollution control agencies (CPCB and SPCB) up to the task?***

3.4.1. The Water (Prevention and Control of Pollution) Act 1974 created a Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCB) with the main function of the CPCB being "*to promote cleanliness of streams and well in different areas of the States*" and of the SPCB being "*to plan a comprehensive program for the prevention, control or abatement of pollution of streams and wells in the State*". (https://indiankanoon.org/doc/867156/)

3.4.2. The Central Pollution Control Board (CPCB) and the State Pollution Control Boards (SPCB) have been in place since the Water Act, 1974 at the centre and in each of

the River Ganga basin states (HP, Uttarakhand, UP, Haryana, Delhi, Rajasthan, MP, CG, JH, Bihar and West Bengal).

3.4.3. The very fact that despite the presence for almost 3 decades of these agencies, even in the year 2019, the River Ganga requires a special effort and project to 'clean' it, points to institutional failures, amongst other things and calls for a review followed by either strengthening or complete makeover of these institutions.

In this context it is a matter of record that a proposal for the creation of a National Environment Protection Authority (NEPA) was mooted in 2009 whereby the roles and effectiveness of both CPCB and SPCBs was reviewed and few options were suggested. NEPA was projected to be a statutory authority created by an act of the Parliament and made autonomous to remain effective. (https://www.indiawaterportal.org/sites/indiawaterportal.org/files/NEPA%20-%20Discussion%20Paper.pdf)

While nothing came out of that exercise, there is no reason why a review of the functioning of both CPCB and SPCBs is still not in place to empower and make them deliver on their respective mandates.

## 3.5 Primacy of Flow in River Ganga

***How serious are we to the primacy of Flow in the River Ganga?***

3.5.1. Flow is central as it is true of any other river to the existence of river Ganga. At least three 'Principles' in Ganga Authorities Order, 2016 allude to the requirement of 'Flow' in River Ganga. Para 5 mandates the State on the maintenance of ecological flow of water in river Ganga.

3.5.2. **Flow in river Ganga or in any other river is not a static but a dynamic entity**. It varies over seasons, months, days and even within the period of a day. This has happened over centuries and resultantly the biota (plants and animals) associated with it has adapted itself to this dynamic pattern. Stream flow data of Ganga basin is treated as classified by Govt. of India. (https://www.ceh.ac.uk/sites/default/files/Future%20Ganga%20Workshop%20-%20Sharad%20Jain%20-%20NIH.pdf)

3.5.3. Despite data secrecy it is common knowledge that over the course of a year the flow in river Ganga varies from a couple of thousand cusecs at Haridwar in lean period to over several lakh cusecs during the monsoon months.

> "At the town of Hardwar, and at the Kharra Head, where the Ganga and Jumna leave the mountains and issue into the plains, the dry weather discharge may be estimated at 8,000 and 4,000 cubic feet per second respectively; in seasons of extraordinary drought, this has been diminished, but as a fair average of the amount of discharge during ordinary dry seasons, the above may be accepted with every confidence in its trustworthiness."[5]

3.5.4. It is well known that in river Yamuna very high flows were recorded during the floods in June, 2013. "Haryana Irrigation Minister H.S. Chattha said Monday that there has been an "unprecedented discharge of 8.06 lakh cusecs in river Yamuna, which has never been received so far in a month of June". **This kind of extreme variation in the flow within Ganga basin is its natural character and maintenance of such flow dynamics shall be necessary for a rejuvenated river Ganga.**

3.5.5. ***Flow belongs to the river.*** Flow is what makes a river and distinguishes it from all other forms of water bodies. When the flow or a part of it is obstructed and diverted away from the river course, the ability of the river to fulfill its various natural functions gets compromised. In other words, the river no longer remains healthy. In recent times, the ill- effects of massive diversion of waters away from river channels have been seen with rivers running dry or near dry in significant stretches. This has led to an emerging concern to maintain 'minimum ecological flows' which basically amounts to striking a compromise between human water needs as well those of river health and eco-system function.

3.5.6. Environmentalists now recognize that arbitrary 'minimum' flow of rivers is inadequate as the structure and function of a river ecosystem and adaptations of dependent biota are dictated by patterns of temporal variation in river flows.

3.5.7. ***Flow is a major determinant of physical habitat in rivers.*** The complex interaction between flow and the physical habitat governs the distribution, abundance and diversity of the stream and river organisms. It flushes and replenishes the sediments. Flow regime changes lead to habitat alterations, changes in species distribution and abundance and loss of native biodiversity. The biological communities of fluvial ecosystems are assembled from the organisms

that are adapted to regional conditions, including the physical environment and food resources, and are further refined through interactions with other species. Biological assemblages with a mix of diverse species are expected to carry out various ecosystem functions.

3.5.8. A term which has gained currency is called as E-flow. Short for Environmental Flow, E-flow concept has been under discussion and development since the 1990s and the Brisbane Declaration (2007) defines it as "the quantity and quality and timing of water flows required to sustain freshwater ecosystems and the human livelihoods and well-being that depend on these ecosystems."

3.5.9. It is notable that the E Flows perspective is an attempt to find solution to problems subsequent to their creation. Thinking of approaches to prevent the problems from arising is very rare. As Iyer (2005) puts it, we should ask the question, "**How much water can be extracted /diverted without affecting the ecology / environment downstream?"**[6]

3.5.10. One way of looking at the question of maintaining requisite flows in river Ganga is by emphasizing on the demand side rather than supply side management of water withdrawn from the river system. This shall mark a change in approach, where water is allowed to be diverted from the rivers in the Ganga basin is to meet essential water needs and no more. This could be achieved through greater water use efficiencies in agriculture, industry and domestic consumption as well as recycle and reuse of treated grey water created out of diverted river water to meet needs such as irrigation, industries and non-consumptive domestic needs. Accordingly, a '**Diversion Threshold**' which ensures that environmental functions of rivers in Ganga basin are not allowed to be compromised are first set for each of its major tributaries at major diversion points and rules and regulations are put in place to achieve the said goal.

3.5.11. This river first approach shall correspond roughly with Richter (2010) proposal of a 'Sustainability Boundary Approach' as well as Iyer (2005) very valid comment.

3.5.12. ***Ganga is sum total of its tributaries.*** Flow in river Ganga is the sum total of all that is contributed by its tributaries, big and small spread over its basin. Rain and sub surface flows are the main sources of river discharge, with a limited contribution from the meltwater of the Gangotri Glacier at the source of the river. The discharge along the river demonstrates a step wise increment due to the contribution of the major tributaries draining different parts of the basin. The large contributions are from the Yamuna, Ghaghara, Kosi, Gandak, Son and Gomati rivers.

3.5.13. Two official agencies which have a critical role in the maintenance of flow in our rivers including River Ganga are the Central Water Commission (CWC) and the Central Ground Water Board (CGWB) in the Union ministry of Water Resources (since renamed Ministry of Jal Shakti). The fact that majority of rivers in the country have today become anemic, with the India Rivers Week, 2016 finding that almost 70% of rivers are dying, it reflects poorly on the two agencies.

3.5.14. It is no surprise that in 2016, the then Ministry of Water Resources, River Development and Ganga Rejuvenation commissioned (Mihir Shah Committee) a report to look into the restructuring of both CWC and the CGWB. The said report titled 'A 21st Century Institutional Architecture for India's Water Reforms' has made detailed recommendations including creation of an apex body called the National Water Commission (NWC) which shall include both CWC and CGWB within it for better integration. http://mowr.gov.in/sites/default/files/Report_on_Restructuring_CWC_CGWB_0.pdf

**RESTORING FLOWS**

Manu Bhatnagar, INTACH

So far river conservation has focused on river pollution with its visible impacts, foul odours and colors, a spike in water borne diseases, contaminated surface and groundwater. These aspects readily grab media attention and excite public concern. Success in pollution control has become a yardstick of governance. Pollution, however, is a technical issue, one which has complexities but is amenable to known technical solutions and responsive to heavy capital outlays.

However, the far greater challenge is that of restoring a modicum of flow to anaemic rivers. Ultimately, it is the flow which gives life to the river and connected aquifers. The recovery of flows is dependent on successful adoption of basin level management.

Several countries are far ahead of India in the practice of basin management. India's several National Water Policies have all laid stress on the need for river basin management. In practice not a single basin plan has been made other than several masterplans whose only objective is to establish the quantity of water which can be exploited from particular basins and the locations of hydrological interventions [dams and barrages] to divert river waters.

Basin management of even medium rivers is hampered by several difficulties. Interstate rivers demand cooperation between upper and lower riparians which is difficult to achieve in increasingly contested times. But most importantly rivers flow through several administrative jurisdictions and hierarchies and the basin boundaries and administrative boundaries are rarely coincident. Thus, data collection is not on basin lines but based on administrative boundaries.

In spite of the National Water Policy of 2012 advocating a basin approach for river management authorities are averse to forming basin management organizations for the probable reason that no concerned organization, departments, administrative jurisdiction or political authority is willing to subordinate itself to an overarching, community driven basin authority which will constrain them to respect the basin hydrology and ecology.

On these grounds the attempts to apply basin management approach for major rivers would appear to be a distant dream. On the other hand, basin approach has greater chance of success at the level of sub-basins such as those of minor and medium rivers especially those which flow intra-state to begin with.

The cumulative impact of basin management at tributary level would then incrementally result in the basin management of the higher order stream. Improvement in river flows in tributaries would result in enhanced flows in higher order streams.

## 3.6 Ground water – Surface water relations and dynamics in the River Ganga basin

***How well do we understand the Ground water – Surface water relations and dynamics in the River Ganga basin?***

3.6.1. Ganga Authority Order, 2016 states that "*Integral relationship between the surface flow and sub surface water (ground water) shall be restored and maintained*."

3.6.2. According to records:

a) Ground water currently meets 85% of drinking water and industrial needs and 80% of irrigation needs in River Ganga Basin
b) Out of 820 Blocks in River Ganga basin only 620 blocks are safe.
c) By 2025 it is expected that extraction of ground water would double from 27BCM to 64 BCM and number of safe blocks would be reduced to 400
d) 4 million Tube wells or 40% of country's Tube wells are located in the River Ganga basin

3.6.3. A recent[7] study has found:

- "In summer (pre-monsoon) of recent years, low water level among the last few decades has been observed in several lower Indian reaches of the Ganga (or Ganga) river (with estimated river water level depletion rates at the range of −0.5 to −38.1 cm/year between summers of 1999 and 2013 in the studied reaches).

- Here, we show this Ganga river depletion is related to groundwater base flow reduction caused by ongoing observed groundwater storage depletion in the adjoining Gangetic aquifers (Ganga basin, −0.30±0.07cm/year or −2.39±0.56 km3/year). Our estimates show, 2016-base flow amount (~1.0×106 m3/d) has reduced by ~59%, from the beginning of the irrigation pumping age of 1970s (2.4×106 m3/d) in some of the lower reaches.

- The net Ganga river water reduction could jeopardize domestic water supply, irrigation water requirements, river transport, ecology etc. of densely populated northern Indian plains. River water reduction has direct impact on food production indicating vulnerability to more than 100 million of the population residing in the region.

**Ecological Integrity of Ganga River Basin: The Importance of Groundwater and its interaction with Surface water.**

Himanshu Kulkarni and Siddharth Patil, ACWADAM

The ecological integrity of the Ganga River Basin (GRB) can be significantly improved, protected and conserved through a systematic approach to groundwater management and governance in the river basin. In doing so, one suggests the following key elements in this approach:

- Firstly, it is important to provide an increased identity to groundwater while acknowledging the unified nature of surface water and groundwater in policy. While doing so, it is equally important to acknowledge the potential role that participatory groundwater management and governance will play through an increasing recognition of citizens' role and action at different scales.
- Much of the understanding of water in the GRB is at regional scales and inferences in practice and policy are drawn on the basis of regional findings. The complex interplay of social and hydrological dynamics makes it essential to aggregating an understanding of integrated water from local scales to sub-basin to basin levels to demystify these complexities.
- The almost central significance of base flows in the context of E-flows in the GRB is compelling enough to develop a deeper understanding of the relationship between recharge, groundwater storage and base flows. 'Base flows', therefore, must become more central to both research and development program themes in the GRB.
- An eco-system approach to aquifer management can be adopted for the GRB, keeping the balance between livelihoods and ecosystem in mind. Such an approach will also be fruitful in developing a participatory form of water governance in the region. Hence, E-flows could become a more central indicator of the effectiveness of integrated water management of surface and groundwater in the GRB.
- Shallow unconfined aquifers have gone into a state of great disrepair almost throughout the GRB. Reviving and protecting these shallow unconfined aquifers is most significant to maintaining and reviving base flows, which in turn, will help in rejuvenating the GRB in general and the Ganga in particular.
- Water laws coherent with aquifers as common pool that are governed through community-level, decentralized governance must become central to the theme of protecting and conserving the integrity of surface water and groundwater in the GRB, an approach that will not only ensure ecological integrity of the GRB but will also hold potential in the management of other river basins in India.

## 3.7 Floods and Sediments movement in River Ganga basin

***Do we understand floods and sediments movement in River Ganga basin well enough?***

3.7.1. Annual flooding is characteristic of all rivers in the Ganga plain. The Ganga River rises during the wet monsoon but usually its high banks restrict the floodwater from spreading. Overtopping and lateral spreading occur only in certain areas. Water moves into active floodplain also through gullies cut through the levees (bunds) of the river. The floodplain is usually .5 – 2 km wide, sloping gently away from the levees and ending against a step, several meters high, leading to the next alluvial surface. This active floodplain surface is flooded almost on a yearly basis, the rise in stage varying between 2 and 8 m along the river[8]. **Amongst other things one of the key roles of floods is to transport sediments, large and small, down the river course. River Ganga and its tributaries are known to erode as well as deposit sediments on its banks.**

**3.7.2.** The river Ganga receives sediments from the Himalaya as well as the Peninsular region. River Kosi, one of the largest tributaries of the Ganga, carries second highest load of silt and sediments in the world (172 million tonnes; 2774 tonnes/ km2) after the River Huang Ho (1887 million tonnes; 2804 tonnes/km2). The total measured flow of suspended sediment in the tributaries to the Ganga River is 488 × 106 t/ yr, while the quantity of sediment moving in the Ganga at Farakka is 729 × 106 t/yr, of which 328 × 106 t/yr is transported down the Hooghly river. More than 90% 0f the river sediment is deposited on floodplains and in the basin and the remainders are carried to the delta. In the active channel, sedimentation forms mid-channel bars, side sand bars deposits of different size and floodplains[9].

3.7.3. The river receives high sediment load from Ghaghara, Gandak and Sone rivers in and around Patna through floods. Floods play important roles in river ecology especially in tropical rivers. They import energy, matter and biota from the catchment landscapes to the river and creates new, high quality habitats. Floods also help in longitudinal, lateral and vertical connectivity essential for maintaining the ecological health of river. The annual floods flush out most of the pollutants from the river and save the rivers from eutrophication[9].

3.7.4. Rivers have traditionally been a source of boulder and sand to meet local requirements as construction material. These were removed manually and transported using animal (bullock carts or ponies) power. The adverse impact on the rivers of this removal was more than compensated by fresh transport and deposition by the rivers of fresh boulder and sand during the next monsoon high flows.

3.7.5. In recent times technological advancement specially in form of bulldozers, earth movers and tractors, construction of dams and barrages (which inhibit movement downstream of boulders and sand) and widespread real estate constructions have combined to take a heavy toll on the boulders and sand present in rivers and depleted them beyond recovery in many stretches. The adverse impacts of such **unsustainable boulder and sand removal from rivers** is on river biodiversity, bank stability as well as its ability to recharge ground water or maintain base flows in rivers during the lean season**.** Sand and boulder mining has also over time emerged as a 'low risk, low investment and high profit' enterprise resulting in formation of mafias and crime syndicates.

**Sediment Management of The Himalayan Rivers: A Challenge for River Managers**

Rajiv Sinha, Department of Earth Sciences, Indian Institute of Technology, Kanpur (CURRENT SCIENCE Volume 115 Number 3, 10 August 2018)

A long-term sediment management strategy has never been a part of any protocol of river management, not just in India, but in several other parts of the world. A nation like India hosting several large rivers originating in the Himalaya, the world's highest and most active mountain belt and hence a huge sediment production factory, needs a sediment management framework more than any other country.

As an example of the first-order sediment budgeting, data from the Kosi river, one of the most sediment charged tributaries of the Ganga draining through Nepal and north Bihar, may be illustrative. Our estimates suggest that the total mass of sediments accumulated between Chatra and Birpur (reach upstream of the barrage) during the last 54 years (post-embankment period) is ~1082 million tonnes, which translates to 408 million m3 in volume of sediments accumulated at a rate of 5.33 cm/yr. This is attributed to the relatively smaller area of sediment accommodation within the channel belt, i.e. ~142 km2 between the two stations. Between Birpur and Baltara (reach downstream of the barrage), the available depositional area is almost five times that between the Chatra and Birpur stretch. As a result, sedimentation rate in this stretch is lower (2.83 cm/yr), but the total sediment accumulation is very high, ~2053 million tonnes, that translates to 774 million m3 of sediments. Similar estimates are urgently needed for the Ganga and all its major tributaries.

It is amply clear that sediment management must form an important component of management strategies for the Himalayan rivers. The Ministry of Water Resources, River Development and Ganga Rejuvenation, New Delhi has recently circulated a draft policy on sediment management. The draft policy document has put forward several important suggestions and has also proposed a set of useful guidelines, which if implemented, can bring phenomenal change in the health of the rivers. However, the policy is heavily tilted towards promoting navigation rather than focusing on improving river health, so much so that the navigation requirements can overrule several guidelines. Instead, sediment management plans must be based on a strong understanding of sediment dynamics aimed at improving river health for which detailed studies may have to be initiated, wherever needed.

Sediment management plans should also be linked to river health assessment and habitat suitability. Several planform characteristics define the ecological habitats, including longitudinal connectivity in the river that is severely affected by excessive aggradation. Also, several tributaries of the Ganga are trans-boundary rivers, and therefore, it is important to engage Nepal and Tibet in designing long term sediment management strategies, particularly those related to soil erosion and mass wasting processes in the hinterland which are major sources of sediment flux in the river.

## 3.8 Protecting the flood plains in River Ganga basin

***How well are we protecting the flood plains in River Ganga basin?***

3.8.1. One of the 'Principles' in Ganga Authorities Order, 2016 states "*Bank of River Ganga and its flood plains shall be construction free zone……"*

3.8.2. The importance and extremely critical role of floodplains in the well-being of rivers has been well described by Mussared (1997)[10] as under:

*"Floodplains are as important to rivers as bark is to trees. Most of the processes that drive life in rivers happen around their edges. Just as the sap flows through the outermost ring of a tree, not through its centre, the life blood of river ebbs and flows on its floodplains. The vegetation growing there isn't mere decoration; it's a river's roots and leaves."*

3.8.3. The role of floodplains in the life of river has been well described in an NGT Expert Committee (Babu Committee) report submitted in OA No 6 of 2012 and 300 of 2013. It goes on to say:

The floodplains play a critical role in determining the ecological characteristics of a river and provide many ecosystem services. They form a crucial link between the adjacent upland and terrestrial habitats and the river. The major and most important functions of floodplains include:

a) Moderation of flood peaks through temporary retention of water and spread of water
b) Enhancement of groundwater recharge in larger area and improvement of ground water quality
c) Stabilization of banks by the vegetation and maintaining channel form
d) Maintenance of high biodiversity and high production of natural resources
e) Provision for fresh sediment with high fertility
f) Filtering sediments, chemicals and nutrients from upslope sources and thereby improving the water quality
g) Maintenance of good stream habitats for fish (and other wildlife also)
h) Provide space for ox bow lakes and relict river channels that constitute important biodiversity habitats

3.8.4. Clearly floodplains constitute an extremely important part of rivers and their protection against construction and land use change is critical for the health of River Ganga**.**

3.8.5. A move to notify a River Regulation Zone (RRZ) on the lines of Coastal Regulation Zone (CRZ) was first initiated in 2002. This was to undertake zonation within river's floodplains so that activities within the floodplains could be legally prohibited or regulated. After a snail's pace progress, the move got a fillip in 2011 during Shri Jairam Ramesh's tenure as Environment Minister to soon lose traction again once he was shifted out of the MoEF. Yet again, in 2014, when Sri Prakash Javadekar became the Environment Minister, he was persuaded to take up the issue. A draft was prepared again with the active assistance of Prof. Brij Gopal and it was circulated to all the state governments for their views. But the move went no further soonest Sri Javadekar was shifted to another ministry. The nationwide River Regulation Zone (RRZ) still remains a pipe dream.

3.8.6. There is nothing on record to suggest that the NMCG has issued any instructions to Ganga river basin states regarding prohibitions on flood plain constructions as provided under Ganga Authorities Order, 2016.

## 3.9 Baseline data on the Biodiversity in the River Ganga basin

***Do we possess a good baseline data on the Biodiversity in the River Ganga basin against which improvements in river health could be assessed?***

3.9.1. In Indian sub-continent, the Ganga River ecosystem supports 25,000 or more species ranging from micro-organisms to mammals….[11]

3.9.2. According to Prof Sinha (2014) an Integrated Research Programme was initiated in 1985 under the Ganga Action Plan by 14 universities mostly located along the Ganga almost in the entire river length from Srinagar (Garhwal) to Sagar Island at selected sampling locations during 1985-88.

3.9.3. Patna University continued study on the faunal diversity in general and the Ganga River dolphin in particular in the Ganga river systems in Nepal and India and in the Ganga in Bihar stretch and other tributaries. The Central Inland Fisheries Research Institute (CIFRI) undertook an exploratory survey of the River Ganga simultaneously at 43 centres from Tehri in the Himalaya to Kakdwip near Sagar Island during 1995-96 in order to collect holistic information on the status of its environment and fishery.[9]

**GANGA FAUNAL BIODIVERSITY IN THE HIMALAYAN ZONE – Mahseer as a case in point**

Prakash Nautiyal, H. N. B. Garhwal University, Srinagar, Uttarakhand

The Himalayan Mahseer resides migrates in the mountainous tract of the Ganga river system utilizing selected spring fed tributaries for spawning. Mahseer migrate upstream of the Ganga in foothills to spawn and these tributaries are the nurseries for the juveniles. This is an elaborate migration because it utilizes/needs this period (February to June) to produce viable sperm and ova, especially latter.

Since last century mahseer Gangetic stock has declined, adversely impacting its fishery. What was stated for Doon in 1871 "…breeding fishes are destroyed in great numbers and the small fries also captured…" is true even today.

Two main constraints natural and created are responsible for the decline of mahseer. Slow growth rate, hence delay in sexual maturity, low fecundity, demersal eggs, long hatching periods, habitat destruction due to barrage and dams along with overexploitation act synergistically to impact recruitment process of mahseer stocks. Consequently, the age group 0+ to 4+ constitute 90% of total population at present time. A population composed wholly of pre reproductive adolescents and oldsters too feeble to breed will not increase at all in the near future.

The mountain tract has a very specialized biota adapted to living in torrents. Even single celled algae have mechanism (mucilaginous stalks) to maintain themselves in fast flowing rivers. The invertebrates too have a diversity of adaptations. The fish fauna of torrential glacier fed rivers have adhesive pads of varying shape and size and are specialized to live only in 'cold waters'. Some of these are important to capture fishery (snow trout and mahseer species) and hence form a source of livelihood to many living close to the river. *Tor putitora* also has recreational and religious value. *Barilius bendelisis*, *Glpytothorax sp*., and loaches are suitable for aquaria trade. The producer community in these rivers are dominated by diatoms and contribute to grazing chain. The macro invertebrate community largely contributes to both grazing and detritus chain as primary consumers. Both diatoms and macro-invertebrates are of great value in bio-assessment as they are good indicators of the water pollution. Various indices are being used for water quality assessment, especially the rivers on which hydropower has developed.

## 3.10 Afforestation along River Ganga

***Are we on the right track while attempting Afforestation along River Ganga?***

3.10.1. 'Principles' in Ganga Authorities Order 2016 states that:
"*Lost natural vegetation in catchment area shall be regenerated and maintained*"

3.10.2. NMCG currently supports forestry interventions for Ganga at project cost of Rs 2300 crores as per the Detailed Project Report (DPR) prepared by Forest Research Institute, Dehradun for a period of 5 years (2016-2021) (https://nmcg.nic.in/NamamiGanga.aspx#) .

3.10.3. The DPR for Forestry Interventions for Ganga planned to be executed over a 'riverscape' states:

- **Vision**: "Biodiversity of river Ganga ecosystem is valued, conserved, restored and wisely used while ensuring ecological integrity, maintaining ecosystem services and healthy river (aviral dhara and nirmal dhara) and delivering benefits for all life forms."
- **Objectives:**

a) Promote community driven sustainable land and ecosystem management of the riverscape while improving and maintaining the forest / vegetation cover in the buffer zone along the course of river Ganga and its tributaries
b) Protection and conservation of the representative biodiversity of the Ganga riverscape
c) Promote and support livelihood opportunities for local communities
d) Adopt, integrate and implement innovative approaches and modern technology for rejuvenation of Ganga and its tributaries, knowledge management, enhanced capacity and monitoring and evaluation

3.10.4. The Ganga riverscape for the purpose of the DPR has been defined as the entire catchment of Bhagirathi, Alaknanda and Ganga sub basins in the state of Uttarakhand and a 5 km buffer around either side of the bank lines of Ganga stem from Haridwar to Ganga Sagar. In addition, the riverscape also included a 2 km buffer on either side of different tributaries of river Ganga except the river Yamuna and its tributaries.

3.10.5. The DPR claims that the 'consideration of 5 km and 2 km buffer was achieved based on scientific insight and extensive consultation.' While mention is made of consultations held, there is little in terms of scientific basis for arriving at the extent of 'riverscape' except that a consensus suggested this during consultations? **How could a fixed distance be scientifically derived at for a system as**

**complex as a river and for the varying orders, sizes and dimensions of its tributaries?**

3.10.6. While the DPR claims resort to good science and extensive consultation it remains to be seen whether the approach and action plan taken up under it delivers the results as per its objectives or not? And whether the approach as taken requires reconsideration?

## 3.11 Impacts on River of dams, barrages, embankments and pseudo bridges in River Ganga basin

***Are we underestimating the adverse impacts of dams, barrages, embankments and pseudo bridges in River Ganga basin on the health of River Ganga?***

3.11.1. According to Water Resources Information System (WRIS) there are some 795 dams and 181 barrages/weirs on different rivers in the Ganga basin. (**Map 1**). Thus, the rivers in Ganga basin are replete with dams and barrages which have destroyed both their longitudinal and lateral connectivities. Embankments along rivers in several regions (Bihar in particular) in the basin and pseudo bridges with their approach roads raised as cross embankments in many rivers have also played havoc with the integrity of river space transforming the nature of floods and increasing later's ferocity.

3.11.2. Most of these dams have been designed to impound water during the monsoon months and release water into canals during the lean season. Since the monsoon rains are the life and blood of Indian rivers, the adverse impact of this impoundment on the health of the streams especially in the downstream of the dams cannot be insignificant.

3.11.3. It is a matter of concern that despite the ill effects of existing dams having become apparent with expert reports (Ravi Chopra Committee report) highlighting their impacts the state continues to push forward new dams. There are also many old dams/barrages that are either past their productive life or become useless due to high siltation, there is no talk of their decommissioning, something which is fast catching up in many other countries like the USA and those in the European Union.

3.11.4. It is also a fact that a sharp reduction in monsoonal and non-monsoon period flows in our rivers is a direct result of flow diversions at various dams and barrages.

3.11.5. Flow regulation has affected hydrology of Ganga basin. Due to diversions for irrigation, downstream flows are considerably reduced in lean season. Intense ground water pumping is lowering water tables in the basin which is contributing to reduced lean season flows. Vertical fragmentation of habitat and ecosystems

due to dams is also affecting aquatic species in river as well as riverine and riparian ecology[12].

***While there are mentions of these negative impacts it is not known if any effort is underway to mitigate them?***

3.11.6. Due to intensive river engineering and increasing demand of water as a resource, the ecological status of rivers worldwide is decreasing at a much faster pace than that of most terrestrial ecosystems[13].

3.11.7. A modeling study in the Upper Ganga Basin (UGB) which is perhaps the first attempt to analyze the impacts of water infrastructure development by comparing flow changes under natural and present (post damming) conditions found that on average, annual flows at present are 2-8% lower than under naturalized conditions. Higher flow reduction in the dry season (up to 70% in February) is detected, compared to just a small percentage change in the wet season. Therefore, various dams and barrages constructed to date have reduced mainly the flows during the dry season – when irrigation water demands are the highest. Flow regulation through dams and barrages has also changed the timing of annual extreme water conditions such as the date of minimum and maximum flows. The change in the timing of the minimum flow date is, however, affected more than the maximum flows[14].

3.11.8. It may be noted that there are far more structures on streams in the Lower Ganga Basin (LGB) - these originating from Rajasthan, MP and CG - with absence of the benefit of any glacial melt accruing to them. Obviously, the adverse impact of those structures on the health of those streams and ultimately the River Ganga cannot be small.

## 3.12 River health monitoring methods

***How far are the current river health monitoring methods and results true to the actual state of the River Ganga?***

3.12.1. It is the Central Pollution Control Board and the State Pollution Control Boards which are currently responsible for monitoring the state of health of River Ganga. Often Central Water Commission (CWC) also publishes its findings regarding water quality in rivers.

***Water Quality assessment***

3.12.2. Assessment of water quality in rivers against set standards for identified parameters is the method that is followed.

3.12.3. "In order to assess water quality of river Ganga, the Central Pollution Control Board has set up 57 water quality monitoring stations on the main stem of river Ganga, in association with State Pollution Control Boards of Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal". (http://cpcb.nic.in/wqm/pollution-assessment-ganga-2013.pdf)

3.12.4. "The core water quality parameters studied are temperature, pH, conductivity, dissolved oxygen (DO), biochemical oxygen demand (BOD), nitrate, nitrite, total coliforms (TC), and faecal coliforms (FC). Besides, several other location-specific parameters are also studied". (http://cpcb.nic.in/wqm/pollution-assessment-ganga-2013.pdf).

***Biological Testing***

3.12.5. CPCB for the first time has initiated what is called as the Biological testing of River Ganga. "Biological testing of River Ganga was initiated in April, 2017 and completed in June, 2017 at 44 RTWQM locations (Pre-monsoon phase)". (http://cpcb.nic.in/uploads/healthreports/Biological-Water-Quality-Assessment-2018.pdf)

3.12.6. "Bio-monitoring is the biological surveillance of benthic macro-invertebrate (BMI) communities dwelling in freshwater bodies. Benthic macro-invertebrates are of particular interest because they are a diverse group of long-lived, sedentary species that react strongly and often, predictably to changes in water quality. Taxonomic richness (Diversity Score) and composition (Saprobic Score) characterization of benthic macro-invertebrate communities is an effective method for assessing biological health of aquatic ecosystems.

3.12.7. The sampling process has been standardized according to the nature of substratum. In Uttarakhand stretch benthic macro-invertebrate sampling involved lifting and brushing of stones. In sandy river bed of Uttar Pradesh stretch net or sieve was placed firmly on river bed against river current and animals were collected into net or sieve after washing. In Bihar and West Bengal, where river bed consists of mud and silt, 5 grab samples were picked up by the shovel and samples were washed in sieve by river water and animals were picked up by forceps into tray. Unidentified specimens were preserved in formalin (4%) and brought to the laboratory for further identification.
http://cpcb.nic.in/uploads/healthreports/Biological-Water-Quality-Assessment-2018.pdf

3.12.8. It may be noted that these tests are presently carried out only on locations on the River Ganga main stem. While the assessment of water quality and biological testing at predefined locations on River Ganga main-stem is welcome, but whether

it is enough to establish the true state of health of river Ganga remains a moot point. **So, while there might or not be an improvement in water quality against identified parameter's standards whether these standards truly represent natural and pristine conditions of River Ganga remains debatable?**

3.12.9. Clearly simply testing for traditional water and biological parameters shall not be enough to establish the true state of health of River Ganga for as can be seen that **newer threats** keep emerging which need to be assessed and guarded against too.

**Un-segregated waste disposal: an alarming threat of antimicrobials in surface and ground water sources in Delhi.**
Velpandian et al, 2018 reports that:

"Metallo-β-lactamase (NDM-1) also known as "super bug" is considered as a major health concern due to its capability of hydrolyzing a wide range of β-lactam antibiotics, making them ineffective in life threatening infections. The link between emergence of resistance and environmental factors are unknown. Hereby, we report a major environmental concern caused by the leaching antibiotics and other compounds from the landfill in Delhi into hydrologic cycle. When the water samples from 48 places including surface (River Yamuna) and aquifers within 40 km in Delhi were subjected for the analysis for the presence of 24 antibiotics (against bacteria, fungi and protozoa) along with 4 other commonly used Active Pharmaceutical Compounds (APCs), this study revealed that aquifers are extensively affected by these compounds to the levels >0.01µg/L. Geographical plot of aquifers with higher levels of APCs attributed to a 30 year old un-segregated landfill mountain. Leachate from this landfill with higher levels of APCs was found to drain continuously into surface waters. We further reveal that apart from therapeutic usage, the main source of ecological exposure could be due to the disposal of unused and expired APCs into landfills. It is a matter of serious concern in terms of multi-drug resistance and might create irreparable damage to the ecological system. This study warrants the enforcement of regulations for the disposal of unused /expired APCs in high density population areas."

***Are effluent standards as notified by CPCB enough monitoring tool to measure river health?***

3.12.10. An important point of view is that river monitoring needs be based on stream standards (standards for the receiving waters) instead of effluent standards. According to Prof. Brij Gopal the term 'Nirmal' has no defined parameters as the river water quality changes along its course as a rule. What is needed is to assess the self-assimilation capacity of River Ganga. That too is not unlimited, and hence waste discharge must be regulated in its quantity and quality to the extent that the river can assimilate those wastes.

3.12.11. **Standard Effluent** is the standard of effluent that a given wastewater treatment plant (WWTP) needs to produce based on a set maximum inlet load in terms of Flow, BOD, SS (Suspended Solids) & Ammonia (NH4), Nitrate (NO3), Nitrite (NO2), Total Nitrogen (TN), Orthophosphate (OP) and Total Phosphate (TP) if specified. The outlet effluent parameters are set relative to the influent parameters.

3.12.12. **Stream standard** is the standard of the water in a particular water course to which a sewage treatment plant is discharging into. If a stream standard exists the Effluent standard for a particular WWTP is set by working back from the Stream standard. For example, if a water course is used for drinking water, bathing or as a fishery, the stream standard and thus the effluent standard discharging into that stream will be set relatively high and will probably include low BOD/SS and NH4/TN/TP concentrations. However, if a watercourse can provide significant dilution/biodegradation then the stream standard can be set lower, thus resulting in a lower effluent standard.

3.12.13. The stream standard is often set relative to the 'assimilative capacity' of a watercourse. This means how much dilution/biodegradation it can provide before pollution such as Oxygen stripping or eutrophication results.

3.12.14. **It is thus the self-assimilation capacity of River Ganga that should be monitored as indicator of river health/ecological integrity and not simply the water quality against standards of few pre-defined parameters, which is of little use or relevance by itself.** Whenever, inflow of wastes exceeds the assimilation capacity, the river is polluted. This could then be measured in terms of the length of river stretch through which the water quality has been restored to the level before the entry of waste water. As a result, the absence/presence of 'dilution flow' which is critical for the river's self-rejuvenation capacity shall emerge as the key element to monitor than just the quality of water.

## 3.13 Impacts of Classifying Data on River Ganga Basin

***Are we aware that water data secrecy on River Ganga basin is hampering better and accurate research and planning and leading to poorly informed decision making?***

3.13.1. Internationally, access to information has been recognized as a fundamental human right that is critical to good governance, participation, and democratic deliberation. …In recent years, the need for greater transparency and access to information specifically on water, climate and environmental issues has also been internationally recognized. Principle 10 of the Rio Declaration on Environment and Development 1992, advocates for greater citizen access to information on environmental issues at a national level, and greater civic participation in decision-making processes.
https://www.indiawaterportal.org/sites/indiawaterportal.org/files/water_and_climate_data_in_the_Ganga_basin_water_alternatives_2015.pdf

3.13.2. Apart from the general paucity of hydrological and water resources studies with fine spatial resolution in the Ganga Basin, the inherent problem of this basin is the availability of observed discharge data, against which models can be calibrated and validated. Discharge data in the Himalayan part of the basin are scarce due to lack of measurement stations. In the downstream plains, although discharge data from gauging stations exist, these data are not accessible to the public due to national security laws in India. This leaves most of the hydrology studies of the Ganga, which are carried out by the government agencies, being classified and not accessible in the public domain. In addition, simulated data are also not widely shared, hence impeding their use in subsequent water resource applications.
http://www.hydrology.nl/images/docs/alg/2012.01_Impacts_water_infrastructure_climate_change_hydrology_Upper_Ganga.pdf

3.13.3. Over the years, there has been needless secrecy in access to water data for researchers and stakeholders, which has meant that the quality of water management has suffered, and conflicts have been exacerbated[15].
http://mowr.gov.in/sites/default/files/Report_on_Restructuring_CWC_CGWB_0.pdf

3.13.4. River Ganga is mainly a tri-nation river with Nepal (13% basin area) being the upper riparian nation and Bangladesh (4% basin area) the lower riparian as compared to India (79% basin area) which holds the largest chunk of the river basin. It may be mentioned that a small chunk (4%) of Ganga basin also lies within China [Tibet] [16].

3.13.5. The only reason why an upper riparian state might wish to withhold river data from free public access is to presumably prevent the lower riparian from contesting the construction of any structure which might be under planning or under construction by an upper riparian fearing further retention, diversion and loss of river water due to the latter.

3.13.6. The current ground reality is that almost the entire water that does reach the delta is primarily that which enters river Ganga in its middle stretch originating either from Nepal or from the southern tributaries of river Ganga from the states of MP and CG. This is because resulting from flow diversions from existing structures like dams and barrages already standing on river Ganga and Yamuna there is hardly any water that is reaching the middle stretch of the river sourced from its upper stretch in the states of Haryana or UP. Thus, there does not seem any need any longer to maintain secrecy regarding river flow data pertaining to its upper stretch.

3.13.7. Secondly now every major southern river (Chambal, Sindh, Betwa and Sone) originating from the state of MP and CG is also already dammed more than once and hence there is no sense anymore to withhold river flow data pertaining to these southern tributaries as well.

3.13.8. As regards river data pertaining to rivers in the north that originate from Nepal, since there is no scope of any new structure on them within India's borders there is no reason why India should be maintaining data secrecy regarding those rivers.

3.13.9. As regards the tributaries that originate within Jharkhand in particular the river Damodar basin, its secrecy makes no sense since Damodar meets river Ganga much lower down the main stem which has no connection with the lower riparian state?

**What about smaller rivers?**
Manu Bhatnagar

Major rivers are regularly making the news and receiving some attention from official circles although their data is scarcely available in the public domain. On the other hand, the plight of medium and minor rivers receives little or no attention with consequent humongous data gaps – they are at the mercy of Irrigation Departments for merciless bleeding and exploitation or for callous disposal of untreated effluents.

## 3.14 Non-River Issues

***What about 'non river issues' which are critical to the rejuvenation of River Ganga?***

3.14.1. The problems of river ecosystem degradation caused by improper management of land use, loss of floodplains due to embankments, clearing of riparian vegetation, discharge of domestic and industrial wastes without effective treatment, and introduced exotic species (Plants or fish) cannot be overcome by ensuring adequate flows alone[6].

3.14.2. River Ganga is the end destination, sooner or later, of the products of various human activities which takes place within its basin. And these activities are not limited just to the direct polluting influences but includes the process of urbanization, industrialization or chemical agriculture taking place within the basis.

**Understanding Land use complexities – River Hindon Sub Basin**
Manu Bhatnagar

The basin is a socio-economic-ecological-hydrological landscape. Our approach in drawing up a basin management plan for the Hindon River encompassed several relevant aspects. The first task was to draw up an accurate basin map showing the entire system of tributaries and canals and the extent of areas of different districts which fell within the basin.

Thereafter, a land use landcover mapping [over a time series] was carried out which showed the trends in land related changes. This revealed the declining forest cover [<2%] and within that the decline of the dense forest cover. The SPOT satellite images were further used to derive the sub-basin boundaries of lower order streams. Topo-sheets of Survey of India in conjunction with satellite imagery provided spot levels on the watershed line as well as the main drainage line.

Climate data showed the significant decline in rainfall over a 50 year period. Soil patterns were examined. Groundwater data of the CGWB showed the water table exploitation as 100%. The import of water from the adjacent Upper Ganga Canal was estimated. These figures helped to build the supply side picture.

On the demand side the main sector of use was irrigation and the consumption of water was estimated crop-wise district-wise for both rabi and kharif. This showed that 72% of the water in the basin was being used only for sugar cane necessitating import of water from the Ganga Canal. Other uses were comparatively modest but estimated nevertheless. Thus, district-wise domestic urban and rural water use [based on census data] and industrial use was estimated. Losses by way evaporation, groundwater and soil moisture, surface runoff were estimated.

On the socio-economic side a significant portion of the basin population was involved in sugar cane production and related industries. There is serious overproduction of sugarcane beyond the crushing capacity and paying capacity of the mills leading to annual conflict between growers and mills. There is little awareness amongst farmers about water conserving techniques or market linkages for organic products. As most of the land is privately owned the essential requirement of expanded forest and tree cover requires innovative partnerships, policies for growth of trees on private lands.

Adoption of water saving agronomic techniques and cropping patterns requires enormous campaigning, demonstration projects and supportive policies. Floodplains stand completely encroached, if not by buildings then by cultivation which has eliminated riparian vegetation and its associated habitats. Of 117 floodplain lakes visible in the 2000 satellite imagery only 38 remain on date. All these are daunting complexities but without grappling with them river conservation will not succeed. We urgently need pilots on the above line in various geographies within the country.

## Water Use in Irrigation

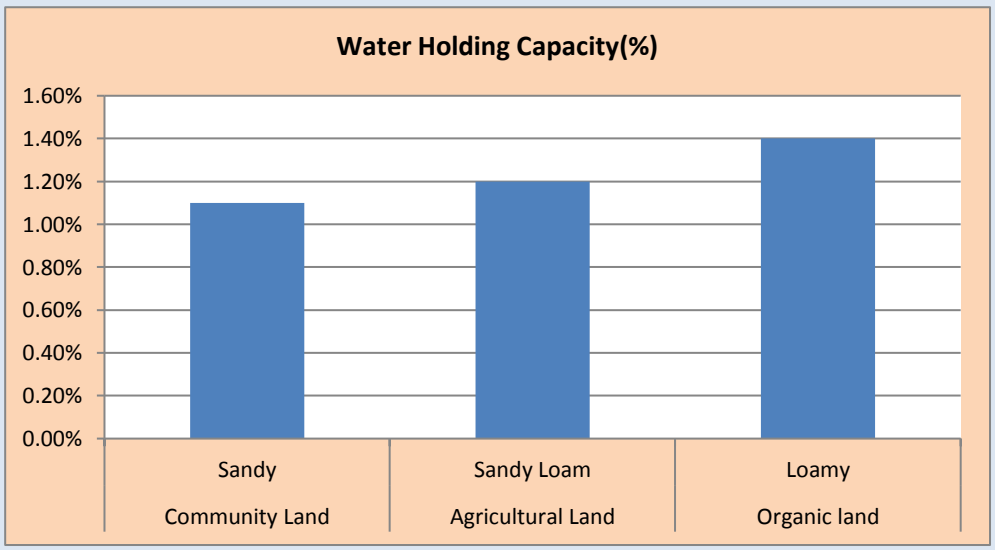
Ritu Singh

Agriculture accounts for more than two thirds of global water use. Regional hydrology is severely impacted due to wasteful use of water for irrigation in agriculture – 2.5 times than the actual water requirement. India has 18% of world population, having 4% of world's fresh water, out of which 80% is used in agriculture. Poor water use efficiency (38%) is the primary reason for water diversion from river systems. Dams, aqueducts, and other infrastructure have dramatically altered our rivers, causing enormous ecological damage.

As agriculture forms the largest land use in any watershed, this can contribute towards largest reduction in water use by adopting sustainable land management practices. Sustainable agricultural practices can reduce water use in irrigation by half by focusing on sustainable soil/land management methods - composting, mulching, increasing soil carbon, increasing infiltration, and by discontinuing use of chemical fertilizers and pesticides. In case of drought or dry spell, protective irrigation can be provided at critical growth stages.

Sustainable farming employs cropping pattern based on "Climate-Soil-Crop" relation, uses native seeds that require lower inputs like fertilizers, therefore their water demand too is low. Water demand is further reduced by traditional mixed cropping and agroforestry practices that provide leaf litter/biomass for mulching and act as wind barrier that reduces evapotranspiration rates.

These changes, however, require paradigm shift in farming methods at a landscape and regional scale. Farmers, currently, do not have the knowledge and capacity to change their systems on their own. For example, they are unaware of which critical growth stages in crop production require protective irrigation. Large scale capacity building programmes are required for the same. At small scale it has been demonstrated on field. Comparative water holding capacity in various fields after only one year of suitable sustainable farming inputs is shown below.



Counter arguments usually provided include the "need" of crops – that a certain amount of irrigation is "needed" by certain plants, e.g., wheat required 5 irrigation as flood irrigation, regardless of soil type, local weather conditions, evapotranspiration rates etc. This need is mostly of highly resource dependent HYV seeds, not of native/ landraces. The "need" also correlates with input of chemical fertilizer that require water for dissolution and compacted soil conditions that lead to low infiltration and soil moisture.

**Conclusion**

-Sustainable soil management leads to better water holding capacity, increasing soil moisture and reducing water demand
-Mulching and no tillage in summer leads to less evaporation
-Creating wind barriers also reduces loss of water through evaporation
-By increasing organic matter in soil, water demand was reduced by 30% in mustard and Bengal gram
-Kharif crop is rainfed, soil improvement helped in tiding over dry spells
-Improved infiltration in field

### 3.14.3. Following issues further deserve attention and remediation:

a) Ill effects of large scale and mechanized sand and boulder mining from riverbed and relentless ground water withdrawal from within the basin

b) Negative effects of developmental projects like Inter linking of Rivers, River Front beautification projects and recently promoted Inland Water Transportation (IWT) project.

**National Inland Waterways in Ganga and its Tributaries - Massive Interventions in the Rivers**

Shripad Dharmadhikary & Avli Verma, 2018

Development of waterways has a few basic requirements. Most basic is the availability of water throughout the year. Waterways require the development of fairway with adequate width and depth for the plying of vessels. Various Indian rivers do not have this required depth or width naturally. Hence river conservancy works like bandalling, dredging or building of dams or barrages are needed to develop the fairway. Each of these processes disturbs the natural morphology and ecology of the riverine systems. For instance, Effects of dredging include increase in turbidity in water bodies, which in turn decreases the penetration of sunlight required by the aquatic flora and fauna. In addition to releasing settled sediments, dredging has severe impact on many of the aquatic species found in the rivers. Nachiket Kelkar, a wildlife expert, highlights the impacts of dredging on Gangetic Dolphin - the national aquatic animal of India in his article 'A River Dolphin's Ear-View Of India's Waterways Development Plans (2017)' as:

" Over 90 per cent of the Gangetic dolphin population distribution in India overlaps with the extent of the proposed waterways. This list includes existing waterways on the Ganga (1,620 km.), Brahmaputra (891 km.), the Bengal Delta and Sundarbans (>200 km.), the Barak river and tributaries in Assam and Bengal (>400 km.), and the Ghaghra (340 km.), Gandak (300 km.), Kosi (236 km.), Chambal (402 km.), Beas (191 km.), and Mahananda (81 km.). Of these, the Barak, Ghaghra, Gandak, and Kosi waterways are to be expedited. In Bihar, the surviving 1,200-1,500 dolphins are highly vulnerable to dredging and navigation impacts. Vessels of the Inland Waterways Authority of India have been regularly dredging inside the Vikramshila Gangetic Dolphin Sanctuary in Bihar – possibly without environmental or wildlife clearances. 'Unprotected' reaches of the Ganga and its tributaries also hold viable dolphin populations, but environmental impact assessments for the NW-1 wrongly assume that mitigation measures apply only to Protected Areas such as Vikramshila."

Many of the dredging operations have commenced for fairway development and tenders are being floated for many more. For example, hard strata was removed at the Ghazipur-Varanasi stretch on NW-1. Dredging work has also commenced on the Farakka-Kahalgaon stretch (146 Kms) on NW-1[1]. The estimated quantity of dredging required for this stretch only is 2.865 million CuM. Further, Dredging operation has also been initiated for developing the stretch of Krishna river between Vijayawada to Muktiyala for movement of cargo on NW-4.

Associated Infrastructure like terminals, jetties, etc. will also have to be developed for berthing of vessels, storing and handling cargo. Handling and shipment of the bulk and hazardous goods like coal, fly-ash, fertilisers, cements, iron-ore, chemicals etc. on these riverine terminals are a source of water pollution for rivers. In addition to the development of new infrastructure, existing and proposed infrastructure like low-lying road and railway bridges will have to be dismantled or

reconstructed for the passage of ships/vessels. Moreover, development of these riverine ports, terminals will mostly involve land acquisition, and restriction or relocation of fishing sites. Around 193 acre of land has been fully acquired for the construction of Sahibgunj multimodal terminal in Jharkhand for NW-1. As many as 485 families are identified as Project Affected Families by the district administration.

**MoEFCC's stand**

In spite of the fact that dredging and ports are included as activities which require environmental clearance in the EIA Notification 2006, as amended from time to time, developments on Ganga for NW-1 has been exempted from the requirement of prior environmental clearance on the grounds that ongoing dredging is Ganga is only maintenance dredging. According to EIA notification, 2006, as amended from time to time, maintenance dredging is exempted only if it is included in the Environmental Management Plan and environmental clearance has been obtained for the project, which has not been obtained for NW-1. Similar project of capacity augmentation in the waterways of Goa (NW-27, 68 and 111) was granted Terms of Reference under EIA notification 2006 by the MoEF&CC. The recommendations of the Expert Appraisal Committee to appraise this project as Category 'A' and to include inland waterways, jetties and terminals in the EIA notification with reference to specific issues addressing river as living entity, changing hydrology, riparian rights, transboundary impacts, protection of banks and floodplain zones of the river system was overruled by the Ministry of Shipping.

This project is being implemented with very little involvement of the local population. The Detailed Project Report (DPR) for NW-1 has not been made public. DPRs available for tributaries of Ganga - Gandak (NW-37), Kosi (NW-58), Ghaghara (NW-40) also leave several important questions unanswered from the perspective of disposal of dredged material, solution to the problem of silt in these alluvial rivers, and to tackle their notorious nature of shifting channels. These issues have been discussed in Manthan's preliminary report on National and International Waterways of Kosi and Gandak rivers (2018). With the latest order passed by the National Green Tribunal in Bharat Jhunjhunwala and others vs IWAI and others (including MoEF&CC and National Mission for Clean Ganga), MoEF&CC has been directed to clarify its stand on the requirement of environmental clearance for waterways by 31st January 2019.

However, MoEF&CC has been too ambiguous and passive on this issue for too long, hence wider consensus and discussions are required amongst different stakeholders to save Ganga.

**Riverfronts Development Projects on Ganga and her Tributaries - Cosmetic projects that do not restore, respect and enhance the vital river ecosystems that thrive, or once thrived in and around the river.**

Venkatesh Dutta, 2018

Natural flow regimes of rivers in India are already challenged due to various hydropower, diversion and river-linking projects. A new-fangled threat is trend of riverfront development projects in the name of river beautification. The riverfront development projects on Ganga River and her tributaries may result in loss of river ecosystems and river processes due to over-dominance of channel engineering. The ecology of the river, its floodplain, and other key fluvial characteristics are being transformed substantially without improving the water quality. For example, the widespread ecosystem degradation caused by filling of wetlands, channelization and concretization of the floodplains has led to a physical, mental and spiritual disengagement with the cultural landscape of the Gomti riverfront. The river banks, which are ecologically very dynamic, are designed to be largely undeveloped which is useful for bank storage, maintenance of floodplain biodiversity besides connecting older channels of the river and the wetlands. Integrity of river banks is maintained naturally through periodic drought and flood cycles. The natural riverfront is not a hard boundary, but a zone that shifts with time and topography. The dynamic aspect of the riverbanks and shoreline has always been a basis of riverfront vegetation and water-edge habitats.
'Canalization' of rivers through cosmetic approaches

They are nothing but cosmetic attempts to convert a river into a canal. Riverfront development enthusiasts associated mostly with irrigation department or land development agencies give reasons like 'connecting the city back to its rivers by activating riverfronts' behind supporting large-scale civil engineering projects. They also claim that such projects are attempts towards 'urban renewal' and 'heritage tourism'. In essence, riverfronts are treated as extension of urban spaces by developers. In doing so, they are not only destroying critical floodplain habitats but also altering river system's integrity.

**Recipes for rivers' demise**

In all of the riverfront projects, generally a weir, dam or barrage is constructed for the urban stretch both in the upstream and downstream segment of the river to retain water at a designated level the year round. The river banks are then heavily concretized to provide spaces for social and public infrastructure such as car parking, plaza, walkways, restaurants, theme parks, gardens etc. The improvements in river water quality and improving the waste management system or drainage have been given secondary or no importance while designing such projects.

Dodging facts to get environmental clearance under 8(a) and 8(b) of EIA notification

Strangely, in all riverfront development projects, environmental impact assessment (EIA) is by default considered 'not necessary' as the type of projects for which prior assessment is needed does not mention riverfront development projects. The developers take the easy way of 'building and

construction projects' or 'township and area development projects' (mentioned in Schedule 8(a) and 8(b) of EIA notification, 2006) for seeking NOC from the environmental agency. This is really strange. The EIA study does not consider the loss of sand banks, and other habitats which are potentially breeding sites of amphibians including turtles.

**Conclusion:** The riverfront projects are ecologically undesirable and cosmetic projects that do not restore, respect and enhance the vital river ecosystems that thrive, or once thrived in and around the river. Our river engineers need to know that riverbanks and riverfronts should never be concretized where the ecological wellbeing of our water edge habitats are protected, restored and enhanced, regardless of how high the commercial and profit-making values add to the economy. Rivers make their own waterfronts – naturally, planners should invest in ecological wellbeing, and must not create ecosystems that is contingent upon their destruction.

**Interlinking of Rivers: A Dangerous Idea**

Mihir Shah, 2019

The proposal for interlinking of India's rivers (ILR) is based on a series of erroneous presumptions. It is claimed that since some parts of India chronically have floods and others have droughts, the solution is to divert water from surplus river basins to deficit ones, so that everyone can live happily ever after! Is it true that some areas in India have too much water? Try telling the north-eastern states that! Did you know that Sohra (previously known as Cherrapunjee), one of the highest rainfall hotspots on the planet, today suffers from an acute shortage of drinking water? The reason for that lies precisely in the old paradigm of water management, where we have failed to protect our catchment areas, destroyed springs and over-exploited groundwater. Climate change has aggravated the situation.

Today, my organisation, Samaj Pragati Sahayog, is working hard to find a solution to this vexed problem but I can tell you in Sohra, with only 70,000 people and as much as 8,000 mm of rain (10 times that of Delhi), we still have no water to spare for anyone else in the country! In the sub-continent, given the dependence on the monsoon, the periods when rivers have "surplus" water are generally synchronous. And a recent study finds a significant decrease in monsoon rainfall over water "surplus" river basins in India, thus raising questions about the basic presumptions of the ILR project.

The Himalayan component of the ILR project plans to store water in dams on the Ganga and the Brahmaputra, in the supposedly surplus northern and eastern states and transfer that water via canals to the water-short central, southern and the western regions.

The Peninsular component attempts something similar on peninsular rivers, again transferring supposedly surplus water from the east to the south and west. Overall, the attempt is to connect 44 rivers via 9,600 km of canals at an estimated cost of ~11 trillion. This is only an approximation of the actual cost, which is likely to be much higher (given expected delays in implementation) and does not include costs of energy, farm and forest submergence and human displacement.

What is truly ironic is that, given the topography of India and the way the links are envisaged, they might totally bypass the core dryland areas of central and western India, which are located on elevations of 300 to 1,000 metres above mean sea level.

In recent years, scientists have begun to carefully examine the potential impact of such large interventions in India's river systems. A 2018 study of 29 of these 44 rivers published in the renowned international science journal Elementa finds that ILR will submerge 3,400 sqkm of land and displace approximately 700,000 people, other than the huge additional displacement that would be caused by the vast canal network. It will also decrease river flows for 24 of the 29 rivers (as much as 73 per cent), reducing freshwater deliveries to wetlands and estuaries. Waterways will be exposed to new contaminants, invasive species, and disease-causing agents and the already vulnerable deltas of the Indian subcontinent will be further compromised due to reduced silt deposited by rivers in their deltas by as much as 87 per cent. Reduced stream-flows will likely affect delta salinity conditions and under a future rising sea-level scenario, the salinity of groundwater and river channels is expected to increase. Climate related salinity incursion in rivers and deltas will be exacerbated by the decrease in river mouth discharge. Rare ecosystems and vital agricultural areas would become more vulnerable to storm surges, river flooding, and heightened salinity.

Finally, we must recognise that the ILR could profoundly impact the very integrity of India's monsoon system. The continuous flow of fresh river water into the sea is what helps maintain a low salinity layer of water with low density, in the upper layers of the Bay of Bengal. This is a reason for the maintenance of high sea-surface temperatures (greater than 28 degrees Celsius), which create low-pressure areas and intensify monsoon activity. Rainfall over much of the sub-continent is effectively controlled by this layer of low-salinity water. A disruption in this layer because of massive damming of rivers under the ILR and resultant reduction in fresh water flows into the sea, could have serious long-term consequences for climate and rainfall in the subcontinent, endangering the livelihoods of a vast population.

Rivers are not human creations like roads and power lines, to be twisted and turned at will. They are living ecosystems that have evolved over hundreds of thousands of years. In our arrogance we have already caused them much damage. It is time now for us to urgently come together to regenerate our river basin ecosystems, weaving our interventions into the delicate fabric of nature, with humility and wisdom, heeding both science and spirituality.

Excerpted from https://www.business-standard.com/article/opinion/interlinking-of-rivers-a-dangerous-idea-119080801731_1.html (Business Standard, 8 Aug, 2019)

## 3.15 Cultural Dimensions of River Ganga

***How well do we understand the Cultural dimensions of River Ganga basin?***

"*The Ganga is the river of India, which has held India's heart captive and drawn uncounted millions to her banks since the dawn of history. The story of the Ganga, from her source to the sea, from old times to new, is the story of India's civilization and culture, of the rise and fall of empires, of great and proud cities, of the adventure of man and the quest of the mind which has so occupied India's thinkers*..."

- Jawaharlal Nehru in 'The Discovery of India' (1946)

3.15.1. Hinduism in India is a very strong example how rivers may become central elements of religious and social life – and how a purely utilitarian Policy may impair these structures[17]. Losses of significant cultural ecosystem services may exacerbate social conflicts[18].

3.15.2. Rivers and floods are metaphors for constant change, for the unification of constructive and destructive forces that have driven philosophers since Heraklit's ''panta rhei''; and the esthetic values of sinuous meanders, rounded pebbles, or mirroring water surfaces imbued painters and sculptors. The rhythm of running water is at the same time monotonous and highly diverse, and has inspired musicians to compose pieces such as Smetana's Vltava (The Moldau), or much of J.S. Bach's diverse work. All these technological and the spiritual linkages of human beings to rivers have contributed to diverse forms of culture.

3.15.3. Along with alarming loss of biodiversity, we register a loss of cultural diversity linked with rivers and floodplain wetlands (Ricaurte et al., 2014; Wantzen et al., 2008b), as ecological services provided by river systems are not available any more (e.g. fish), or because traditional-cultural use of river-borne resources is ''outdated'' (i.e. they are not considered to be economically feasible any more) today, or because people have lost the notion of a healthy river (e.g. due to pollution) and prefer to have the river canalized and covered by concrete. However, the economics behind these views are often incomplete, as important financial elements are overlooked, for example, inland fisheries are for many of the world's people the primary source of dietary protein (Dugan et al., 2010) and costs for restoration of deteriorated ecosystems are often manifold those of the benefits. There is an urgent need to reevaluate and to reprioritize our action[19].

## 3.16 International Dimension of River Ganga

***How well do we appreciate the international dimension of River Ganga?***

3.16.1. The Ganga River System originates in the Central Himalayas, and extends into the alluvial Gangetic Plains and drains into the Indian Ocean at the Bay of Bengal. Its basin area (1.09 million km2) spreads across India (79%), Nepal (13%), Bangladesh (4%) and China (4%). The river is of high importance to riparian countries with an estimated 410 million people directly or indirectly depending on it[16].

3.16.2. Nepal is the water tower of Ganga. Four large tributaries (Mahakali, Karnali, Gandak and Kosi) and fiver medium rivers (Babai, West Rapti, Bagmati, Kamala and Kankai) contribute 47 per cent of total water flow reaching Farakka. They provide 75 per cent of the water flow during the lean months (March, April, May). (https://www.downtoearth.org.in/indepth/conflict-over-ganga-9059)

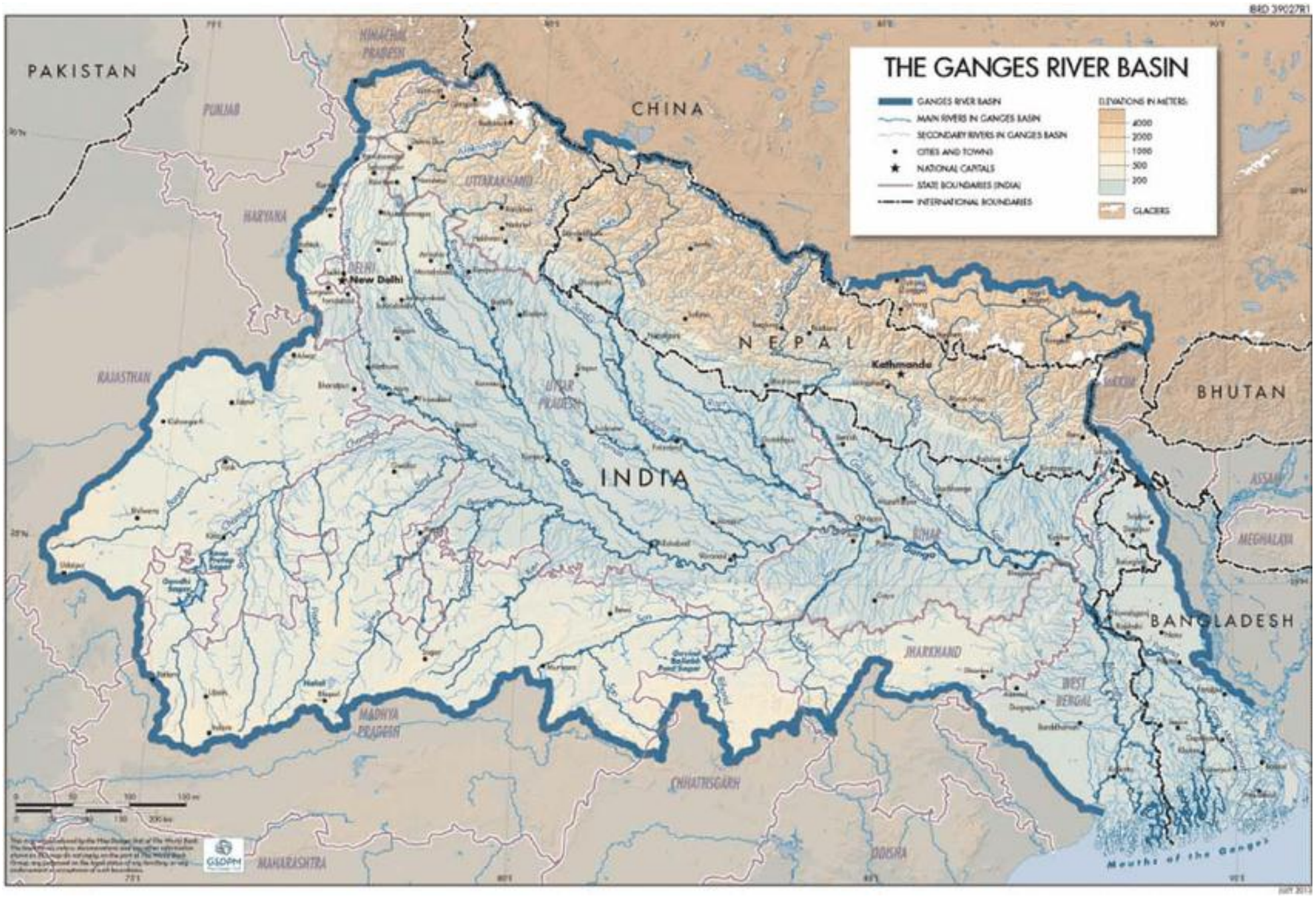
3.16.3. The river flows from dry areas to wet areas in the east, causing massive floods in eastern Uttar Pradesh, Bihar, West Bengal and in Bangladesh. The floods were never considered a curse. Over the last thousands of years, the rich silt attracted millions of settlers, turning the Ganga basin into one of the most densely populated regions in the world.

3.16.4. Eighty (80) per cent of the total run-off in Ganga flows only in four months: June to September. A quick look at the average annual rainfall over different cities in the basin shows its spatial nature.

3.16.5. **Annual Rainfall West to East Along the Ganga Basin;**

Delhi **712mm;** Allahabad **977mm;** Patna **1165mm;** Kathmandu **1379mm;** Kolkata **1648mm** and Dhaka **1969mm**
(https://www.downtoearth.org.in/indepth/conflict-over-ganga-9059)

3.16.6. Thus, for a sustained rejuvenation of river Ganga, it would be necessary to acknowledge and appreciate the international dimension of the spread of its basin.




**Map 2: International Dimensions of Ganga Basin**

**Source:** https://www.orfonline.org/research/eco-hydrological-perspective-monsoon-high-flows-ganga-padma-system-imperatives-flood-management-55944/

## 3.17 People's Role in Governance of River Ganga

***Do we have a clear concept about people's role in governance of River Ganga basin?***

3.17.1. One of the 'Principles' in Ganga Authorities Order, 2016 state :
"*Public participation to be made an integral part of processes and practices of River Ganga rejuvenation, protection and management*"

3.17.2. While Ganga remains a source of religious faith and provider of spiritual succor to millions, the same people have no stake or even interest in its well-being. This is because the state agency has usurped its management role from local people and their institutions. This needs reversal if river Ganga needs to have a sustained and sustainable rejuvenation.

3.17.3. It is strange that when a colonial power (British) wanted to create a structure over river Ganga at Haridwar, it went through a consultation process before an agreement (1911) with local people's representatives could be arrived at.

3.17.4. It is sad that after independence, the Indian state could not see the pitfalls and the ill effects that had arisen from change in hand of the management of water and water sources from the local people into the hands of government functionaries. Newly independent India continued to follow the same policies and management practices that the colonial power had put into place with an ulterior motive of revenue generation.

**NMCG initiatives** (https://nmcg.nic.in/index.aspx)

3.17.5. Identification and training of GANGA PRAHARI and GANGA MITRA are two of the activities that NMCG has promoted with following objectives:

- Ganga Praharis are self-motivated and trained volunteers from among the local communities working for biodiversity conservation and cleanliness of the Ganga River with the ultimate objectives of restoring the Nirmal and Aviral Dhara.

- Ganga Mitra is a Task Force at grass root level of selected people of urban, sub-urban and rural areas on the bank of river Ganga to help in rejuvenating the Ganga and its associated water bodies.

3.17.6. While these initiatives are laudable, it remains to be seen if these get translated into a people's movement and more importantly if these lead to cementing local people's critical role in the actual governance of River Ganga?

**SANDRP's suggestions on People's Role in Governance**

One of the major reasons for the failure of the GAP, NRCP and NGBRA is that their functioning is top down, with absolutely no clearly defined norms for transparency, accountability, participation and inclusive management. Unless we completely change this, no amount of money, no amount of technology, no amount of infrastructure or institutions is going to help the Ganga.

We need management system for every STP, every freshwater plant, every city and town, every 3-5 km of the river, every tributary and so on. At least 50% members of the management committees for each of them should be from outside the government, including community members. The people whose lives and livelihoods depend on river including fisherfolk, boat people, riverbed cultivators, local sand miners, communities depending on river for different water needs have to be represented in such management system. That will also create an ownership in river rejuvenation effort. This is also applicable to urban areas and all the tributaries.

This is also true for our environmental governance of dams, hydropower projects, flood control projects, water supply projects, and so on. Today there is no credible environmental management at planning, appraisal, construction, operation or decommissioning stage.
(https://sandrp.in/2014/07/08/will-this-ganga-manthan-help-the-river/)

**Interstate Cooperation for Ecosystem Services**
Srinivas Chokkakula

"Is a system of compensating upper riparian states for ensuring Ganga's ecosystem services to lower riparian states feasible?" I was asked to engage with this question. Pondering over this one has led to more questions, and fewer answers. Why will a lower riparian want to compensate an upper riparian? What are the modalities of such a transaction? Who will facilitate it, and where? Can it happen bilaterally? What about the rest of the riparians? We can perhaps find some answers, but more troubling policy questions followed. Why should an upper riparian be advantaged? Why should it happen only over Ganga? Why not other rivers? And then, larger and philosophical questions: Does financialization of a public good and interest help? Does it not widen already existing asymmetries between states?

These questions call for a more comprehensive measure to meet the challenge: an ecosystem for interstate river water cooperation and collaboration. Does India have such an ecosystem? This may be the right question to begin with. Before setting out to address this, it will help to understand what prompted the hope and optimism around the initial question about upper and lower riparian states collaborating for better environmental outcomes.

The often cited source of this optimism is the European experience of improving river water quality in Rhine through collective action of riparian nations, followed by other rivers in Europe. These are remarkable instances to learn from, but the tendency is to assume that the experiences can be transferred and replicated unconditionally - without paying adequate attention to the process and the path dependency of these success stories.

The International Commission for the Protection of the Rhine (ICPR), the focal point for much of the action on Rhine, goes back to 1950. ICPR provided the institutional space for the nations to negotiate collaborative actions to address pollution in the Rhine. The deliberations and negotiations were facilitated by ICPR under several bilateral and multilateral conventions and conferences. For instance, ICPR held the Berne Convention in 1963 which eventually led to the well-known Salt Agreement in 1976 against pollution by chlorides and other chemicals in the Rhine. The Netherlands, Germany and Switzerland agreed to contribute to reduction of pollution from coal mines in France. In a similar manner, ICPR had been an anchor to engage with several other specific issues such as dangerous substances and thermal pollution. Some of these led to interesting reciprocal arrangements. A lower riparian built a fish ladder for fish and other organisms travel into the reaches of an upper riparian, as a reciprocal response to another upper riparian's efforts in controlling pollution. Over time, the ICPR's scope has increased from controlling pollution to achieving good ecological status in the Rhine.

These engagements were not all inter-governmental but shaped by active participation of nonstate actors as well.

What goes unnoticed in this inspiring story of ICPR is the evolution of the European cooperation, the bedrock of ICPR's success, institutionalized now as the European Union (EU). This cooperation began after the Second World War, initially to overcome economic challenges with the formation of the European Economic Community (EEC). The EEC published an environmental policy in 1970s, followed by several other directives related to environment including the Water Framework Directive (2000). ICPR's wide ranging conventions and deliberations relied on the power and authority of EU's directives. EU's own legitimacy accumulated over the 50 years of its evolution through the deliberative consensus of the member countries. In this process, the member countries had to concede, to some extent, their sovereign powers in the interest of their collective good. EU's directives are binding on the member countries.

When member countries do not comply, EU is empowered to take punitive measures. In other words, EU has led to equalizing and normalizing the upper and lower riparian asymmetries, turning the Rhine rejuvenation into a collective action problem.

India's ecosystem for interstate cooperation has to build on such legitimate institutional spaces to deliberate and negotiate collective action for progressive outcomes. The various elements of an ecosystem for interstate cooperation – politics, policies, laws, institutional solutions and practices - can evolve, and be effective only when these emerge out of a deliberative consensus of the States – the key stakeholders. Convening for, and forging such a consensus is particularly challenging in Indian context for at least two reasons. First, unlike Europe, Indian States' interstate relations are characterized by antagonistic politics over interstate river water allocations, quantity (individual interest) and not quality (collective interest). The challenge of interstate river water governance has to contend with these antagonistic relations. Second, the States' appreciation of this crucial agenda and their response will be uneven – depending on how their respective interstate interests emerge and escalate.

Is there such a forum to deliberate interstate cooperation over rivers in India? The response is unfortunately an unequivocal no. The track record of interstate river water disputes resolution would reveal that no such forums that States trust exist. There has never been a sincere and deliberate efforts to create and nurture such avenues, institutional or political. Generally, India' approach to interstate river water governance has been skewed, excessively focused on resolving conflicts and much less on enabling cooperation. Consider the following. The Interstate River Water Disputes Act 1956 has been amended more than dozen times. In contract, the River Boards Act 1956 has never been amended so far, even after several commissions declared it as a "dead letter." More interestingly, none of the existing river boards are created using the force of the act.

This negligence of enabling interstate cooperation is the foremost and primary gap that has to be addressed. Interstate river water governance has a special status in the Indian constitution. The Article 262 provides for barring the jurisdiction of any court, including the Supreme Court, over interstate river water disputes. It is perhaps not coincidence that the peculiar feature is followed by another article (263) that provides for Interstate Council. This constitutionally provided institutional space can be an avenue for States to deliberate and negotiate interstate coordination for dispute resolution of rejuvenation of rivers. However, the Interstate Council has been located as a department of the Ministry for Home Affairs. This positioning affects how States perceive this is a reliable and legitimate institutional avenue. It is not that the need for such an institutional space has not been felt. The National Water Resources Council has been established in 1983 with the Prime Minister as the Chair and the Chief Ministers of States as members. For inexplicable reasons, this has largely remained defunct. The first step then, towards an ecosystem for interstate river water cooperation, is to revisit the constitutional provisions and consider elevating and strengthening the Interstate Council towards an autonomous, neutral and empowered institutional space for interstate deliberations. It does not look that ambitious when we consider the swiftness with which such a deliberative consensus of States has been achieved for GST reforms.

## 3.18 Climate Change and the River Ganga Basin

***How far are we alive to the Climate Change situation vis a vis the River Ganga basin?***

3.18.1. Impacts from climate change on a region's average temperature and hydrology can be serious. Eddy Moore, head of the Earth Systems and Climate Change group at Alterra Wageningen University and Research Centre in the Netherlands, and who coordinated a study on the impact of climate change on the Ganga Basin informed Down To Earth Magazine in 2015 that:

"*Changes in the monsoon rain due to temperature rise will impact people. Our regional climate models show a clear trend of rising temperatures in the Ganga basin: 1-2°C by 2050. However, it is not easy to predict when and in which parts of the basin the precipitation changes will be severe because of the large natural variability in rainfall. It will increase in some parts and decrease in the others. More research is needed to reduce uncertainty. Models show extreme events that happened once in 20 years will happen once every two years in future*.

3.18.2. Himalayan glaciers, often called the third pole are losing their ice cover fast. In fact, double as fast since the turn of the century than the 25 years prior to that, according to a new study. Researchers from Columbia University claimed that the glaciers have lost more than a quarter of their ice in the last four decades. They sifted through declassified US spy satellite images from the mid-1970s and took help of modern satellite data and looked at 650 glaciers and four-decade record of ice along the 2,000 kilometers mountain chain.

3.18.3. The study, published in Science Advances journal claims, the Himalayas lose an average of 4 billion tons of ice annually from 1975-2000. After 2000, however, the glaciers started melting twice as fast, losing about 8 billion tonnes, every year up to 2016. Lower-level glaciers have been shrinking 5 metres height annually since 2000.

3.18.4. Researchers blamed global warming caused by human activities mainly for the drastic melting. The glaciers are shrinking at similar rates all along the mountain chain, indicating a common cause. Temperatures in the region have risen by an average 1 degree Celsius between 1975-2000 and 2000-2016.

3.18.5. Melting glaciers will affect great rivers that flow through China, India, Pakistan, and Bangladesh. This, in turn, will have a serious impact for billions depending on these rivers in recent future.

3.18.6. To stop this temperature, rise and to cool the planet, slowing down greenhouse gas emissions won't be enough. Current conditions will have to be reversed, which will be the greatest challenge for the human race in the coming years.

**South Asia's Hotspots: The Impact of Temperature and Precipitation Changes on Living Standards.**
Mani, Muthukumara, et al, 2018.

The 2015 Paris Agreement on climate change sets a target of limiting average global temperature increases to 2°C (3.6°F) relative to preindustrial conditions. RCP 4.5 represents a future in which some collective action is taken to limit GHG emissions, with global annual average temperatures increasing 2.4°C (4.3°F) by 2100. Therefore, the book labels RCP 4.5 as a "climate-sensitive" development scenario. RCP 8.5 is closer to a scenario in which no actions are taken to reduce emissions, and global annual average temperatures increase 4.3°C (7.5°F) by 2100. The book labels RCP 8.5 as a "carbon-intensive" development scenario.

Global climate models are the primary tool for projecting how a given RCP scenario will affect the Earth's climate. Climate models are designed to approximate fundamental laws of physics, modeling interactions between the atmosphere, land, and oceans. This research considers 18 global climate models covered by the Climate Model Inter-comparison Project (CMIP5), and assesses their performance in reproducing historic weather patterns observed in South Asia. On the basis of this performance criterion, 11 models are selected that perform best. The research uses these 11 climate models to project long-term changes in average temperature and precipitation throughout South Asia.

The average prediction by these climate models is that annual average temperatures in South Asia will increase 1.6°C (2.9°F) by 2050 under the climate-sensitive scenario, and 2.2°C (3.9°F) under the carbon-intensive scenario. These increases are relative to 1981– 2010 conditions. Projected changes in precipitation are highly uncertain, in part because they are heavily dependent on cloud microphysics, which are difficult to represent in current global climate models. The average climate model prediction is that average monsoon precipitation will increase 3.9 percent under the climate-sensitive scenario and 6.4 percent under the carbon-intensive scenario by 2050.

If average precipitation increases, some areas that have historically experienced low rainfall could benefit. It is also likely that extreme precipitation events will become more common, especially because of the large simultaneous temperature increases.

Extreme precipitation events would cause an increase in damage and economic disruption, whereas decreasing precipitation would result in less overall water availability in South Asia, which would reduce agricultural yields and water security in some areas.

# 4. RECOMMENDATIONS

## 4.1. Ganga Assembly: Need to Promote Peoples Participation to Inform Decision Making

4.1.1. A Ganga Manthan was organized on 7th of July, 2014 at Vigyan Bhawan, New Delhi. It was a national level consultation to facilitate interaction with various stakeholders including policy makers and implementers, academicians, environmentalists, saints and spiritual leaders from all faiths and NGOs for the cause of Ganga Rejuvenation. While a welcome first step, a one-day assembly remained no more than a lip service to a huge cause and resulted in nothing more than a glossy publication.

4.1.2. Since the cause of River Ganga rejuvenation is multifarious and complex and cannot be achieved just through the mechanism primarily of pollution abatement measures, there is a need to constitute a **GANGA ASSEMBLY** of standing nature with a wide representation (Academicians, scientists, researchers, sociologists, administrators, technologists, saints and spiritual leaders, legal experts, authors, media persons, legislators, representatives of local people with livelihood dependence on the river, NGOs) membership and a considerable life period, say 2 years, so that various issues regarding River Ganga rejuvenation are threshed out in a transparent and participatory manner. The Ganga Assembly needs to reflect the voices and opinions from all over the River Ganga basin and beyond in the country. A person of considerable eminence and scholarship (if need be a former Judge of the Supreme Court of India) may be requested to convene the Ganga Assembly.

4.1.3. It would be expected that the Ganga Assembly provides clear drafts, guidelines and action plans on following and related matters:

a) Legal measures including draft of a People's River Ganga Rejuvenation Bill (Draft as proposed by late Swami Sanand (Prof. GD Agarwal) to form the basic draft)
b) Governance and Institutional measures including publication of river data
c) Ecological, Scientific and technological measures needed to restore the health of River Ganga and its tributaries
d) Measures to restore the spiritual, cultural aspects of River Ganga
e) Measures to create a people's movement for River Ganga rejuvenation
f) Measures to solicit international cooperation from within the River Ganga Basin

**Is the Ganga a living entity?**
Neha Sinha, Bombay Natural History Society, 2018

That people worship the River Ganga, refer to her as a 'mother', and a source of miraculous rejuvenation is well known. Tragically, what is even better known is the fact that the Ganga has become the most polluted river because of our excesses.

In 2017, the Uttarakhand High Court delivered a unique judgment. It gave Ganga rights similar to that of a living person; in effect saying it was a living entity. In many ways, this can be seen as a culmination of people's spiritual inclinations towards the river; but did the religious aspect impact the judgment? Judgments too sit within society and the grammar of cultural inheritance, and this is not my primary concern. My primary concerns are twofold- firstly, if Ganga is a living entity, then what is it that makes her/it a living entity? Secondly, how can a judgment like this be implemented so that the river exists like a real person?

The Collins dictionary describes an entity as 'something that exists separately from other things and has a clear identity of its own'. Most things have identity. A chair for example has identity—that of being a piece of furniture which people sit on, an entity that is not a table. But in human society, there is a hierarchy of identities. Language, jurisprudence and human civilization gives more value and greater identity to something that is living. A tiger, as an animated, live entity, will have more value than a chair. Thus, Ganga as a 'live' person will have more identity as just a river.

Ganga has been personified a great deal- seen as a woman, a nurturing mother, and a carrier of life. The personification of this bountiful deity clashes sharply with our treatment of her. Thus, on an ontological level alone, the Judgment seems to right historic wrongs. At the same time, orders like this are not unique. In 2011, Ecuador recognized the Rights of as something that could be defended in Court. In 2017, New Zealand recognized the river Whanganui as an entity in its own right. The river would be a legal person with the rights, powers, duties, and liabilities of a legal person.

Interesting, the prospect of being a 'person' is closely linked to ecological integrity and health of the system. The Guardian newspaper quotes tribal negotiators for the case as saying:
- "We have fought to find an approximation in law so that all others can understand that from our perspective treating the river as a living entity is the correct way to approach it, as in indivisible whole, instead of the traditional model for the last 100 years of treating it from a perspective of ownership and management." - Gerrard Albert, lead negotiator for the Whanganui iwi tribe.

'New Zealand river granted same legal rights as human being' (2017), The Guardian
Thus, to answer my first question, the Ganga – or a river at the scale of the Ganga—is a living entity because of its ecological integrity, and a recognition of this integrity. The river is a cornucopia of life, carrying various forms of life and biodiversity: algae, Gangetic Dolphins, fish, waterbirds, otters, turtles. Thus, assailing this integrity would mean assailing the life of the Ganga, and this integrity needs to be maintained now. There is no point giving any personification or so-called Rights to Ganga if she is ecologically dead—and thus metaphorically dead, too.

This brings us to the second question, of how rights can actually be given to a non-human entity, a river. A non-human (and indeed also some marginalized humans) do not have the agency to speak. Lidia Cano Pecharroman, in a 2018 article titled 'Rights of Nature: Rivers That Can Stand in Court' argues:

"*A legal person, formed by a set of people or goods, holds legal personhood and is also given rights and duties by the law. Exercising these rights and duties would be the next step, but not every person holds legal competence to do so on its own*."

Theories of animal-sentience say rights can be given through representation. Alasdair Cochrane, in his book, 'Sentientist Politics: A Theory of Global Inter-Species Justice' suggests that "Institutions should include dedicated representatives of non-human animals whose job should be to translate the interests of animals into deliberations over what is in the public good for their communities."

Representation of the rights of a river in decision-making is clearly one way out. But it has to be the right kind of representation. The 2017 Uttarakhand High Court judgement made 'parents' for the Ganga river. Among others, these included the Director, Namami Gange project for cleaning and rejuvenating the river, the Chief Secretary and the Advocate General of Uttarakhand. Some would argue these are terrible parents to have – as they have historically presided over the destruction of the Ganga through the fragmenting National Waterways Act and wanton water pollution.

'Parentage' or guardianship of the river should therefore happen under scrutiny, and these representatives should be changed if they do not fulfil their role. The representation should also happen within the framework of Indian judicial precedents. In Centre for Environmental law, WWF -I versus Union of India (2013) 8 SCC 234, the Supreme Court held that wild animals are not the property of even the State. The Wildlife (Protection) Act, 1972 also states in Section 39 that Wild Animals are not the property of the State. Thus, the wild animals in the Ganga need to be treated with respect. As an extension of this – and if we consider Ganga to be a wild animal—it/ she should be allowed to flow over it/her floodplains and not be barraged or dammed in a way that changes fundamental character.

To sum up, with or without Court orders, Ganga is a living entity only because the river contains life forms. Being a living entity or person means a certain level of health, in this case ecological integrity. In order to enjoy rights of a person, a river like Ganga needs to have representatives who stand for its various forms of supporting life—wildlife, fishermen, and the needs of the ecosystem itself. 'Parents' or these representatives should be open to scrutiny.
I suggest the bare bones of a 'Ganga Best Interest Standard':
Ganga has an inherent right to live and shall be protected by law, subject to the exceptions provided out of necessity. Ganga has also honour and dignity which cannot be arbitrarily deprived of and its rights and privacy have to be respected and protected from unlawful attack.
Ganga's ecological integrity and species need preservation, not just management and cleaning.
Ganga will be represented not just for existing but with a standard of best interest.

## 4.2 Role of NMCG

2.2.4. It would be useful for the NMCG to take up following measures to support informed decision making by the Ganga Assembly:

i. Establish the consensus situation with regard to the likely impact of Climate Change on various components of the River Ganga Basin with **special emphasis upon enhancing the longevity of glaciers and the sustainability of current precipitation levels**
ii. Define terms like Ganga Rejuvenation to its natural and pristine state and decide on a reference past
iii. Review the list of Principles listed in the Ganga Authorities Order, 2016 for Rejuvenation, Protection and management of River Ganga and make additions as found appropriate
iv. Commission aquifer mapping in all the sub basins of the River Ganga Basin under the current countrywide aquifer mapping project of Jal Shakti Ministry on priority
v. Establish the rejuvenation needs of all the tributaries which are in need of the same
vi. Review and establish sound method/s for monitoring the health of River Ganga Direct the IITC to complete the task of the preparation of RGBMP and commission a peer review of the same
vii. Establish the actual rate of evapo-transpiration in the River Ganga Basin
viii. Take necessary steps to implement the No Construction Zone principle within the River Ganga floodplains as mandated by the Ganga Authorities Order, 2016
ix. Determine E flow regime in every sub basin within River Ganga Basin
x. Impose a moratorium on the construction of any structure (dam, barrage, embankment, etc.) within the River Ganga Basin till the Ganga Assembly has decided on the same
xi. Review and cease its support to developmental projects like ILR and IWT and concretized beautification projects such as River Front Developments

## 4.3 Experts' Recommendations

a. Introduce Integrated River Basin Management at the level of 2nd, 3rd and 4th order streams
b. Introduce a massive program of water saving agronomic practises, efficient irrigation technologies, effecting changes in cropping patterns through strategic orientation of MSP for water saving. The target would be to almost entirely irrigate crops through rain, groundwater and soil moisture.

c. For restoring e-flows, ***all proposed projects in the Ganga River Basin should be cancelled***. The construction of all projects in the headstreams of the Ganga should also be cancelled forthwith
d. Among medium-term measures, ***old dams should be decommissioned*** **as irrigation efficiencies are mainstreamed**
e. With the advent of renewables and surplus capacity in thermal power generation proposals for further HEPs should be dropped and the decommissioning of existing ones considered
f. The ***inland waterways and riverfront development projects should be withdrawn*** as they are harming the Ganga. Same applies to **Interlinking of Rivers** scheme.
g. Urban settlements should move towards water efficiencies [for example promoting the use of dry toilets] and recycling of treated water
h. Integrity of the floodplains as space for the rivers may be maintained as envisaged in the Ganga Authorities Notification and also in the draft River Regulation Zone. Enforcement mechanisms for the same need to be instituted.
i. Data collection regarding hydrology of smaller rivers is mostly absent. Data collection regarding flows at various points even at the level of 2nd and 3rd order streams needs to be instituted urgently.
j. Currently, all riverine hydrology data is collected by the CWC. The same agency is also responsible for river diversion projects and river linking projects. There is a clear conflict of interest as the data can be subjected to manipulation to justify exploitative projects which cannot be justified on the grounds of benefit/cost ratio. Even outdated data can be used which is no longer valid under climate change circumstances. The data generation arm of CWC must therefore be insulated and made independent of the project wing. Procedures of data collection and real time data must be readily available on the website. Alternatively, there could be an independent, autonomous body engaged in collection of data relating to rivers.
k. Urgent steps need to be taken to implement the recommendations of the Mihir Shah Committee (2016) so that CWC and CGWB start to function in more integrated manner.
l. **An autonomous institute for the Ganga** should be established rather than a one controlled only by the government. Change to bring in more non-govt experts aboard in various advisory forums and existing decision-making structures.

**Basin Governance – The Missing Link**

Manu Bhatnagar

Despite the National Water Policies (1987, 2002 and 2012) stressing the need to adopt basin level management for rivers, no concrete steps have yet been taken towards setting up of empowered basin management organizations. Reliance has been placed upon the existing administrative structures which are simply not geared towards basin management. Considering that:

- Basin boundaries are not coincident with District boundaries.
- Therefore, data collection is on administrative unit basis and not on basin basis.
- That no level of the administrative hierarchy is willing to subordinate itself to the water-based diktats of an empowered basin management organization.

**First Step** would be to address basin management of tributaries and their direct tributaries. Some of these tributaries would be intra-state hence easier to address and others would have some more complexities owing to their inter-state nature.

**Second step** would be to **collect the data on basin basis**. This would require that relevant statistics which are collected at village, block and district level be color coded for their pertinence to a particular basin. Thus, for e.g., if a district falls in 2 basins then statistics of villages falling in one basin would be color coded according to the color code imparted to that basin whereas statistics pertinent to a different basin would be color coded as per the assigned color code of that basin. This exercise is not difficult to carry out and would start building the picture of the basin and its water consumption while at the same time embedding a basin approach mental pattern in the minds of the decision makers and administrators at all levels. River maps, hitherto the preserve of irrigation departments, would become common currency as river basin-based administration maps.

**3rd** step in this regard would be to **establish the water budget of a basin**. The budget is based on the resource side ledger which includes rainfall, surface flows, evaporation losses, groundwater resources and perhaps recycled water. On the consumption side the ledger would include irrigation requirements, domestic [including rural and livestock] and industrial consumption. The budget would thus show whether the basin is living within its resources sustainably or overexploiting its resources or drawing upon other basins for its activities or a combination of both.

**4th step** would be analysis of the water budget which would reveal **points of intervention**. These could be related to cropping pattern, water saving agronomic practices, domestic/industrial water efficiencies, use of recycled water, enhancing forest cover in catchments, detailed aquifer mapping.

The **5th step** would be to **insert the basin management organization at a high level in the administrative hierarchy.** For intrastate river this may require a state level administrative reorganization. At interstate level this may require the Central Govt to intervene and perhaps even constitutional changes to enable interstate basin organizations. The **role of the basin managers would be decisive in allowing/disallowing developmental projects based on their impact if any on the basin water budget and river health.**

**Cumulatively**, the sum of basin management of tributaries would aggregate to basin management of the highest order stream (**Ganga** in this case) in due course.

A start has to be made somewhere after all.

## 5. REFERENCES


1. Anonymous. 2015. Ganga Basin Water Balances - Data Extraction and Analysis using Available Hydrological Model outputs. INRM Consultants, New Delhi
2. Everard M., Sharma O. P., Vishwakarma V. K., Khandal D., Sahu Y. K., Bhatnagar R., ... & Kumar V. (2018). Assessing the feasibility of integrating ecosystem-based with engineered water resource governance and management for water security in semi-arid landscapes: A case study in the Banas catchment, Rajasthan, India. Science of the Total Environment. 612: 1249-1265.
3. Gupta N.K. (2016). Temporal Variation of Inflow to the Dams of Rajasthan State with Special Reference to Ramgarh and Bisalpur Dams. PhD Thesis. Malaviya National Institute of Technology.
4. Anonymous. 2018. River Stretches for Restoration of Water Quality. Central Pollution Control Board. New Delhi.
5. Cautley, Proby Thomas (1864). *Ganga canal. A disquisition on the heads of the Ganga of Jumna canals, North-western Provinces*. London
6. Gopal, B. 2013; Environmental Flows, NIE, New Delhi
7. Mukherjee, A., Bhanja, S.N., Wada, Y. 2018, Groundwater depletion causing reduction of base flow triggering Ganga river summer drying. in www.nature.com 13 Aug, 2018.
8. Singh, Indra B. 2007. The Ganga River. In: Large Rivers Geomorphology and Management Edited by Avijit Gupta. John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex PO19 8SQ, England
9. Sinha, RK. 2014. Ecology of the River Ganga -Issues and Challenges. Conference Paper.: https://www.researchgate.net/publication/284003792
10. D. Mussared.1997. Living on Floodplains; CRC Freshwater Ecology, Australia
11. Singh, M et al, 2006; Bibliography of Environmental Studies in Natural Characteristics and Anthropogenic Influences on the Ganga River. Environ Monit Assess (2007)
12. Jain, S.K., Jeuland, M.A., Bharati, L. and Khan, Z.H. 2016. Surface Water Resources. In: The Ganga River Basin. Status and Challenges in Water, Environment and Livelihoods. Ed by Bharati, L., Sharma, B.R. and Smakhtin, V. Routledge. New York
13. Garcia-Moreno et al., 2014. *http://dx.doi.org/10.1016/j.ecohyd.2015.12.003*
14. http://www.hydrology.nl/images/docs/alg/2012.01_Impacts_water_infrastructure_climate_change_hydrology_Upper_Ganga.pdf
15. Shah, M. 2016. A 21st Century Institutional Architecture for India's Water Reforms. Report submitted by the Committee on Restructuring the CWC and CGWB. New Delhi.
16. Jain, S.K., Agarwal, P.K., and Singh, V.P. 2007. Hydrology and Water Resources of India. Netherlands. Springer.
17. Alley, Kelly D. 2012. The Paradigm Shift in India's River Policies: From Sacred to Transferable Waters. In B.R. Johnston et al. (eds.), Water, Cultural Diversity, and Global Environmental Change: Emerging Trends, Sustainable Futures, Springer pgs. 31-48

18. Daniel, T.C., Muhar, A., Arnberger, A., Aznar, O., Boyd, J.W., Chan, K.M.A., Costanza, R., Elmqvist, T., Flint, C.G., Gobster, P.H., Greˆt-Regamey, A., Lave, R., Muhar, S., Penker, M., Ribe, R.G., Schauppenlehner, T., Sikor, T., Soloviy, I., Spierenburg, M., Taczanowska, K., Tam, J., von der Dunk, A., 2012. Contributions of cultural services to the ecosystem services agenda. Proc. Natl. Acad. Sci. U. S. A. 109, 8812–8819, http://
dx.doi.org/10.1073/pnas.1114773109.
19. Wantzen, K.M., Ballouche, A. , Longuet, I., Bao, I., Bocoum, H., Cisse´, L., Chauhan, M., Girard, P., Gopal, B., Kane, A., Marchese, M.R., Nautiyal, P., Teixeira, P. and Zalewski, M. 2016. Ecohydrol. Hydrobiol. (2016), http://dx.doi.org/10.1016/j.ecohyd.2015.12.003